Pilot scale testing of the SepAir on Witbank coal seams

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DECLARATION

I, Jo Vani van Brakel, hereby declare that the project entitled “Pilot scale testing of the SepAir on Witbank coal seams”, which was completed in fulfilment of the requirements for the degree of Masters in Chemical Engineering with Minerals Processing at the Potchefstroom Campus of the North-West University, that it has never been submitted to any other academic institution and is my own work.

No plagiarism has taken place during the completion of the project, and due credit and references were given throughout the project to work that was not my own.

J van Brakel

DELIVERABLES OF THE STUDY

- Pilot scale testing of the SepAir on South African coals
  International conference (Presentation and conference paper)
  XX International Coal Preparation Congress (ICPC 2023): Australia, 16–19 October 2023

- Pilot scale testing of the SepAir on different Witbank coal seams
  National conference (Presentation)
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- Pilot scale testing of the SepAir on Witbank coal
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ABSTRACT

There has been an increase in focus on dry beneficiation technology over the last couple of years due to water scarcity and the environmental impact of wet beneficiation. Dense medium separation uses a large amount of process water and is very expensive. The process water in use poses a significant environmental risk if not treated, which consequently adds to the high cost associated with dense medium separation. There has been extensive research into a variety of processes, and all have their benefits and limitations. The SepAir technology, which is pneumatic separation, has been showing promising efficiencies. The material is fed to the SepAir unit over a perforated mesh conveyor that screens out the ultrafine particles with the remaining material separated by means of density. The separation takes place when an upwards draft is induced through suction into a vortex section.

Although the SepAir has performed well on Northern hemisphere coal, it is not sure how this technology will perform on Southern hemisphere coal. South Africa forms part of the Southern hemisphere coal deposits, which is difficult to process in comparison with the Northern hemisphere coals. This is due to the high near-density material present in Southern hemisphere coals. A SepAir pilot plant was purchased to test South African coal, and more specifically the Witbank coal deposits.

The tests were conducted using the aforementioned pilot plant which has a capacity of 40tph. Various seams of the Witbank coal deposits were treated on four different particle size ranges, namely, 10x25mm, 10x50mm, 25x50mm, and 0x50mm. The tests considered three independent variables, which were: feed to plant, the speed of the mesh conveyor, and the speed of the suction fan. The performance of the SepAir was measured in terms of yield, cut-point density, Epm, and organic efficiency. Samples were taken for each test and sent for float and sink analysis consisting of fractional analysis done for proximate analysis, calorific value (CV), sulphur, and abrasive index. The aim of the project was mainly to test the maximum feed quality upgrade achievable by making use of the SepAir.

Desirable results were achieved from the test work conducted as significant CV upgrades and ash, sulphur, and abrasive index reductions were observed. Cut-point densities varied from 1.4 kg/m^3 to 2.2 kg/m^3, depending on the product quality specification aimed for, while Epm values of 0.06 to 0.24 were obtained. The SepAir's efficiency is however highly dependent on the amount of near density material present and at the low cut-point densities and consequently high feed quality upgrades, the yield was compromised. It was also found that high amounts of misplacement were present, but fortunately more misplacement of the product (floats) was observed in the discards (sinks) than vice versa. It was therefore decided that due to the high amount of misplacement present and the low yields obtained that further test work was required on testing the capability of the SepAir to perform double stage beneficiation.

The primary stage consisted of treating the feed material for a maximum upgrade and minimum yield to achieve export coal requirements. The discards were then retreated to run for a maximum yield and achieve domestic market specifications. This resulted in desirable upgrades as well as an increase in the overall yield.

The results indicated that the SepAir can treat South African coal at high feed quality upgrades and at a desired efficiency.

KEYWORDS: Dry beneficiation, SepAir, Southern hemisphere coal, air plant.

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Abbreviation	Description
ADB	Air dry basis
APC	Aperture
AI	Abrasive index
ANOVA	Analysis of variance
ARB	As received basis
CV	Calorific value
Epm	Ecart probable moyen
FC	Fixed carbon
FGX	Fuhe Ganfa Xuan mei
HSD	Honesty Significant Difference
ISO	International organisation for standardisation
MIAS	Moisture in analysis sample
NAR	Net as received
NGM	Near-gravity material
RB	Richards Bay
ROM	Run-of-mine
SPI	Standard precipitation index
TS	Total sulphur
VM	Volatile matter
XRT	X-ray transmission sorter

CHAPTER 1 INTRODUCTION

1.1 Background and motivation

Coal is currently the primary fuel for electricity generation in South Africa as it accounts for over 80% of the electricity available in the South African electricity grid (International trade administration, 2024). South Africa is the seventh largest coal producer in the world and the fifth largest coal exporting country (Mining Technology, 2023). The country also operates commercial synfuel plants that convert coal to liquids. With the above in mind, it is clear that the South African economy is largely dependent on the coal industry. It is estimated that South Africa has 53 billion tons of recoverable coal reserves (Eskom, 2021). The majority of the coal mined in South Africa comes from the Witbank and Highveld coalfields, but these reserves are quickly depleting (Dworzanowski, 2019). Another major coal reserve in South Africa is the Waterberg coalfield, which contains approximately 40–50% of the remaining coal reserves in South Africa (Steyn, 2021). However, the Waterberg region in the Limpopo province has a low rainfall, which restricts large scale development of coal processing plants (Department of Energy, 2018).

The Waterberg coalfield forms part of the Lephalale region. The precipitation through the year of this area is minimal and the average rainfall per year only amounts to 391mm. The maximum monthly rainfall is observed in the month of January with an average rainfall of 84mm (Climate Data, 2021). The standard precipitation index (SPI) is used as an indication of the possibility of rainfall for any duration and assists in evaluating the severity of drought (South African Weather Service, 2023). The SPI for January 2021 to December 2022 is available in Figure 1, which indicates that the Limpopo province, which includes the Waterberg area, is a moderately dry area.

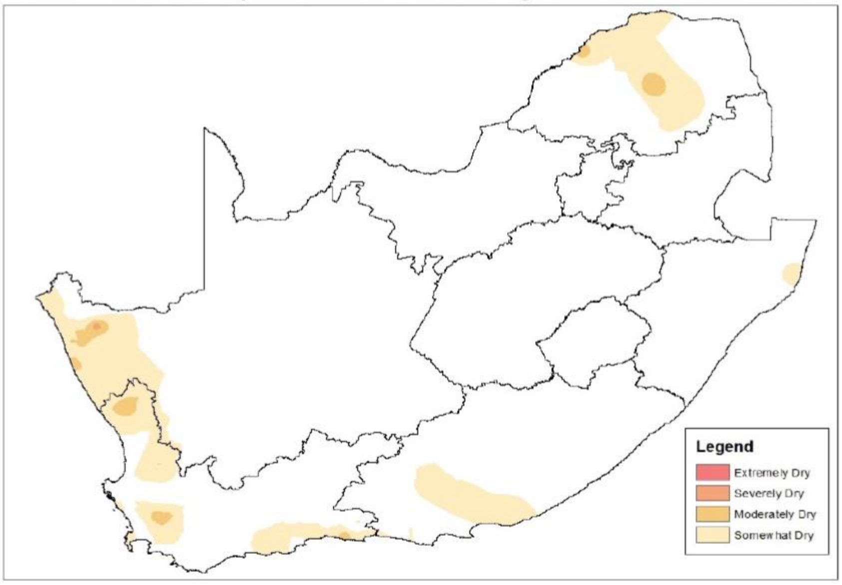

Figure 1: Standard precipitation index (SPI) January 2021–December 2022 (South African Weather Service, 2023)

Apart from the Limpopo area, South Africa has an arid to semi-arid climate, with an average annual rainfall of 465 mm, which is half of the world average (Viljoen & van der Walt, 2018). Although the coal reserves in the Witbank area is rapidly depleting and the focus is shifting to the Waterberg coal reserves, it is important to consider the environmental factors affecting these coal fields and to ensure that water use is minimised. It is therefore important to focus on the different coal processing methods available.

South Africa forms part of the Southern hemisphere coal deposits, which is difficult to process in comparison with the Northern hemisphere coals. This is due to the high near-density material present in Southern hemisphere coals (Horsfall, 1980). When processing run-of-mine (ROM) coal, otherwise known as raw coal, an upgrade of the feed is generally required to meet market specifications. To improve coal quality, washing may be required, which is a process during which impurities, such as stones and other minerals that are of higher density, are separated from the lighter or less dense particles, in this case coal. To upgrade for a low ash specification product, the separation is generally at a lower separation density, which consequently increases the amount of near-density material (Horsfall, 1980), especially when treating South African coal.

The client specifications and feed qualities determine the degree of separation required. Different beneficiation methods are available in the industry, with dense medium separation the predominant method in use (Dwari & Hanumantha Rao, 2007). Dense medium separation, however, uses a large amount of process water and is very expensive (de Korte, n.d.). The process water in use also poses a significant environmental risk if not treated correctly, which consequently adds to the high costs associated with dense medium separation.

With the water crisis in mind, the mining industry in South Africa is forced to develop methods that will reduce water use. As a result, the last decade saw an increased focus on dry beneficiation technologies. Numerous dry beneficiation processes have been in use since the early 1900s, most reporting a low separation efficiency. Extensive research has been conducted into a variety of processes such as the X-ray transmission sorter (XRT), Fuhe Ganfa Xuan mei (FGX) separator, air jigs and many more, each with its own benefits and limitations.

A new dry beneficiation technology that was developed by Gormash Export, is the SepAir technology. The SepAir technology design is a combination of traditional pneumatic separation principles and vortex technology. Its separation mechanism for density separation is based on an upward flow of air in a fluidised bed section, feeding into a vortex chamber that facilitates accelerated particle removal. The whole assembly is located above a perforated cloth, otherwise known as a mesh conveyor (Stepanenko, 2020). This is not a new principle of separation but has not been applied to coal beneficiation.

In principle, particles that are less dense can be lifted by means of a force of suction that has to be of such magnitude that it overcomes the force of gravity. With particles that are of higher density, the force of gravity will supersede the suction force. They will therefore be unhindered and referred to as waste or middlings (Hughes, et al., 2019). When considering this principle for coal preparation, the less dense coal particles will therefore be separated from the denser material, such as denser coal particles, stones, and shale, and taken as product.

The SepAir has been showing promising efficiencies on Northern hemisphere coal, but it was unsure how this technology will perform on Southern hemisphere coal. Coaltech therefore decided to purchase and import a 40tph pilot scale SepAir plant in 2019 and test it on South African coal, and more specifically the Witbank coal deposits. Coaltech conducted test work prior to this research project (de Korte, 2021), which delivered results and therefore supported additional research. Collaboration between various coal producers and researchers with the manufacturer resulted in the use of South African coal for this project.

1.2 Aim and objectives

Due to the limited knowledge of the SepAir's performance on Southern hemisphere coal, the aim of this research was to test the capabilities of the SepAir when treating South African coal and to determine the best operation settings to obtain a maximum feed quality upgrade.

To achieve the aim, the objectives of this research were to test the following:

1. The effectiveness of mobile screens to deliver a fractional feed within the size ranges of 12x25mm, 12x50mm, and 25x50mm;
2. The capabilities of the SepAir when coal with different material properties such as size ranges, various coal seams, and the amount of near-density material are introduced;
3. The operational characteristics of the SepAir when testing the effect of three independent variables on the various size ranges and coal seams. The variables were as follows:
    - Feed rate to the plant
    - Mesh conveyor speed, which translates into the bed depth
    - SepAir fan speed

A combination of spot tests and efficiency tests were done to determine the variable that has the biggest influence on the SepAir's efficiency, as well as the best operation point for each variable at each size fraction for a maximum feed quality upgrade. The tests were done to determine the influence each variable has on the cut-point and efficiency of the SepAir.

1.3 Layout of report

In order to achieve the aim and objectives of this research project, the following outline was used to effectively navigate the project.

Introduction

- Background and motivation
- Aim and objectives

Literature review

- Coal
- Coal markets
- Coal preparation
- Different dry beneficiation methods
- The SepAir

Experimental procedure

- Coal sources
- Coal sampling and analysis
- Experimental setup
- Experimental plan
- Experimental procedure - Phase approach

Preliminary results

- Size distribution across the different size fractions
- Challenges encountered with screening
- Spot tests results (Phase one)

Maximum upgrade

- Efficiency test results for maximum upgrade of feed qualities (Phase two)

Additional testing

- Double stage beneficiation results (Phase three)
- Efficiency test results for maximum organic efficiency (Phase four)

Conclusion and recommendations

- Final statements

CHAPTER 2 LITERATURE REVIEW

It is important to fully understand the characteristics of coal and the processes involved in coal beneficiation when conducting research on coal processing. This chapter gives an overview of coal, as well as a short summary of two different coal processes, namely wet and dry beneficiation. Dry beneficiation is discussed in more detail as the aim of this project was to test the SepAir as part of dry coal processing technology.

2.1 Coal

2.1.1 Origin of coal

Coal is a product of peat, which is in turn formed from the sedimentation of plant materials that subsequently undergoes coalification (Ishihara, et al., 2004). When peat subsides and is exposed to water, covered layers form. After the formation of covered layers, clay, silt and sand layers are deposited above these layers (The South African Coal Processing Society, 2002). Over time, the number of these deposited sediment layers increases and due to pressure and temperature differences over a sustained period of time, coal formation begins. The next step of coal formation is called the metamorphic stage. This step occurs when the water and oxygen levels in the coal decrease (The South African Coal Processing Society, 2002).

During the metamorphic stage, different degrees of alteration in the peat occur, which causes coal to differ in "maturity". This is also referred to as different coal ranks. The ranks in ascending order are as follows (The South African Coal Processing Society, 2002):

- <u>Lignite or brown coal</u>: This is the first stage in coalification and appears unconsolidated and woody. Lignite varies from light brown to almost black.
- <u>Sub-bituminous coal</u>: A black coal with a vitrinite reflectance of below 0.6% and volatile matter content of above 40% on a dry ash free basis. It has a higher heating value (CV) and lower moisture content than lignite, does not cake together, and is soft and brittle when exposed to the elements.
- <u>Bituminous coal</u>: Bituminous coal usually has a vitrinite reflectance of 0.6% to 2% and has a minimum volatile matter content of 16.5% on a dry ash free basis. The inherent moisture generally decreases as the rank increases, but it can be different with weathering coal. It is usually between 2% and 8%. South Africa predominantly produces bituminous coal of high volatile matter, high ash value and variable amounts of sulphur (Thomas, 2013).

- Lean coal: Also known as semi-anthracitic coal, which has a vitrinite reflectance of about 2% to 2.5%. It burns with little smoke and has a volatile matter content between that of bituminous coal and anthracite.
- Anthracite: This is the final stage in the coal metamorphosis and typically has a vitrinite reflectance of 2.5% to 6%. Anthracite is known for its low volatile matter of about 10% and therefore has no smoke when it burns. It is very hard and has no caking properties. Anthracite is commonly found in KwaZulu-Natal, South Africa.

Southern Africa, Australasia, India, and South America all form part of the Southern hemisphere, also known as Gondwanaland. The remaining continents all form part of the Northern hemisphere, otherwise known as Laurasia. The coal originating from the Southern hemisphere is normally high in minerals and is quite difficult to beneficiate (Falcon & Ham, 1988). The differences in coal between Gondwanaland and Laurasia is attributed to the conditions at the time and the historical geological events that subsequently occurred while the coal was forming. The Northern hemisphere consisted of carboniferous coal-forming swamps with high humidity levels, while the Southern coal-forming conditions consisted of cold Permian swamps associated with the end of an ice age (Falcon & Ham, 1988). Northern hemisphere coal consists of 40–50% vitrinite, which is a maceral found in coal, while Southern hemisphere coals seldomly exceeds 20–30%. Vitrinite derives from anaerobic conditions where high levels of ground water had been present in the peat swamps. Another maceral found in coal is inertinite, which develops due to aerobic conditions during peat formation. Inertinite is commonly found in coal from Gondwana, the Southern hemisphere, but is only a minor constituent in the Northern hemisphere coals (Thomas, 2013). The Southern hemisphere coals have a lower sulphur content and a higher mineral matter content than that of the Northern hemisphere coals (Thomas, 2013).

2.1.2 Coal properties

Coal is known as an organic sedimentary rock that mainly consists of carbon, oxygen, hydrogen, nitrogen, and sulphur. The inorganic constituents present in coal are referred to as mineral matter (Speight, 2005).

Coal mainly consists of carbonaceous material that includes inherent moisture. Once burned, carbon dioxide and sulphur dioxide are produced (Speight, 2005). When referring to the ash analysis of a coal sample, the sample is combusted in oxygen or air and the remaining ash is an indication of the mineral matter present. The mineral matter can occur in more than 50 or 60 different forms but is in general classified into five major mineral groups (Speight, 2005):

- Aluminosilicates minerals or clay minerals
- Sulphide and sulphate minerals
- Carbonate minerals
- Silicate minerals (mainly quartz), and
- Trace amounts of other minerals

The mineral matter in coal is generally undesirable in coal operations and affects almost all aspects of the industry, namely mining, preparation, and use. The preparation of coal aims to reduce the amount of mineral matter. Coal processing methods may differ depending on the amount of mineral matter that has to be removed effectively (Speight, 2005).

The characterisation of coal is usually determined by proximate analyses, ultimate analyses, calorific value, and swelling index. Proximate analyses measure inherent moisture, ash, volatile matter, and fixed carbon (Falcon & Ham, 1988). The ultimate chemical components, such as oxygen, nitrogen, hydrogen, carbon, and sulphur, are analysed to form ultimate analyses (Falcon & Ham, 1988). The calorific value of coal refers to the energy or heat value of coal and is one of the most important parameters used commercially. The swelling index measures the increase in volume when the coal is heated under specific conditions, which consequently determines the caking properties of coal (Falcon & Ham, 1988). Several other analyses are available to determine the chemical and physical properties of coal, but the above analyses are the most common.

There has been an increase in focus on the sulphur in coal over the last few years as there is more pressure on industries to reduce SO_x emissions (Bodily, et al., 1991). South Africa's coal-dependent electricity producer has been identified as the world's largest single sulphur dioxide (SO_2) emitter (Myllyvirta, 2021), necessitating increased attention to reducing the amount of sulphur in feed coal. Reducing the sulphur content in coal is one of the main reasons for coal beneficiation. It is thus important to analyse the total sulphur of both the feed and the product to evaluate the total sulphur reduction efficiency of the coal process. Sulphur in coal can be present in three different forms (Speight, 2005):

- Organic sulphur, which is bound organically in the coal;
- Inorganic sulphur, such as pyrite or marcasite (FeS_2); and
- Inorganic sulphates, such as calcium sulfate ($CaSO_4$).

Inorganic sulphates accounts for less than 0.1% of the sulphur found in coal. Therefore, there is greater focus on the removal of organic sulphur and pyrites (Speight, 2005)

The inorganic sulphur present in coal can be removed by means of coal beneficiation methods, such as gravity separation. However, the degree of separation is affected by the pyrite distribution over the coal particles. If it is dispersed as small crystals, it may not be possible to extract it by gravity separation technology, but larger pieces present in the coal may successfully be removed (Speight, 2005). Conventional physical cleaning methods cannot remove the finely dispersed pyrite or organically bounded sulphur (Celik & Yildirim, 2000). Chemical cleaning methods, among others, can be used to remove the organic sulphur from coal.

2.1.2.1 Near-density material

The coal seam in the Southern hemisphere, Gondwanaland, of which South Africa is part, is generally known for having high amounts of near-density material, unlike Northern hemisphere coal. Due to the near-gravity material, the Gondwanaland coals of low ash are difficult and costly to process. The washability of various coal seams varies quite significantly, but the high percentage of near-gravity material at most of the separating densities are similar for all coal seams (Horsfall, 1980).

Near-gravity material is the percentage of material present within a range of ±0.1 of the relative density at which the separation of coal takes place (Bhattacharya, et al., 2015). At high densities, the separation of coal and discards is relatively easy due to a low percentage of near-gravity material. At high densities, the near-gravity material can be as low as 10 percent. Unfortunately, when washing for a high-quality coal that has a low ash, separation takes place at lower densities, which increases the percentage of near-gravity material to as much as 70 percent or more in some cases (Horsfall, 1980).

The effects of near-gravity material on the separation process are as illustrated in Table 1 (Bhattacharya, et al., 2015). The near-gravity material affects the separation performance of coal and thus is one of the main reasons for the misplacement of product and discard.

Table 1: The effects of near-gravity material on separation

NGM (%)	Degree of difficulty	Process
0-7	Simple	Almost any process with high tonnages
7-10	Moderately difficult	Efficient with high tonnage processes
10-15	Difficult	Efficient with medium tonnage processes
15-20	Very difficult	Efficient with low tonnage processes; expert operator
20-25	Exceedingly difficult	Efficient with low tonnage processes; expert operator
>25	Formidable	Possible only with exceptionally efficient operators

2.2 Coal markets

Coal can be used in various industries such as electricity generation, synfuels, and within the metallurgy field for steel making. South Africa produces significant amounts of coal and plays a significant role as a producer of coal for exporting and for domestic use, primarily for electricity production (Eberhard, 2011).

Coal production in South Africa has ranged between 228-260 Mtpa from 2010 to 2021, peaking at 261 Mt in 2014 (Minerals council South Africa, 2021). Domestic sales ranged from 68-78% and export sales from 20-31% for 2010 to 2021 (Minerals council South Africa, 2021)

Mpumalanga accounts for approximately 80% of the current coal production in South Africa (Department of Energy, 2018), but the production focus is starting to move away from the traditional Witbank coal fields as most collieries are close to reaching the end of their productive lifespan (Minerals council South Africa, 2023). Currently focus is placed on exploiting the Waterberg coal field in the Limpopo province as it approximately contains a seam thickness of 110m, which therefore makes it a large coal reserve for the coal industry to explore (Department of Energy, 2018). The coalfields in South Africa are shown in Figure 2.

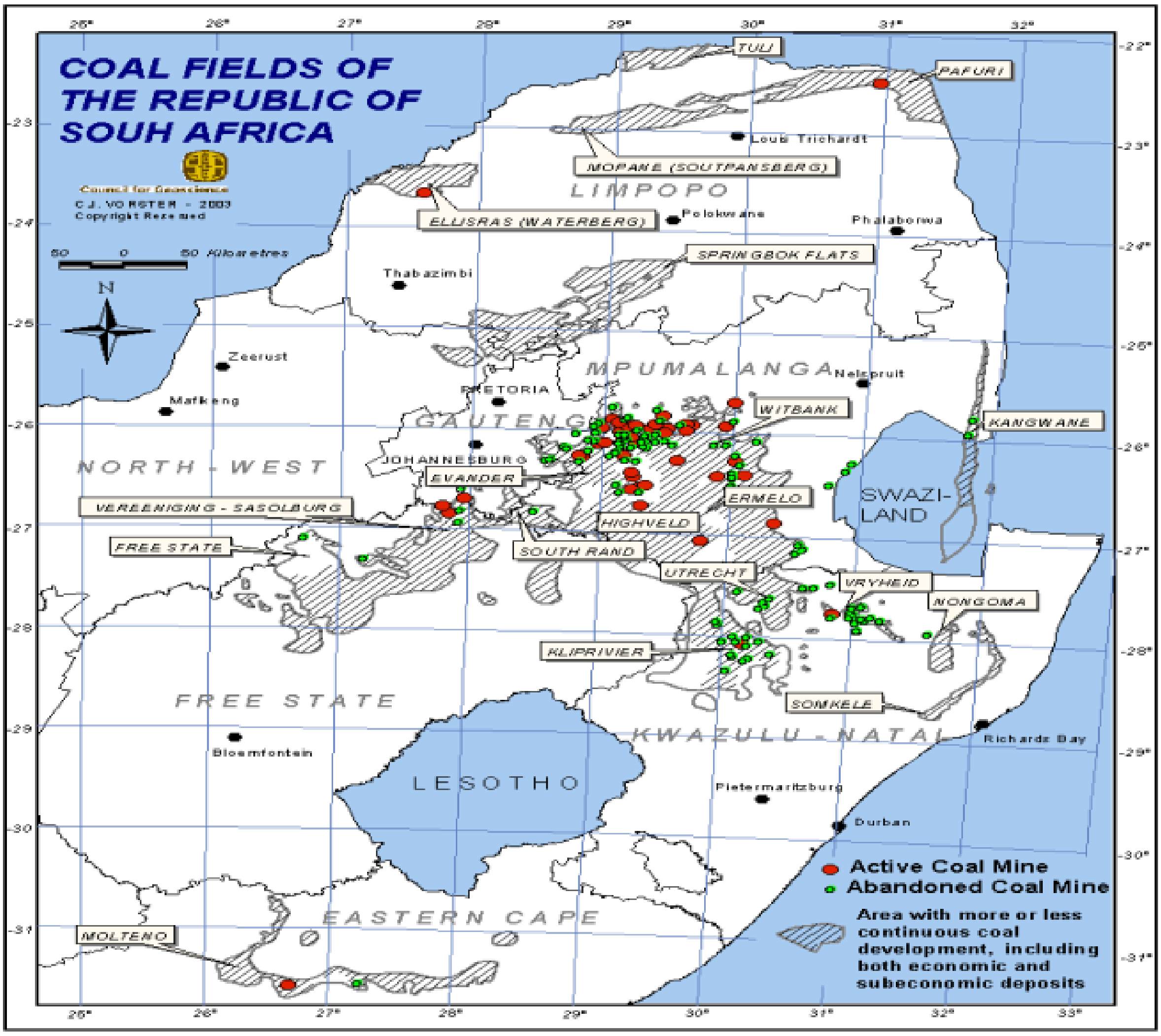

Figure 2: Coalfields in SA (Department of Energy, 2018)

There are four main markets for the South African coal industry, which include the export market, the domestic market for energy supply, the domestic market for synfuels, and the domestic market for heat generation and industrial use. Each of these markets have different quality specifications with which the producer has to comply (Steyn & Minnitt, 2010).

The coal quality specifications for the various grades in the export market are as summarised in Table 2, with “RB” referring to Richards Bay and the numbers 1 to 4 indicating the grades in descending order. The Net Calorific Value (kCal/kg) is indicated rather than the Gross Calorific Value (MJ/kg) as Net Calorific Value, as received basis, is used as the basis of trade (Alakangas, 2016). The Gross Calorific Value can be determined by making use of the calculations according to ISO 1928: “Determination of gross calorific value”. A typical specification list for the domestic energy supply market is available in Table 3. The values available in both tables are reported on an As Received Basis (ARB), unless indicated otherwise.

Table 2: Coal grades (globalCOAL, n.d.)

Parameter	Units	Grade			
		RB1	RB2	RB3	RB4
Net calorific value	kcal/kg Minimum (NAR)	5850	5700	5300	4500
Total moisture	Maximum % (ARB)	12	13	14	14
Ash	Maximum % (ARB)	15	17	23	32
Volatile matter	Minimum % (ARB)	22	21	20	18
Sulphur	Maximum % (ARB)	1.0	1.0	1.0	1.2

Table 3: Domestic market specifications for power supply (Steyn & Minnitt, 2010)

Parameter	Units	Specification	Rejection
Calorific value	MJ/kg (ARB)	21	20
Total moisture	Maximum % (ARB)	10	12
Ash	Maximum % (ARB)	25-33	>35
Volatile matter	Minimum % (ARB)	20	20
Sulphur	Maximum % (ARB)	1.0	2.0
Abrasive index	Maximum % (ADB)	500	550

2.3 Coal preparation

Coal preparation, also commonly referred to as coal beneficiation, is the process of separating coal, which has a low density, from higher density impurities. The coal beneficiation technology primarily focuses on the physical differences between the inorganic and organic components (Groppo, 2017). This section summarises some of the processes involved in the coal preparation cycle to finally produce a product that meets market specifications.

Comminution and screening prepare the coal for downstream processes, whereas coal beneficiation is used to upgrade feed qualities. Coal beneficiation methods mainly include wet and dry beneficiation (Xuliang, et al., 2012).

2.3.1 Comminution and screening

The first step in treating run-of-mine (ROM) coal, is to convert the coarse mined lumps into a more treatable form that can be used in the downstream processes (Eisele, et al., 2013). The process to do so involves crushing and grinding, which are collectively referred to as comminution, and subsequently sorting the material by sizes suitable for the downstream processes. Ore is crushed when it is either compressed against a rigorous surface, or by being forced against surfaces within a constrained motion path (Wills & Napier-Munn, 2006).

Discrete stone and nodular pyrite can usually be removed from the feed to the plant at large particle sizes, such as 50mm, but the more in situ minerals (impurities) present, the harder it is to separate it from the coal (Horsfall, 1980). Since most minerals are finely dispersed throughout the material, liberation is required to ensure a more effective separation. This is accomplished when the particle sizes are reduced by crushing the ore to a certain extent (Wills & Napier-Munn, 2006).

The density of particles is also affected by comminution, as a large heterogeneous particle of a specific density produces several smaller particles of different sizes and densities when subjected to crushing. The same principle is applied when crushing ROM coal. As various smaller particles are produced, the amount of near-gravity material changes in a specific density class and consequently changes the difficulty of beneficiating the coal (Mohanta, et al., 2016). With coarser crushing, the amount of near-gravity material is higher at lower densities than that of higher densities, it is thus harder to beneficiate coal at lower densities.

Once crushing is complete, the ROM coal usually undergoes sizing or classification. The particles are separated according to specified sizes that meet the requirements for downstream processes (Wills & Napier-Munn, 2006).

To ensure the efficient sizing of material, the feed rate and the surface moisture of the feed are among some of the most important factors to take into consideration. The feed rate should be such that the screening time is long enough so that complete separation takes place. When the surface moisture of the feed is too high and clay and other adhesive materials are present, it can lead the material to agglomerate and consequently screen apertures to “blind” (Wills & Napier-Munn, 2006).

Once the screening has been completed, the particle size distribution of the screened product can be evaluated to determine the top-to-bottom size ratio fed to the downstream processes. The particle size distribution can be done by doing a sieving test in the laboratory. Sieve analysis is done by passing a known weight of material through a list of specified sieves with various aperture sizes and weighing the mass retained on each sieve after screening has been completed. The mass retained is then divided by the initial material weight to determine the percentage mass retained at each sieve size. It is advisable to graphically plot the results from the sieve analysis as to fully comprehend the results (Wills & Napier-Munn, 2006)

The particle size distribution of the screened material is mostly evaluated by either the Gates-Gaudin- Schuhmann method or the Rosin-Rammler method. The Rosin-Rammler method is the preferred method in the coal-preparation industry, for which it was originally designed (Wills & Napier-Munn, 2006). The Rosin-Rammler equation is as specified in Equation 1 (Aarne Vesilind, 1980).

<u>**Equation 1**</u>

$$\boldsymbol{Y = 1 - \exp\left(\frac{-x}{x_0}\right)^n}$$

- Y is the cumulative fraction of the material (by weight), which is less than size x
- x_0 is the particle size at which 63.2% of the coal particles (by weight) are smaller.
- n is the uniformity constant.

2.3.2 Separation efficiencies

The effectiveness of any preparation method should be evaluated to ensure that reliable comparisons are available, and that the performance of the plant can continuously be assessed (Sanders, 1978). The separation efficiency of coal beneficiation technologies is generally measured by the Epm value, total misplacement, imperfection, and organic efficiency.

Tromp curves, also referred to as partition curves or distribution curves, are used for the comparison between the ideal and actual separation curves. The difference between the curves is knowns as the Error Area. The Ecart Probable Moyen, (Epm or Ep), is the probable error in separation (Pradhan & Mohanta, 2020). The Epm is calculated as follows:

<u>**Equation 2**</u>

$$E_{pm} = \frac{(d_{25} - d_{75})}{2}$$

where d_{25} and d_{75} indicate 25% and 75% probability respectively for the particles to report to a given product. The d_{25} and d_{75} values are also referred to as partition numbers. The Epm is used to test the efficiency of the equipment as it measures the sharpness of the separation between coal and impurities. In general, the steeper the separation curves, the lower the Epm values, which indicates a very effective separation method or technology (Pradhan & Mohanta, 2020).

In dense medium separation, less dense material, in this case coal, is often referred to as the "floats", while the discard material that has higher densities is referred to as "sinks". The percentage misplacement of clean coal to reject is referred to as floats in sinks, while the percentage misplacement of reject to clean coal is known as the sinks in floats. The percentage actual misplacement is the total amount of misplaced material on both sides of the cut-point density. This can either be calculated from the partition curves or obtained from the washability data at the cut-point density.

Imperfection, (*I*), is used to make the Epm independent of the cut-point densities. The imperfection value gives an indication of the degree of variation from the perfect separation (Mohanta, et al., 2016). The imperfection value can be calculated for both dense medium processes, dry processes, and water-based processes, and is as follows:

For dense medium and dry processes:

Equation 3

$$I = \frac{E_{pm}}{D_{50}}$$

For water-based processes:

Equation 4

$$I = \frac{E_{pm}}{D_{50} - 1}$$

The organic efficiency can be calculated to measure the overall efficiency of the processing technology. Organic efficiency, E_{org}, is defined as the ratio of the actual yield to the washability yield at the same ash value (Sanders, 1978).

Equation 5

$$E_{org} = \frac{(Actual\ yield)}{(Washability\ yield)}$$

2.3.3 Wet beneficiation

Currently, wet beneficiation is the predominant method to upgrade coal. Wet beneficiation processes include, among others, heavy media separation, hydro cyclones, spirals, and froth flotation (Groppo, 2017). It is currently the most efficient process available as wet beneficiation achieves a high-quality product together with high recovery rates (Dwari & Hanumantha Rao, 2007).

Dense medium separation, which is probably the most effective wet beneficiation method, offers several advantages over that of other gravity processes, such as (Wills & Napier-Munn, 2006):

- Sharp separation at any given density is achievable;
- A high degree of efficiency (Epm in the order of 0.02 (de Korte, n.d.)), irrespective of the amount of near-gravity material present;
- Rigid control of separation density;
- Maintainable density for unlimited periods under regular conditions; and
- Probability of rapid density changes.

Dense medium separation processes are the preferred method when washing is required for coals that have a high amount of near-gravity material, as the separation densities can be managed at significantly closer limits (Wills & Napier-Munn, 2006). Dense medium separation is an essential method when washing Southern hemisphere coal, especially in South Africa, due to the great amount of near-gravity material present in the area (Wills & Napier-Munn, 2006).

Wet beneficiation methods, such as spirals and froth flotation, have the capability to process the -6mm material effectively, but there are environmental problems associated with it. Thickeners are required to recover most of the water, and filter presses or slurry ponds are required to reduce the water use and to attempt to close the mines' water circuits (Wills & Napier-Munn, 2006).

Although wet beneficiation is a more efficient process for dense medium separation, the disadvantages are that it is an expensive process and the product requires dewatering to meet client specifications (de Korte, n.d.). The costs of the medium and the equipment required to recover the medium are the main contributors to the high cost of dense medium separation (Wills & Napier-Munn, 2006). For wet processes, the water consumption reaches 0.1 to 0.3 m^3 per ton coal treated (Dong, et al., 2022). With the scarcity of water, especially in countries such as South Africa, processes are required that use less water.

2.3.4 Dry beneficiation

Dry beneficiation offers many advantages over wet beneficiation, such as that dry beneficiation is more cost effective in terms of the capital and operating costs. It is more environmentally friendly as water is only required for dust suppression and not for processing. The final product also has a lower total moisture, which reduces the chances for moisture penalties to meet market requirements (Weinstein & Snoby, 2007).

However, the disadvantages are that dry beneficiation is not as effective as dense medium separation due to lower efficiencies, there are generally higher cut-points, lower yields and with some methods, a reduced throughput. The near-density material is not as easily beneficiated with dry separation and quality control is not always easy (Weinstein & Snoby, 2007).

The increased moisture values in the ROM coal due to an increase in dust suppression requirements also has a negative impact on the favourability of dry processing methods. The higher moisture feed-to-plant decreases the separation efficiency of this equipment as more misplacement occurs. It is important to consider if the low operating and capital costs outweighs the low recovery efficiency (de Korte, n.d.).

Some dry separation techniques compete relatively well with wet beneficiation processes when the product specifications are such that a minimal quality upgrade is required (Hughes, et al., 2019). Air-gravity separators and sensor sorters can easily achieve a minimal quality upgrade on Northern hemisphere coal seams as these seams are easier to separate, mainly due to lower near-density material present (Falcon & Ham, 1988). For Southern hemisphere coal seams in South Africa, Australia, and India, feed quality upgrades by means of dry beneficiation are not as easily achieved. Dry beneficiation may not be able to upgrade Southern hemisphere coals to an export quality, but it might be possible to achieve a domestic market specification.

Currently the best practice with dry beneficiation is to blend the raw fines with the product (de Korte, n.d.). However, this can reduce the final product quality.

2.4 Different dry beneficiation methods

In recent years, the focus has been on improving dry beneficiation practices so that it can compete with wet processing methods in product qualities, yields, and efficiencies.

Some of the dry beneficiation methods available are as follows:

- Gravity separation

- The allair® air jig
- Pneumatic oscillating tables, such as the standard air table
- KAT table
- AKAFlow
- Sensor-based sorters, such as the X-ray transmission sorter (XRT) and Fuhe Ganfa Xuan mei sorter (FGX)
- Air dense medium fluidised bed separators (ADMFB)
- Dry reflux classifier
- Winnower and wind sifter
- SepAir

The following section offers a summary of only a few of the above-mentioned technologies.

2.4.1 Dry beneficiation by sensor-based sorting

Ore sorting by hand was one of the first methods of processing minerals. In the 1940s, electric ore sorting was introduced, but due to the slow and underdeveloped computer technology of the time, this method was not really used widely (Wills & Napier-Munn, 2006; von Ketelhodt & Bergmann, 2010). Ore sorting is defined by Wills & Napier-Munn (2006), as "the appraisal of individual particles and the rejection of those particles that do not warrant further treatment". The sorting of particles can be described in the interactive sub-processes available in Figure 3 (Manouchehri, n.d.).

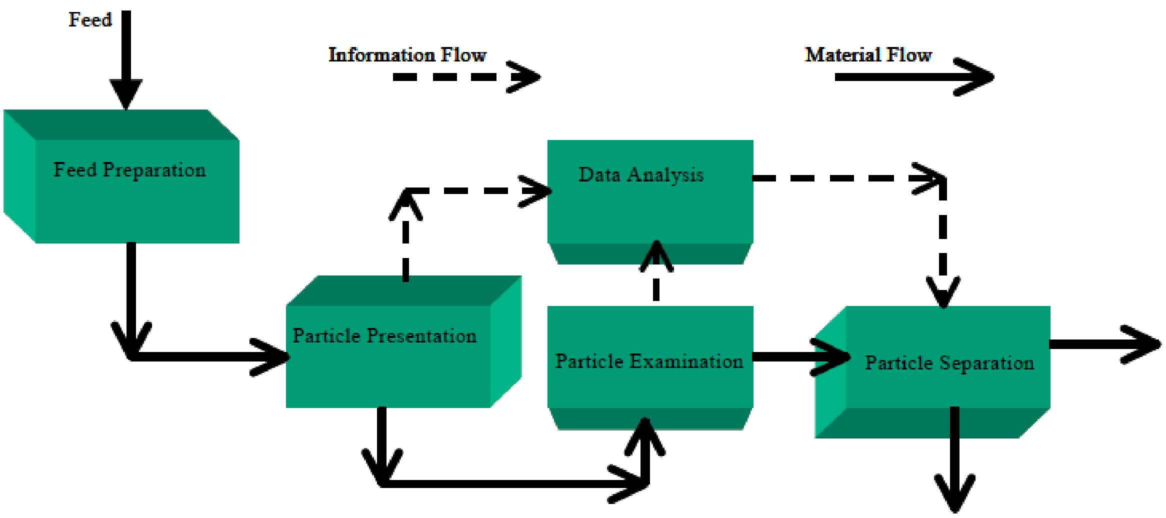

Figure 3: The configuration of sorting machines (Manouchehri, n.d.)

The feed conditions of sorters are critical for all types, as the surface characteristics and particle size greatly influence the separation efficiency of these sorters. According to von Ketelhodt & Bergmann (2010) most sorters require a feed size ratio of 3:1 or 2:1 to be efficient. Feed rate and material handling should be controlled in such a way that the sensor can analyse every single particle (Wotruba, 2006).

The particle separation is done by examination of a particle by a combination of a sensor and a processing unit. Once the examination has been completed and the data analysed, a mechanical system makes the separation. This can be done by air jets and mechanical paddles (Weatherwax, 2007).

There has been an increase in research and development on sorting coal by means of an x-ray transmission (XRT) sensor since it was first developed (Robben, et al., 2014). The XRT are available in two different types, that is a belt- and a chute-type as illustrated in Figure 4 and Figure 5 respectively.

The process of a belt-type XRT can be explained as follows: The feed to the XRT is introduced to the system as a monolayer on a fast-moving conveyor belt. The belt then moves the material to pass a detection system which scans the particles individually. Once the scan is complete, the computer classifies the particles according to a predefined criterion. From the data received from the scanner, a number of high-speed air valves, usually 150 valves per meter of working width, are controlled to eject particles. The particles ejected can be either the product or the discard, depending on the yield, as it is advisable to eject the fraction that has the lowest amount to save compressed air (Robben, et al., 2014).

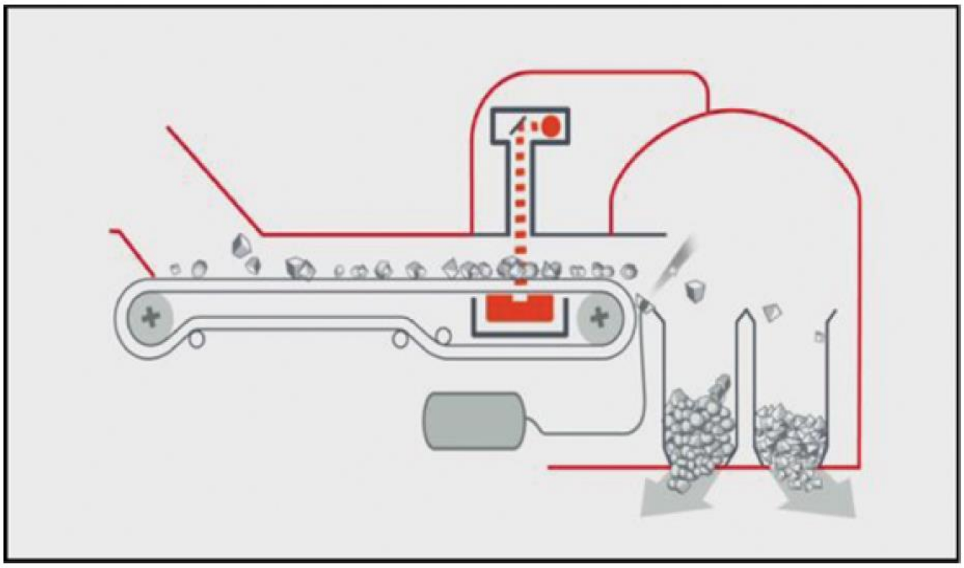

Figure 4: Schematic of a belt-type XRT sorter

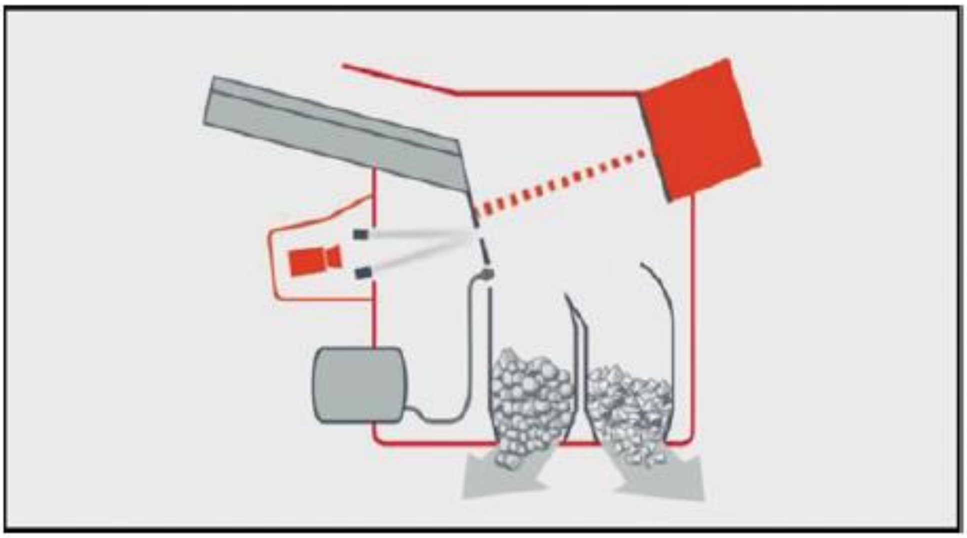

Figure 5: Schematic of a chute-type XRT sorter

The XRT is able to process coarse coal from 30mm to 120mm at throughput rates of 100 tph (Robben, et al., 2014). According to tests conducted by (Robben, et al., 2014) in South-Africa, a chute-type XRT produced Epm values of 0.11 to 0.13 at cut-point densities of 1.60 to 1.70. Tests were also done on a belt-type XRT sorter and Epm results of 0.04 to 0.19 were achieved with cut-point densities of 1.80 to 2.10.

2.4.2 Gravity separation and dry-beneficiation gravity separation technologies

Gravity separation methods separates coal from minerals according to the difference in specific gravity. The separation is based on the movement of particles in response to gravity and other forces.

Other forces apart from gravity include drag forces when a particle is subjected to a viscous fluid, for example air or water. Effective gravity separation is only possible if a marked density difference exists between the coal and the minerals, this can be expressed by the concentration criteria in Equation 6 (Wills & Napier-Munn, 2006).

Equation 6

$$Concentration\ criteria = \frac{(D_h - D_f)}{(D_l - D_f\ )}$$

Where:

D_h = specific gravity of the heavy mineral

D_l = specific gravity of the light mineral

D_f = specific gravity of the fluid medium

Although gravity has a significant effect on the motion of a particle, its motion is also affected by the size of the particle. The separation efficiency of gravity processes increases with particle size (Wills & Napier-Munn, 2006).

Different gravity separation technologies are available in the industry, but a more detailed summary of the allair® air jig, FGX, air-dense medium fluidised bed, and SepAir is provided in the forthcoming subsections.

2.4.2.1 Air jigs

Extensive research has been done in the separation of coarse coal using pneumatic jigs. Allmineral developed the allair® air jig, which is commercially in use in the United States since the installation of the first 50 tph plant in Ohio in 2001 (Zhang, et al., 2011).

The air jig technology is a deep-bed separator that used the advantages of hindered settling and subsequently consolidation trickling (Weinstein & Snoby, 2007). The jigging process is illustrated in Figure 6.

Air is introduced to the jig in two different forms, namely a superimposed pulsated airflow and a continuous flow. The superimposed pulsated airflow causes the stratification and consolidated trickling of particles (Zhao, et al., 2014). Feed material enters the jig process from a surge hopper and onto the deck as illustrated in Figure 7. A variable speed star gate is used to ensure the feed is controlled and particles are uniformly distributed across the full width of the bed (Weinstein & Snoby, 2007). Air jigs have a co-current flow of clean coal and discard, which is unlike the conventual table designs that have counter current product and discard streams. The co-current flow of the two streams enables a thicker bed depth (Weinstein & Snoby, 2007).

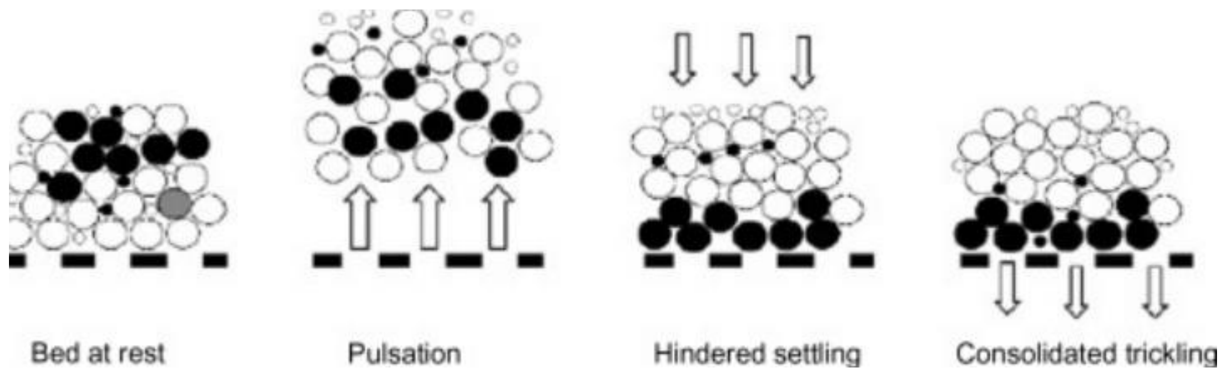

Figure 6: The jigging process (Kumar & Kumar, 2018)

The air jig can separate coal at high-density cut-points, but the plant is limited to treating material at a top size of 50mm (Zhang, et al., 2011) and at throughput rates of 50–120 tph (Weinstein & Snoby, 2007). The cut-point densities for the allair® air jig ranges from 1.95 to 2.20 and Epm values from 0.16 to 0.27 (Weinstein & Snoby, 2007).

The air jig is recommended for use in applications were the amount of near-density material is low, thus at separations of high-density cut-points (Weinstein & Snoby, 2007). Air jigging usually have rather high capabilities with low processing costs but regrettably has low separation efficiencies (Xuliang, et al., 2012).

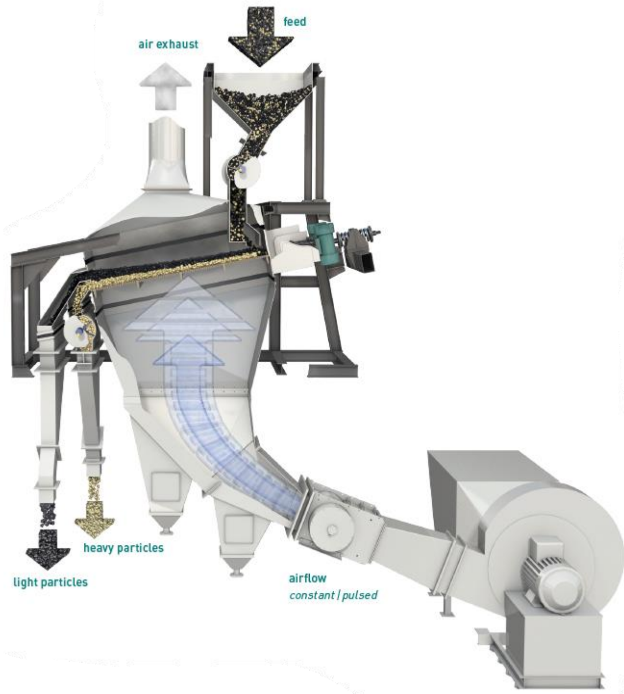

Figure 7: Schematic of the allair® air jig (Weinstein & Snoby, 2007)

2.4.2.2 FGX

The FGX technology is a form of compound dry beneficiation and has already reached renowned status in the coal processing industry. The process consists of a perforated table deck that is supported by a hanging mechanism, as well as a vibrating mechanism and an air chamber (Zhao, et al., 2014). A schematic of the FGX separator is available in Figure 8. The frequency of the deck vibration, the deck angle over the complete length of the deck, the feeder frequency, and the height of the baffle plate, all affects the performance of the FGX technology (Zhao, et al., 2014).

When treating material, a controlled feed enters the separation system at a fixed mass flow rate. A particle bed of the feed material is formed on top of the perforated deck at a specific bed depth. Air is generated by a centrifugal fan that passes through the holes of the deck. The air rate should be sufficient to ensure that fluidisation takes place and lighter particles are moved (Honaker, et al., 2008). Approximately 10–20% of -6mm material is required in the feed to ensure a particle bed of autogenous fluidised medium. The lighter, or less dense material, is found in the top layer of the material collected at the front section of the table, while the heavier, denser, material moves to the bottom of the deck. The high-density material is transported to the narrow end of the table with the help of the vibration and continuous feed material and is discharged as discard. A third stream is also generated, thus the FGX produces three different products, namely clean coal, middlings, and tailings (Honaker, et al., 2008).

The FGX operates well on coal with a top size of 80mm, but the efficiency of the FGX reduces when treating the -6mm material (Dwari & Hanumantha Rao, 2007). The FGX separator is able to achieve Epm values of 0.12 to 0.23 with corresponding cut-point densities of 1.90 to 2.03 (Zhang, et al., 2011)

This technology is capable of high efficiencies when separating coal at high densities but produces low separation efficiencies when separating coal at lower densities (Xuliang, et al., 2012).

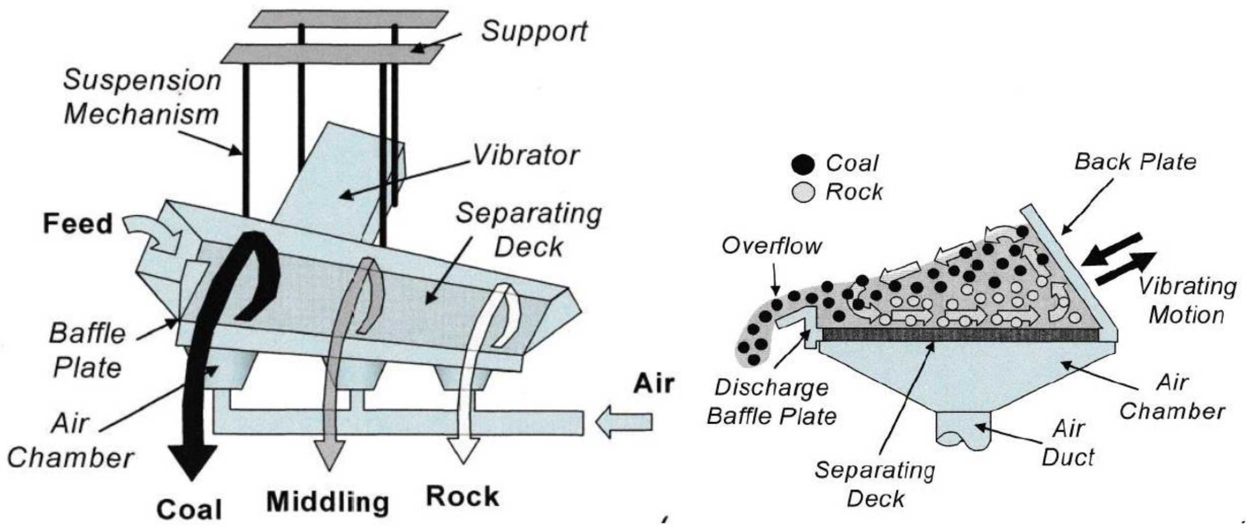

Figure 8: Schematic diagram of a FGX separator (Blaschke & Baic, 2019)

2.4.2.3 Air-dense medium fluidised bed (ADMFB)

The air-dense medium fluidised bed process (ADMFB) is an efficient dry beneficiation method for coal. The ADMFB is different to the conventional coal preparation methods as the separating medium used is a gas-solids fluidised bed, whereas water is used as medium in jigs and air in pneumatic separation techniques (Zhenfu & Qingru, 2001).

Magnetite powder of 0.074 mm to 0.3 mm and -0.5mm coal fines are used for the dense medium in the ADMFB, with compressed air used to produce the gas-solid fluidised bed. The separation densities are controlled by adjusting the number of coal fines in the medium (Dong, et al., 2022).

The separator consists of air chambers and distributors, separation chambers, and transportation mechanisms. The material is fed to the plant by means of an electromagnetic feeder, whereafter separation takes place depending on the bed density. The lighter, less dense, material forms part of the floats and the high-density material part of the sinks. The floats and sinks are transported out of the system by means of a scraper conveyor (Zhenfu & Qingru, 2001). The process is depicted in Figure 9.

The air-dense medium fluidised bed technology offers high separation efficiencies but has limited capabilities and is not as cost effective as air-jigging, due to the costs of recovering the dense medium (Xuliang, et al., 2012). The ADMFB can separate coal at densities of 1.3 to 2.2 with Epm values of 0.035 to 0.065 (Xuliang, et al., 2012). The ADMFB can efficiently treat coal of 6mm to 100mm (Dong, et al., 2022). At coal sizes below 6mm, separation efficiency decreases and the difficulty of medium recovery increases (Zhao, et al., 2014). The advantages of ADMFB technology are that it uses no water, the operating cost of such a plant is approximately half of wet beneficiation technologies, and there is no pollution from coal slime (Zhenfu & Qingru, 2001). However, the biggest disadvantage of the ADMFB technology over that of air jigging or the FGX is that it has a low throughput of only 110tph (Xuliang, et al., 2012).

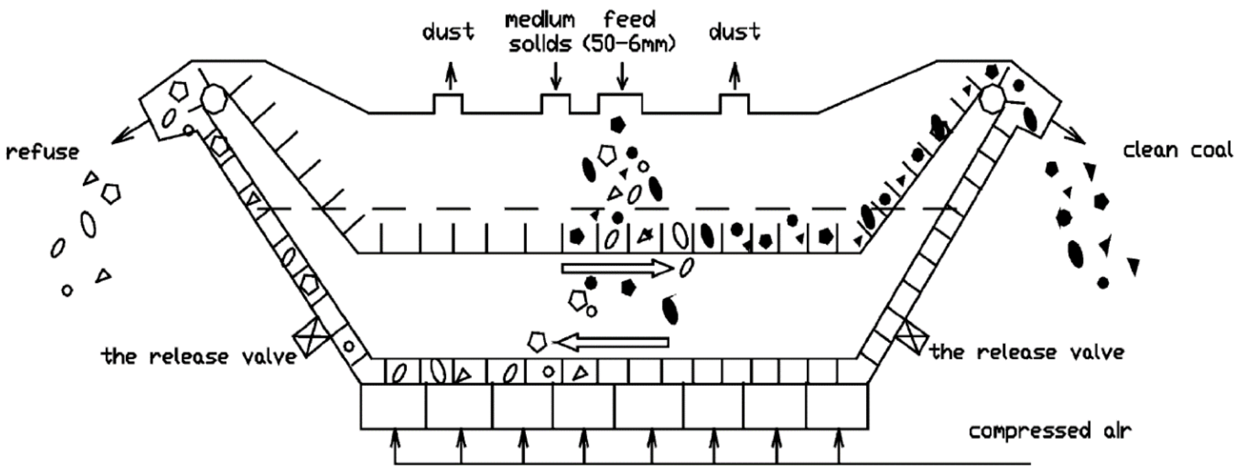

Figure 9: Schematic diagram of an air-dense medium fluidised bed (Zhenfu & Qingru, 2001)

2.5 SepAir

2.5.1 The SepAir technology

Gormash Export implemented a completely new dry beneficiation principle, namely the SepAir technology. The new separation technique separates products based on density in an upward flow of air and into a vortex chamber that is located above a perforated cloth, otherwise known as a mesh conveyor (Stepanenko, 2020). A schematic of the process is illustrated in Figure 10 and an image of a full-scale SepAir unit in operation is available in Figure 11 (de Korte, 2021)

In principle, particles that are lighter and less dense can be lifted by means of a force of suction that has to be such that it overcomes the force of gravity. With particles that are of higher density, such as shale and rocks, the force of gravity will supersede the suction force and they will therefore be unhindered. They are referred to as waste or middlings (Hughes, et al., 2019). The less dense material, in this case coal, will move with the upward motion as described earlier and will consequently be separated from the denser material and taken as product. Dust and fine particles move to a secondary section where the majority of the particles exits the system by means of an air lock valve (de Korte, 2021). Air and the remaining dust particles exit via a secondary cyclone vortex finder and if required, a bag filter can be installed to minimise dust production. The SepAir technology design is a combination of traditional pneumatic separation principles and vortex technology. The SepAir is designed to treat coal of sizes 1–100mm, with a throughput of 45 tph to 220 tph, depending on the size range treated. The SepAir has the ability to produce products of different densities with a singular unit, while the density can be changed instantly (de Korte, 2021). This design has been proven to deliver efficiencies of 95% and above when treating Northern hemisphere coal (Stepanenko, 2020). It is also a low-cost processing technique.

The cut-point densities of the SepAir are determined largely by the fan speed. The pneumatic force created by the fan acts on the feed material laying on top of the perforated mesh conveyor, necessitating a low bed-depth to ensure all particles are exposed to this force, and have an equal opportunity to be lifted into the fluidised bed section (Stepanenko, 2020). The efficiency of the SepAir technology is therefore determined by various factors such as the feed rate to the plant, fan speed, bed depth, coal shape and size, and the amount of near-density material.

The performance of three of the different vortex fluidisation separators are summarised in Table 4 (Hughes, et al., 2019). From the table it is clear that the SepAir is able to provide lower cut-point densities and slightly lower Epm values in comparison with the allair® jig and FGX technologies.

Table 4: Performance data for various vortex fluidisation separators

Method	Particle size range (mm)	Capacity (tph)	Epm	Product yield (%)	Ash reduction (%)	Cut-point density
SepAir*	1-100	45- 220	0.10 – 0.17	85.4 – 93.0	Feed: 13.1 – 19.0 Product: 7.0 – 14.0 Discard: 51.0 – 69.6	1.78 – 1.90 SG ($D50_{density}$)
Allair® jig	0.5-50	50-120	0.16-0.27	70	Feed: 15 - 25 Product: 10.0 – 18.0 Discard: 50.0 – 60.0	1.95 – 2.20 SG ($D50_{density}$)
FGX	6-80	10-350	0.12-0.23	93.1 – 95.4	Feed: 30 Product: 10.8 – 19.4 Discard: 23.4 – 61.3	1.90 – 2.03 SG ($D50_{density}$)

**Results based on Northern hemisphere coal.*

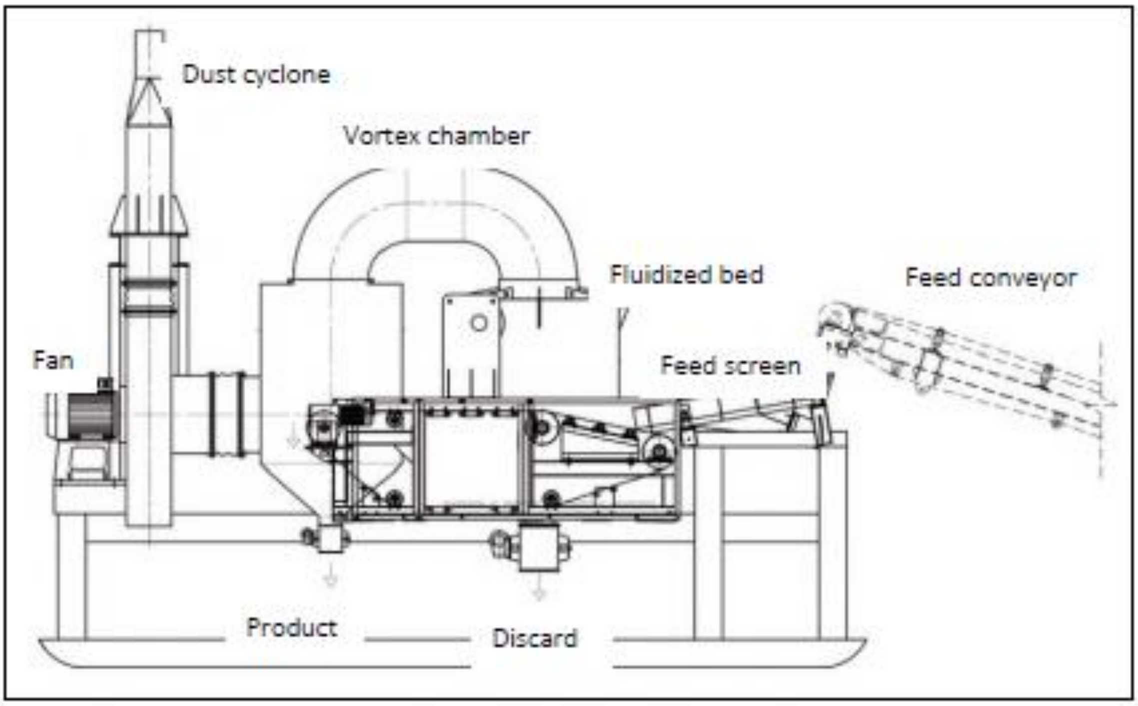

Figure 10: Schematic of the SepAir technology

Figure 11: A full scale SepAir unit in operation

CHAPTER 3 EXPERIMENTAL PROCEDURE

The experimental procedure discussed in this section includes the material used for the test work and the analyses conducted on the feed, product, and discard samples of each test. The test work was done in a phased approach and each phase was discussed in detail in this section.

3.1 Coal sources

The coal received from the various mines had to be crushed to -50mm prior to delivery at the test site. The feed then had to be screened to different size fractions to test the capabilities of the SepAir at the different size ratios.

On site the material was screened to 10x25mm, 10x50mm, and 25x50mm size fractions. The 25mm aperture screening deck was removed from the mobile screening unit to obtain a 10x50mm size range. The undersize (-10mm) was sampled for Coal 1, Coal 2, and Coal 3, and sent for analyses to determine if this size fraction can be added to the product stream.

The sources used for the test work were from the Witbank coalfields in Mpumalanga, South Africa. A variety of coal seams were used and were as follows:

1. Coal 1: One seam opencast from Mine 1
2. Coal 2: Two seam opencast from Mine 1
3. Coal 3: Two seam underground from Mine 2
4. Coal 4: Five seam opencast from Mine 2

All samples were taken and prepared by an ISO 17025 accredited laboratory and in accordance with the following ISO standards:

- ISO 18283: Hard coal and coke – Manual sampling
- ISO 13909-4: Hard coal and coke – Mechanical sampling Part 4: Coal – Preparation of test samples.

Feed samples were taken from each coal source and analysed for quality purposes and to consequently test the feed quality upgrade capabilities of the SepAir. Analysis of each size fraction on an air-dry basis gave the qualities indicated in Table 5.

Details regarding the feed qualities at different density fractions are available as a reconstituted feed for the four different coal sources and are available in Annexure C

Table 5: Feed coal characterisation

Source	Size Fraction (mm)	CV (MJ/kg)	Ash Value (%)	VM (%)	MIAS (%)	FC (%)	TS (%)	AI (mg/Fe)
Coal 1	10x25	18.3	37.1	21.5	2.4	39.0	1.36	1032
	10x50	18.7	36.3	21.8	2.2	39.7	1.39	1237
	25x50	13.9	47.2	22.5	1.6	28.7	1.74	1938
Coal 2	10x25	21.8	27.6	23.9	2.5	46.0	1.51	568
	10x50	20.1	31.1	25.1	2.4	41.4	1.64	877
	25x50	17.9	37.4	25.5	1.9	35.2	1.59	1233
	0x50	20.4	28.4	24.4	2.5	44.7	1.11	601
Coal 3	10x25	21.8	29.4	21.7	2.8	46.1	1.26	143
	10x50	22.5	28.1	25.1	2.8	44.0	1.74	238
	25x50	22.9	27.6	25.1	3.2	44.2	1.30	354
Coal 4	10x25	17.6	35.0	21.7	3.1	46.7	1.27	600
	25x50	17.7	41.6	20.0	2.9	35.5	1.33	964
	0x50	15.9	45.4	18.2	3.2	33.2	1.01	1004

The feed quality for the 10x50mm size fraction for Coal 1 does not balance when taking the feed qualities of the 10x25mm and 25x50mm ratios into account. This can be due to either sampling and preparation errors or the fact that the 10x50mm fraction was not a mixture of the 10x25mm and 25x50mm fractions, but a separately screened fraction. A weighted average is therefore not an accurate reflection of the 10x50mm size fraction.

The analysis for Coal 3 showed that the coarser size fraction, 25x50mm, is the sweetest fraction of the three, which contradict the analyses on Coal 1 and Coal 2. This can be attributed to the fact that Coal 1 and Coal 2 are opencast coal, which is generally not mined clean as most of the interburden and overburden is mined with the coal. Over- and interburden is usually found in coarser fractions. Coal 3 is underground coal, which is mostly mined clean.

According to the reconstituted feeds, Annexure C, the 10x25mm and 10x50mm size fractions for Coal 1 was a more challenging coal source to beneficiate due to the high amount of near density material present To achieve a product quality for either the export or domestic market the amount of near density material was above 20% which indicated, according to Table 1, an exceedingly difficult process. The 25x50mm size fraction for Coal 1 had a lower amount of near density material present at the densities required for separation to meet market specifications.

Coal 2 had the opposite observation whereas the 10x25mm and 10x50mm had a lower amount of near density material present at the desired densities, but higher amounts of near density material for the 25x50mm size fraction, especially for the export market product qualities. Coal 3 was a very difficult coal source to beneficiate for an export market as the amount of near density material was very high at the densities required. The amount of near density material present was substantially more than 25 and according to Table 1, the process degree of difficulty is formidable. The same observation was made for Coal 4.

3.2 Coal sampling and analysis

Sampling was done in accordance with ISO 13909. The laboratory that conducted the sampling and analyses was an ISO 17025 accredited laboratory. The sampling plan was as follows:

1. The feed sample was taken manually from the feed-to-plant conveyor belt per interval product and discard sample.
2. Once the plant reached stability and variables applied to the feed, the plant was “crash” stopped. The product and discard samples were collected by means of 1-ton sampling bags. The product and discard conveyors therefore ran empty into the 1-ton bags.
3. All samples were labelled according to the specific test and stream and transported to the laboratory for preparation and analysis.

Once the samples arrived at the laboratory, they were divided and prepared in accordance with ISO 13909-4 to obtain samples for general analysis, abrasive index, total moisture, sizing, and float and sink analysis.

The coal analyses conducted during the test work are set out in Table 6.

Table 6: Coal analysis

Analysis	Description	Method
Abrasive Index (AI)	An analysis to test the tendency of coal to cause abrasion.	Based on Eskom method
Ash value	The residue of the sample after complete combustion of the coal sample. The residue, referred to as the ash, consists of oxides of iron, aluminium, titanium, magnesium, calcium, and silica (Falcon & Ham, 1988).	ISO 1171
Fixed Carbon (FC)	The remaining organic content of coal after removing the volatile matter, ash and moisture. Obtained as follows: FC=100%-Ash%-Moisture%-Volatile matter%.	ISO 17246
Float and Sink	Determination of the float and sink characteristics of a sample by making use of relative density separation.	ISO 7936
General analysis	Chemical and physical analysis, excluding total moisture.	NA
Gross Calorific Value (GCV)	The heating value of coal, including the heat generated when water vapour is formed and condensed.	ISO 1928
Moisture in Analysis Sample (MIAS)	The water retained within the pores and fissures of the coal particles after the free, or surface, moisture has been removed (Falcon & Ham, 1988).	ISO 11722
Net Calorific Value (NCV)	The heating value of coal. Gross calorific value along with the moisture and hydrogen content. Calculated by making use of an equation considering the moisture and hydrogen content.	ISO 1928

Analysis	Description	Method
Proximate analysis (Prox)	Analysis that includes the ash value, fixed carbon, MIAS, and volatile matter.	ISO 17246
Size analysis	Size analysis by sieving to obtain size distribution information of the sample (Speight, 2005).	ISO 1953
Total Moisture (TM)	The moisture, including the free moisture and the moisture in the analysis sample (MIAS).	ISO 589
Total Sulphur (TS)	Total sulphur consists of different types of sulphur: sulphides, organic sulphur, elemental sulphur and sulphate (Falcon & Ham, 1988).	ISO 19579
Volatile Matter (VM)	The organic and mineral matter derived from the coal as the temperature increases.	ISO 562

3.3 Experimental setup

3.3.1 SepAir

Coaltech imported the SepAir pilot plant to South Africa in 2019. The SepAir pilot plant was designed and manufactured by Gormash Export. A modular feeder, discard conveyor, and product conveyor were added to the SepAir module. The pilot plant has a capacity of 40tph and only requires a 380V electricity supply. A picture of the SepAir can be seen in Figure 12.

Figure 12: The SepAir pilot plant

3.3.2 Specifications

The SepAir consists of a steel mesh conveyor that has an aperture of 0.15mm to screen out the ultra-fines. The steel mesh conveyor feeds the material to pass beneath a 10x80mm nozzle (Figure 13). The nozzle acts as intake to a fluidised bed section where separation takes place by means of gravity when negative upwards pressure (suction) is applied to the feed material. The suction forces are generated by a fan (15 kW) that creates a vacuum when air enters the system at the uptake nozzle. The lighter, less dense material is pulled up through the nozzle while the denser material moves past and is rejected onto the discard conveyor. The product and ultra-fines exit the system by means of a gate valve at the bottom of each vessel as illustrated in Figure 14. Gate valves are used to prevent any additional air from entering the system as it will disturb the air flow, and effectively, the separation.

Additional pictures of the SepAir unit are available in Annexure A.

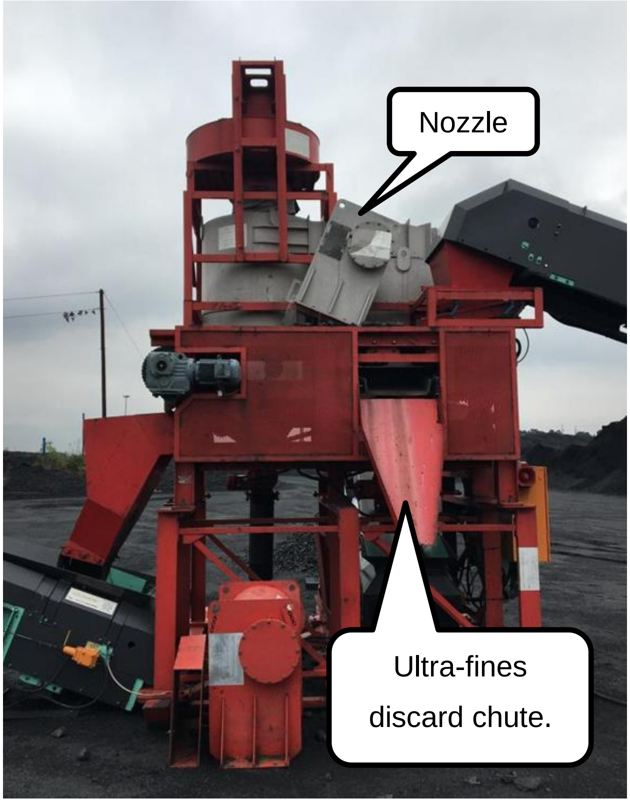

Figure 13: SepAir components (A)

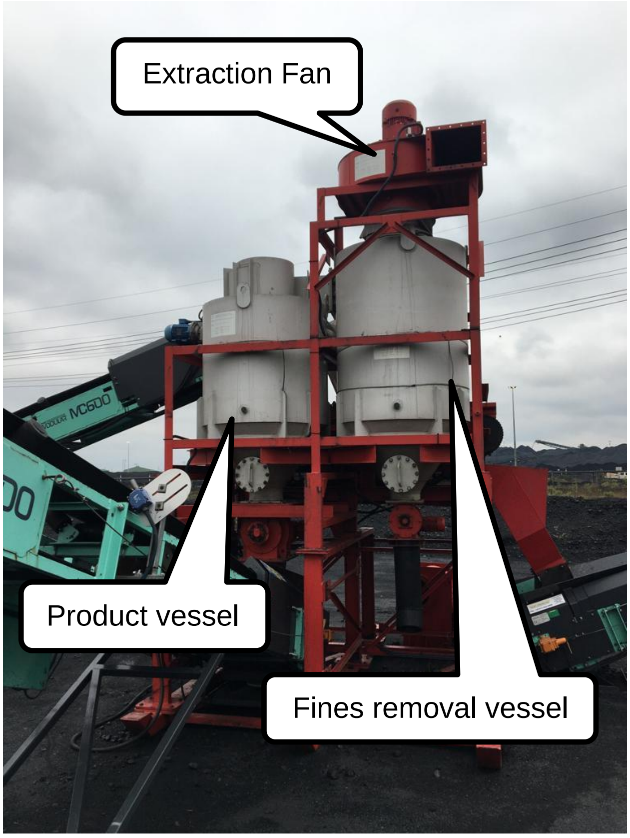

Figure 14: SepAir components (B)

A simplified process description of the SepAir technology is depicted in Figure 15.

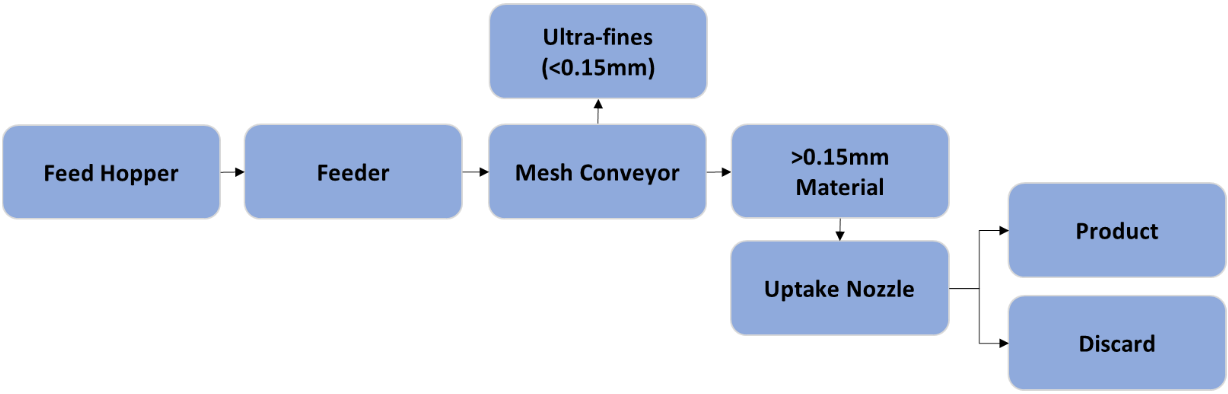

Figure 15: SepAir process block flow diagram

3.4 Experimental procedure

A phased approach was followed for the experimental procedure of this research. There were four phases, each with a specific purpose.

3.4.1 Phase 1

Phase 1 testing consisted out of spot tests. The spot tests were done by varying three independent variables, namely:

1. Plant feed rate (A)
2. Mesh conveyor speed (B), and
3. Fan speed (C)

The three independent variables were tested on different size fractions. The cut-point, product yield, and feed quality upgrades in terms of ash, CV, TS, and AI were the dependent variables. A statistical analysis, specifically a correlation test, was conducted based on the spot test results to determine which one of the three independent variables has the highest influence on the performance of the SepAir. The tests were conducted on Coal 2.

A factorial design was set up to determine the number of tests required to complete Phase 1. The capacity of the SepAir unit is 40tph and thus the two values for (A) were 20tph and 40tph. A speed test was done on the steel mesh conveyor (B) and the two limits were chosen as 30Hz and 60Hz. The fan speed (C) was tested at three different values for each test. The factorial design is illustrated in the table below.

Table 7: Factorial design

Size range	Feed to plant (tph) (A)	Conveyor speed (Hz) (B)	Fan speed (Hz) (C)	Analysis required
10x25mm	25	30	60	Prox, CV, TS, AI
	40	60	65	
			70	
10x50mm	25	30	60	
	40	60	65	
			70	
25x50mm	25	30	60	
	40	60	65	
			70	
0x50mm	25	30	60	
	40	60	65	
			70	

A constant independent variable was determined from the results obtained from Phase 1 and the set points for Phase 2 were subsequently established. The results indicated that the fan speed has the highest effect on the efficiency of the SepAir.

3.4.2 Phase 2

The objective of Phase 2 was to test the capability of the SepAir for a maximum upgrade of the feed quality. This was done by means of efficiency tests. The fan speed from the spot tests performed in Phase 1 that resulted in the best upgrade of the feed quality was selected as the fan speed at the specific size ratio for the Phase 2 efficiency tests. The first test work for this phase was done using both Coal 1 and Coal 2. At size fractions 10x25mm, 10x50mm, and 25x50mm, a single fan speed was selected, while four tests were done at variable conveyor speeds and plant feed rates. Only one test with a fixed feed rate, conveyor speed, and fan speed was done for the size range 0x50mm for Coal 2.

The efficiency of the SepAir for a maximum upgrade of the feed quality was also tested on Coal 4, but here the fan speed was varied at each size fraction while the conveyor speed and feed-to-plant rate remained constant and at the lowest rate. Due to Coal 4 being five seam material, many challenges arise when the material is treated as a high amount of clay material is usually present. A wet and dry fractional analysis was done on a Coal 4 sample (see Annexure D) to determine if clay material was present in the feed. The qualities for the coarser fraction (+50mm) improved significantly after wet sizing was done. The sample revealed big lumps of clay and it had to be thoroughly washed for the clay to dissolve. Pictures of the SepAir blockages caused by Coal 4 are available in Annexure D.

Phase two tests were done on Coal 1, Coal 2 and Coal 4 due to the amount of material available for testing. Coal 3 was only received and prepared for test work during Phase 3.

Table 8: Phase 2 Coal 1 and Coal 2 test schedule

Size ratio	10x25mm				10x50mm				25x50mm			
Test	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Fan speed (Hz)	50				60				65			
Conveyor speed (Hz)	30	60	30	60	30	60	30	60	30	60	30	60
Plant feed rate (tph)	20	20	40	40	20	20	40	40	20	20	40	40

Table 9: Phase 2 Coal 4 test schedule

Size ratio	10x25mm			25x50mm		0x50mm	
Test	T1	T2	T3	T1	T2	T1	T2
Fan speed (Hz)	60	65	70	70	75	70	75
Conveyor speed (Hz)	30			30		30	
Plant feed rate (tph)	20			20		20	

3.4.3 Phase 3

Phase 2 results indicated misplacement of discard in the clean coal stream and clean coal in the discards stream. Fortunately, the majority of the misplacement was the amount of clean coal in the discard stream, due to upgrading the feed quality to a maximum, resulting in the decision to test the SepAir for double stage washing. The motivation for double stage washing is that the overall yield can be increased, consequently the amount of waste generation and movement cost decreased, and two different product qualities can be produced. It was decided to aim for a low-grade export market from the primary stage and a domestic grade from the secondary stage.

All three independent variables remained constant at each size fractions per stage and the test schedule was as illustrated in Table 10. The tests for Phase 3 were conducted on Coal 3.

Table 10: Phase 3 test schedule

Independent variables	Size ratio					
	10x25mm		10x50mm		25x50mm	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Fan speed (Hz)	60	70	55	70	60	65
Conveyor speed (Hz)	30	30	30	30	30	30
Plant feed rate (tph)	20	20	20	20	20	20

3.4.4 Phase 4

The capability of the SepAir to upgrade the feed quality at a maximum, i.e., to obtain a lower cut-point, was tested throughout Phase 1 to Phase 3. This objective was thoroughly put to the test, and it was decided to determine the process conditions to achieve a maximum organic efficiency when upgrading the feed material with the SepAir technology.

For Phase 4, all three the independent variables were kept constant, i.e., constant fan speed, constant conveyor speed and constant plant feed rate (schedule available in

Table 11). The test work for Phase 4 was done with Coal 3.

Table 11: Phase 4 test schedule

Size ratio	10x25mm	10x50mm	25x50mm
Test	T1	T2	T2
Fan speed (Hz)	70	70	70
Conveyor speed (Hz)	30	30	30
Plant feed rate (tph)	20	20	20

3.5 Experimental plan

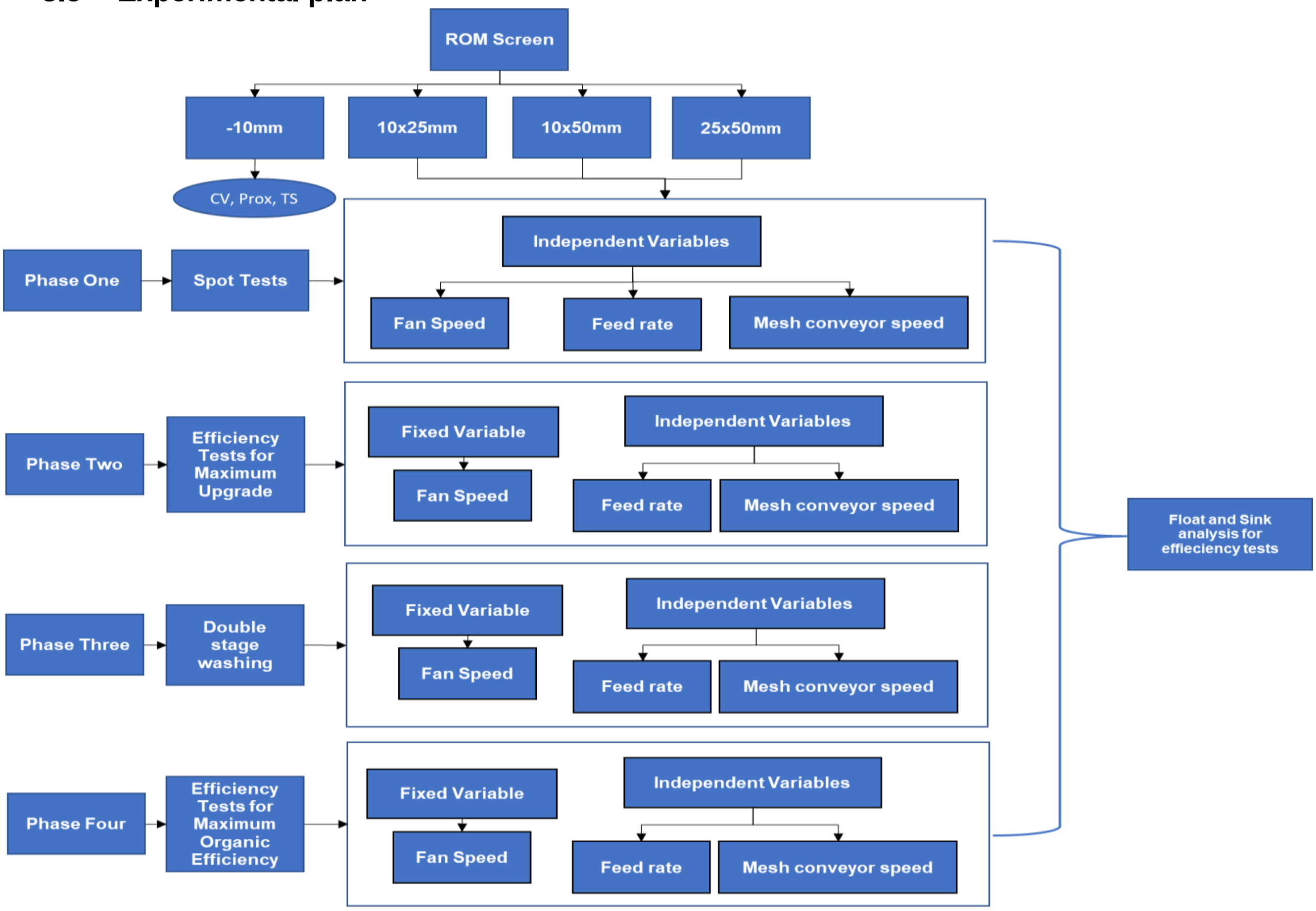

Figure 16: Experimental plan

CHAPTER 4 PRELIMINARY RESULTS

4.1 Screening outcomes

One of the objectives of this research project was to test the capabilities of the SepAir on different size fractions to verify if the SepAir operates more effectively on the different size ratios. The size fractions planned were 10x25mm, 10x50mm, and 25x50mm. Tests were also conducted on 0x50mm material. The screening was done by means of a double deck mobile screen with a 25mm APC top deck and 10/50mm APC slotted bottom deck.

Due to limited availability of the mobile screen, only Coal 1, Coal 2, and Coal 3 were screened prior to the tests using the double deck mobile screen. The material for Coal 1, Coal 2, and Coal 3 were screened for size fractions 10x25mm, 10x50mm, and 25x50mm. Since more material was received for Coal 2 it was decided to test Coal 2 on the 0x50mm size fraction. Coal 4 was received from the supplier in 10x25mm, 25x50mm, and 0x50mm size fractions.

The particle size distributions for all the sources are available in Figure 17, Figure 18, Figure 19, and Figure 20. The Rosin Rammler graphs indicated that the D10 was lower than anticipated due to a high fines content in the sources, as well as inaccurate screening by mobile screens. The fact that dry screening was done with the mobile screens contributed to the inefficiency due to fines agglomerating to the coarser material.

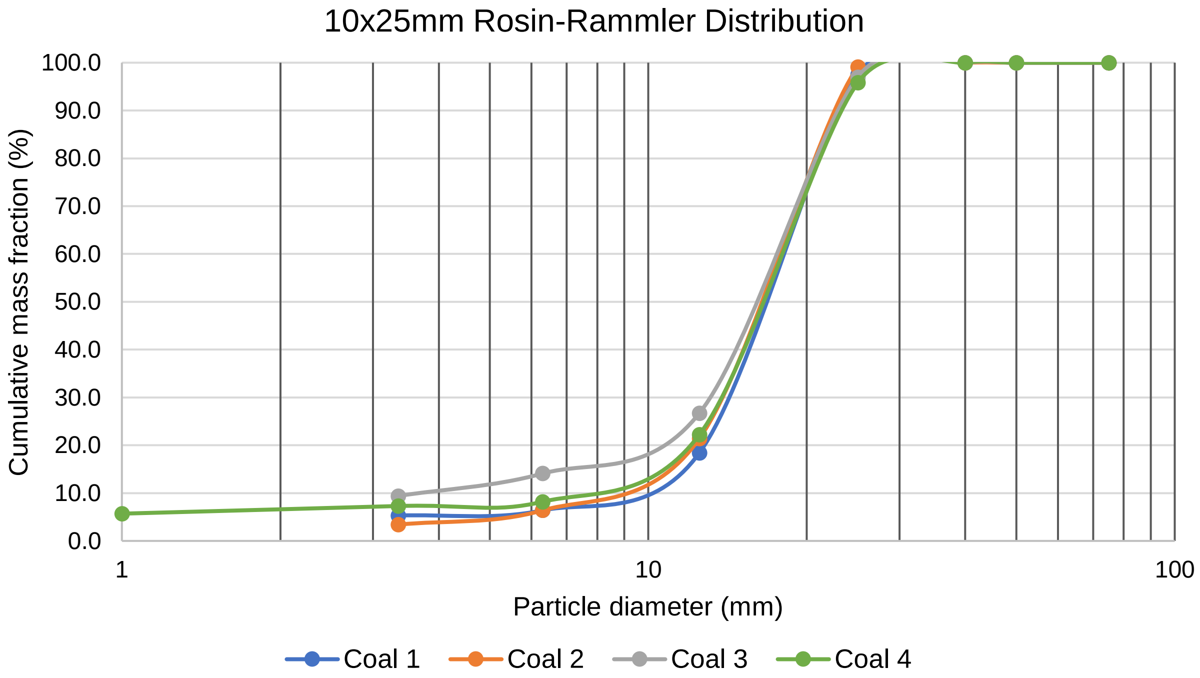

Figure 17: 10x25mm size distribution

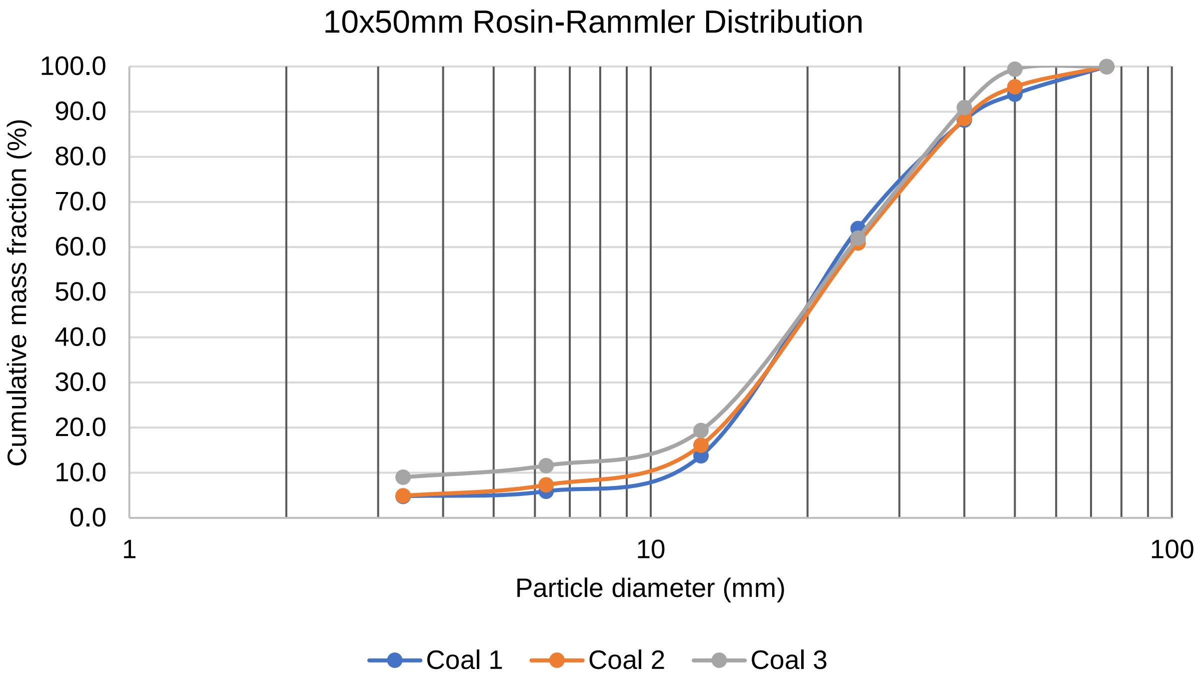

Figure 18: 10x50mm size distribution

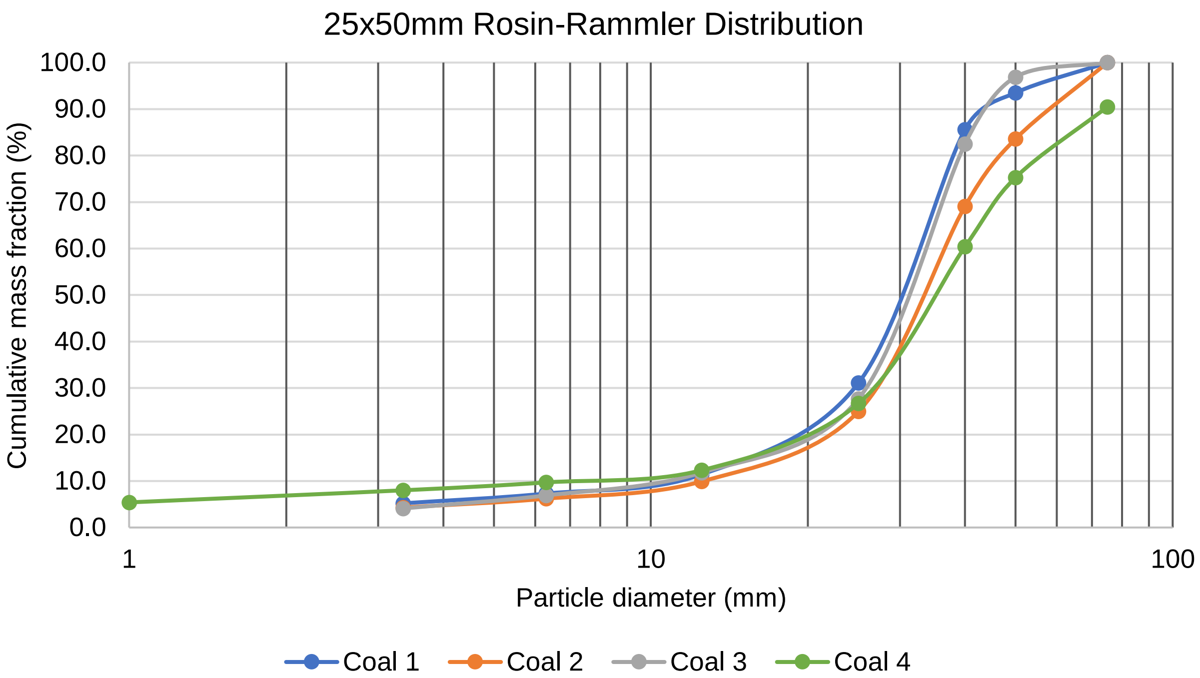

Figure 19: 25x50mm size distribution

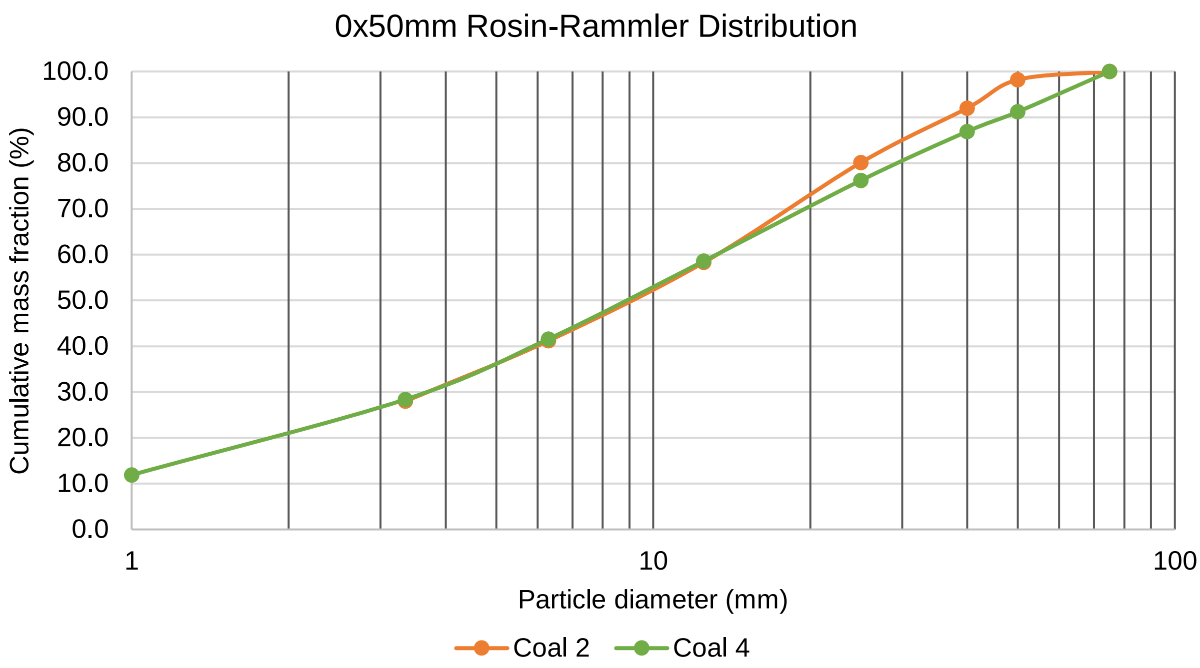

Figure 20: 0x50mm size distribution

The aperture sizes at D10, $D50_{size}$, and D90 were as indicated in Table 12. The results for the 10x25mm size ratio were a D10 at an average aperture size of 8mm and D90 of 23mm. The D10 and D90 aperture sizes for the 10x50mm size fraction had an average of 8mm and 41mm respectively. The D10 for the 25x50mm size ratio was at best 13mm for Coal 2, but 50% ($D50_{size}$) of all the particles passed a 33mm aperture sieve. The D90 for the 25x50mm size ratio was 75mm for Coal 4, which indicates that a high amount of material above 50mm was observed in the feed. The $D50_{size}$ for the 0x50mm size fraction shows that 50% of the feed material is below 9mm, indicating a high fines content for the 0x50mm material. A higher fines content was observed for Coal 3 which in effect could cause more fines to report to the product and could lead to a lower feed quality upgrade.

From the results obtained from the Rosin Rammler size distributions, the size fractions used for all the test work were 10x25mm, 10x50mm, 25x50mm and 0x50mm.

Table 12: Aperture sizes for the various coal sources

Aperture size (mm)	D10				$D50_{size}$				D90			
Coal Source	1	2	3	4	1	2	3	4	1	2	3	4
10x25mm	10	9	4	8.5	18	17	17	17	23	23	23	23
10x50mm	12	8	4	NA	21	21	21	21	41	41	40	NA
25x50mm	12	13	10	6	30	34	32	35	43	58	43	75
0x50mm	NA	0	NA	0	NA	9	NA	9	NA	37	NA	48

4.2 Phase 1 results: Spot tests

4.2.1 Upgrade potential

Spot tests were done by using Coal 2 and formed part of Phase 1 of the experimental procedure as discussed in Chapter 3.4.1. The dependent variables were tested in terms of the plant feed rate, mesh conveyor speed and fan speed, which were varied for the different size fractions as per the factorial design.

The average results for the ash, total sulphur (TS), and abrasive index (AI) percentage reduction as well as the calorific value (CV) upgrade for the four different particle size fractions were as shown in Figure 21. The yields obtained from all the spot tests were as displayed in Figure 22 which indicates that the SepAir has the ability to achieve high yields for a desired feed quality upgrade. Numerous tests were conducted for the 10x25mm (a), 10x50mm (b), and 25x50mm (c) size fractions, but only one test was conducted for the 0x50mm (d) fraction due to limited availability of the material. See Annexure A for detailed results.

On average, ash and TS upgrades above 30% were achieved for the (a), (b), and (c) size fractions, with an average minimum CV upgrade and AI reduction of 19%. The corresponding yields varied from 2.3% to 73%, depending on the cut-point. The cut-point densities for (a) were between 1.74 and 2.15, between 1.75 and 2.24 for (b), and for (c) between 1.69 and 2.30.

The spot test results indicated a preference for the 10x50mm (1:5) size fraction when considering the percentage ash reduction and CV upgrade. With regard to percentage TS and AI reduction, no conclusion could be reached concerning the size range preference.

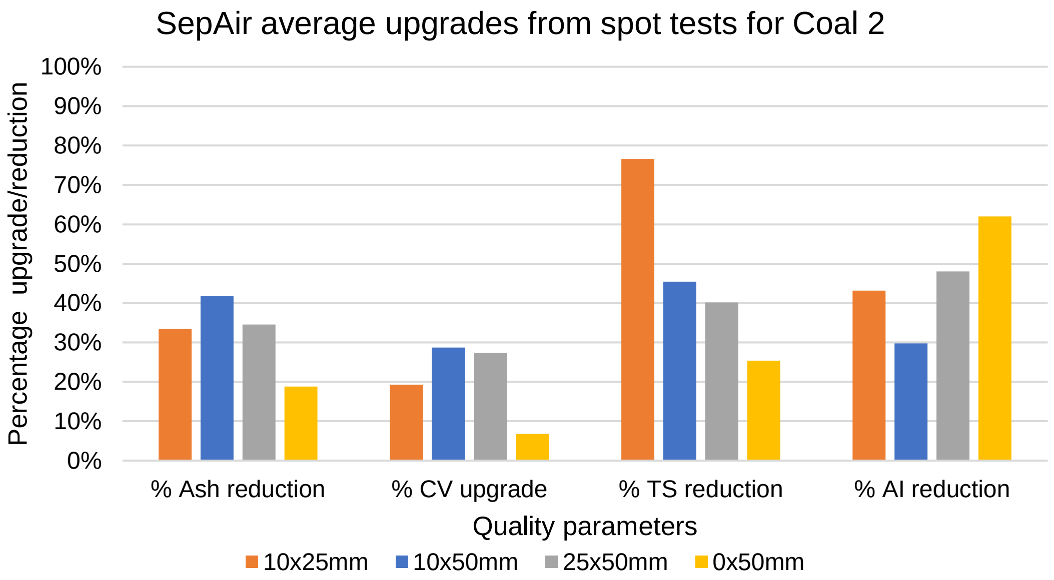

Figure 21: Average feed quality upgrades from spot tests

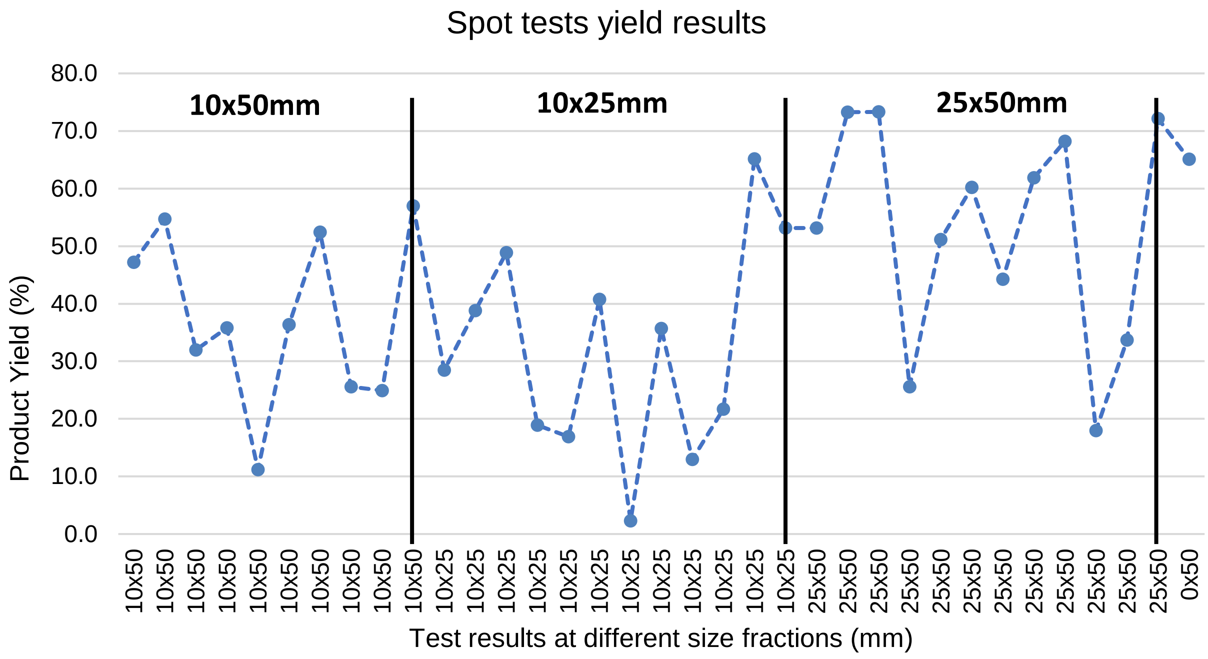

Figure 22: Spot tests yield results

4.2.2 Statistical analysis

The results from the spot tests were used to conduct a statistical analysis to determine the correlation between the dependent and independent variables. A correlation test was done, which indicated that the fan speed was the most influential independent variable as depicted in Figure 23. For the 10x25mm particle size, the feed rate and conveyor speed has an 18% and 14% influence on the cut-point density respectively. The fan speed affects the cut-point density by 66%. The same observation was made for the 10x50mm and 25x50mm particle size fractions, with the fan speed affecting the cut-point densities at higher levels than that of the feed rate and conveyor speed. For the 10x50mm particle size ratio, the fan speed has a 55% chance of influencing the cut-point with the feed rate and conveyor speed a 34% and 5% chance respectively. For the feed rate for the 25x50mm size fraction the effect is 25%, with the conveyor speed affecting the cut-point density by only 11%. The fan speed, however, affected the cut-point density by 66%, the same as for the 10x25mm particles size range.

The graph indicates that the feed rate has a higher influence on the cut-point density when compared to the mesh conveyor speed. As discussed previously, the conveyor speed only had a 5% effect on the cut-point density for the 10x50mm size ratio, which is insignificant.

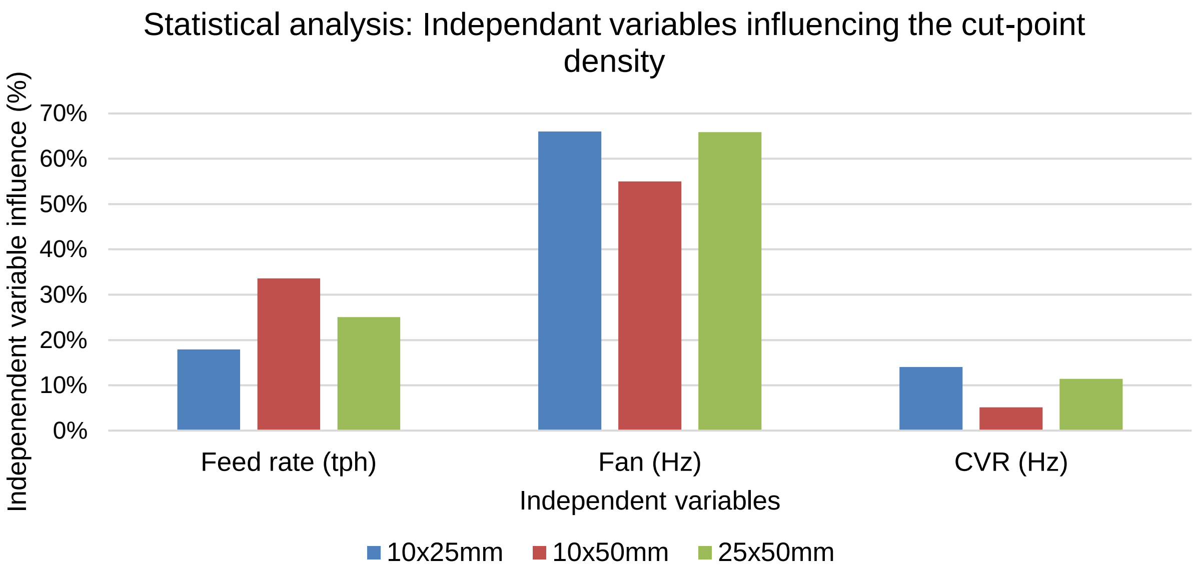

Figure 23: Independent variable influence on cut-point

A comparison between the fan speeds and corresponding cut-point densities ($D50_{density}$) was done to determine if the fan speed can be predetermined for a known size ratio. The data from all the spot tests were plotted as illustrated in Figure 24, Figure 25, and Figure 26. The raw data points along with a linear trendline were plotted on the respective graphs.

The gradient of the graphs indicates that when the fan speed increases, the cut-point density increases. It was also observed that for the same cut-point density, the fan speed is directly proportional to the size of the material. For example, to cut at a density of 1.90 the fan speed for the 10x25mm particles size range was at 56Hz, 62Hz for the 10x50mm size fraction, and 66Hz for the 25x50mm particle size ratio. The data points were vastly scattered as indicated in Figure 24, Figure 25, and Figure 26 due the test conditions and variable differences such as different feed rates and conveyor speeds.

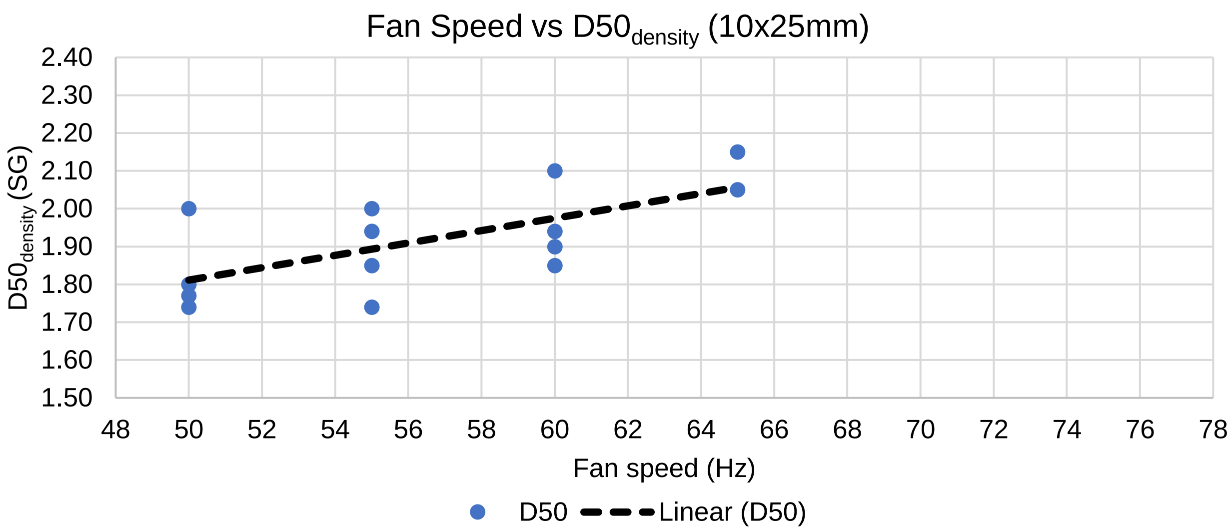

Figure 24: Fan speed vs cut-point density for 10x25mm particle size range

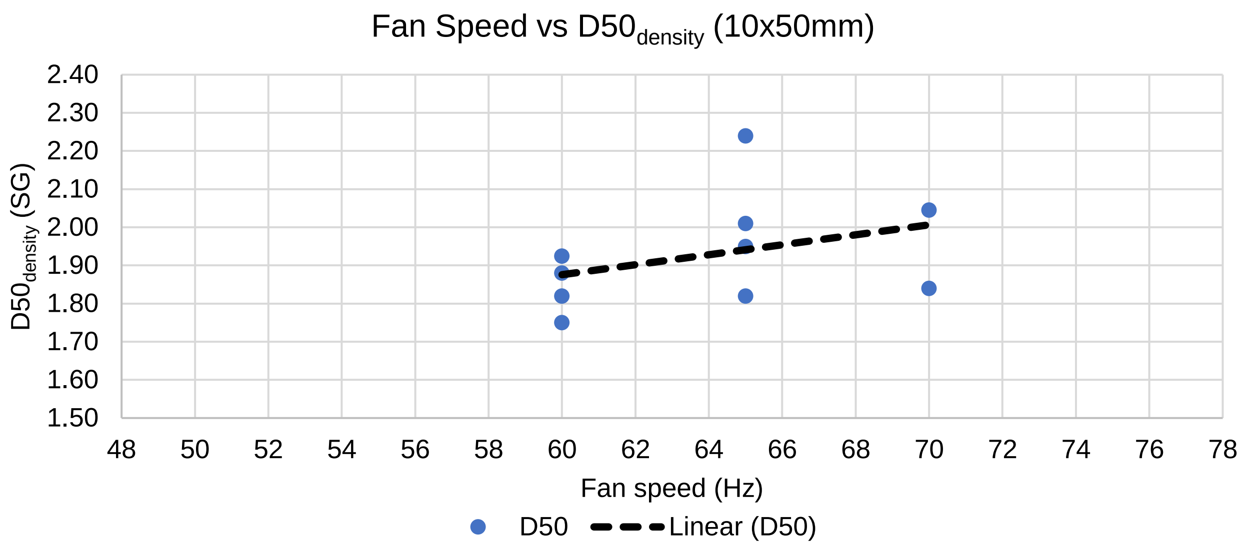

Figure 25: Fan speed vs cut-point density for 10x50mm particle size range

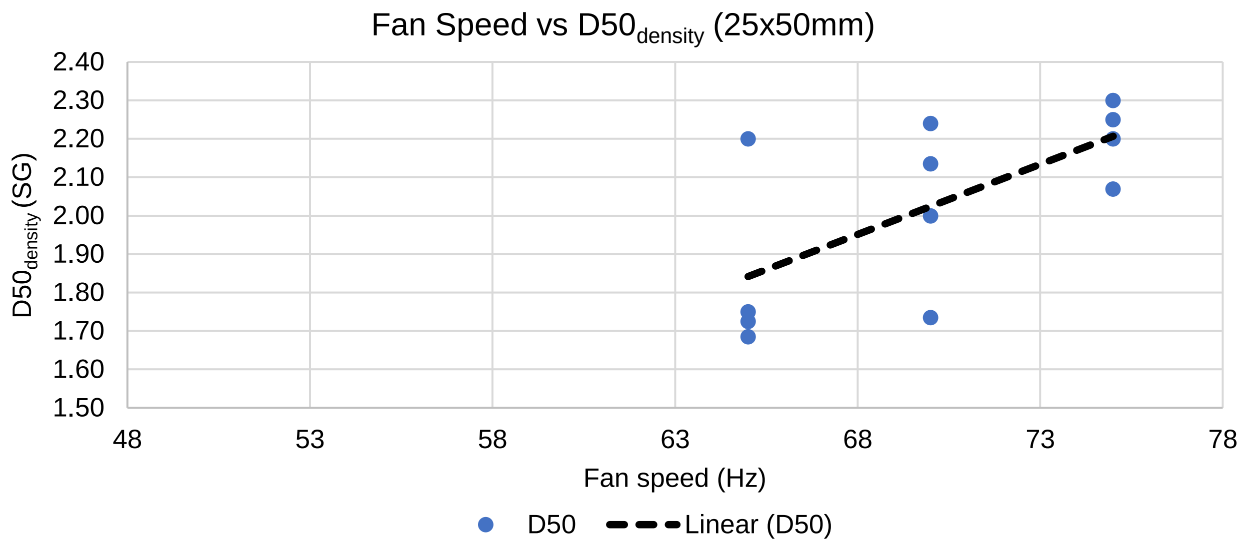

Figure 26: Fan speed vs cut-point density for 25x50mm particle size range

CHAPTER 5 SEPAIR: MAXIMUM UPGRADE RESULTS

5.1 Phase 2 results: Maximum upgrade efficiency

5.1.1 Upgrade potential

Efficiency tests were done to test the capabilities of the SepAir for the maximum upgrade of feed qualities. The tests were conducted for Coal 1, Coal 2, and Coal 4.

The average efficiency data results for Coal 1 were as indicated in Table 13.

Table 13: Efficiency test averages for a maximum upgrade of the feed for Coal 1

Size range	10x25mm	10x50mm	25x50mm	0x50mm
Product yield (%)	13	50	23	NA
D50 (Cut-point density (SG))	1.43	1.78	1.54	
Epm	0.0239	0.2100	0.0844	
Organic Efficiency (%)	18	63	36	
Sink in Float (%)	7.5	8.5	10.4	
Float in Sink (%)	10.5	21.8	13.8	
Total Misplaced (%)	18.0	30.3	24.2	
Near Density (%)	30.5	16.3	20.3	

Low product yields were observed for the 10x25mm and 25x50mm size fractions due to lower cut-point densities, 1.43 and 1.54 respectively. A higher cut-point density was achieved for the 10x50mm particle size range, which resulted in a product yield of 50%. Desired Epm values were achieved for the 1:2 size ratios (10x25mm and 25x50mm), 0.0239 and 0.0844 respectively. The organic efficiencies were not desirable but can be attributed to the low cut-point densities at which the SepAir separated the material and subsequently the high amount of near-density material present. According to Table 1, when the amount of near-density material is between 15–20%, the degree of difficulty is labelled as "very difficult" and between 20–25% it is "exceedingly difficult" to separate. The results from Table 13 indicate that high amounts of near-density material were present at all three the particle size ratios, but it was especially high at 10x25mm. This explains the below desired performance of the SepAir.

The feed quality upgrades for the 10x25mm particle size fractions were as illustrated in Figure 27, which resulted in ash, total sulphur (TS) and abrasive index (AI) reductions of 34.62%, 71.12%, and 63.20% respectively.

The calorific value (CV) upgrade was 24.75%. The feed for Coal 1 at a particle size ratio of 10x25mm was upgraded from a coal that cannot be offered to the domestic market (ash=37.1% and CV=18.4MJ/kg) to a product that complies to both the domestic and export market specifications (ash= 24.3% and CV= 22.8MJ/kg). The same was true for the 10x50mm and 25x50mm size ratios where ash, TS, and AI reductions of 27.87%, 67.3%, and 58.06% were observed for the 10x50mm particle size ratio respectively. The CV upgrade for the latter size range was 18.84%. An ash reduction of 37.21%, CV upgrade of 48.63%, and TS and AI reductions of 59.84% and 64.48% were obtained for the 25x50mm size fraction.

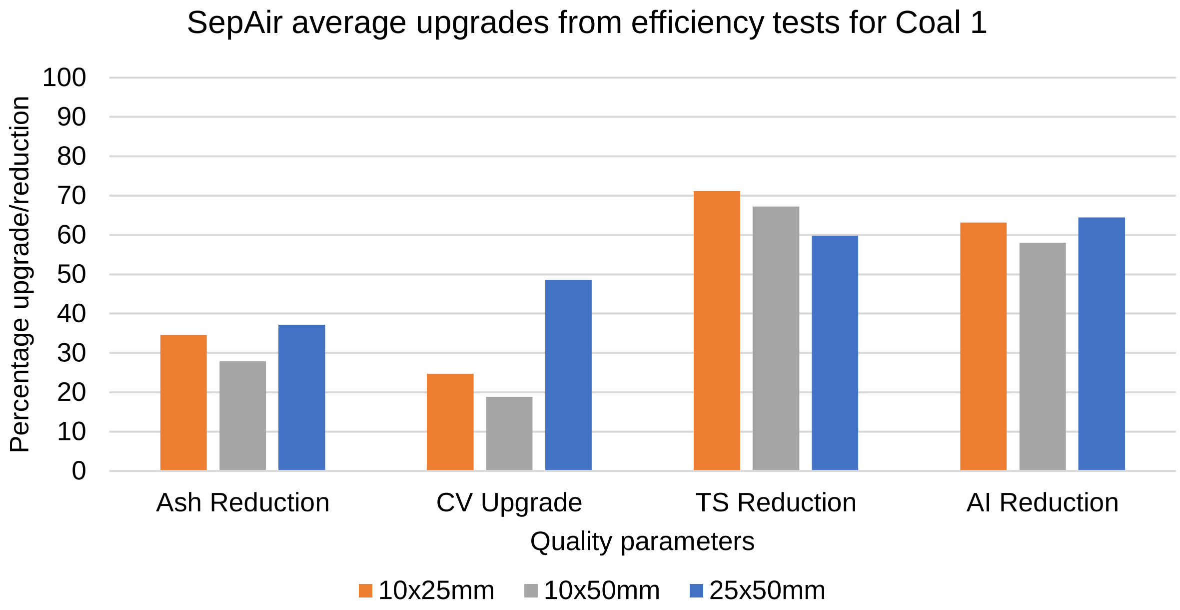

Figure 27: Average feed quality upgrades from efficiency tests for Coal 1

The performance data for the maximum upgrade efficiency tests for Coal 2 are available in Table 14. The results for Coal 2 showed an increase in the product yields in comparison with Coal 1, especially compared to the 10x25mm particle size fractions. This can be due to the higher quality feed material for Coal 2, which did not require a cut-point density of 1.43 (Coal 1) to achieve similar quality upgrades. The higher cut-point density (1.65) for Coal 2 resulted in a higher product yield of 44% in comparison with a yield of 13% for Coal 1. The feed quality upgrades for the various size fractions for Coal 2 are available in Figure 28. The feed quality upgrades for 10x25mm were 38.6% for ash, 16.6% for CV, and 68.6% and 40.1% for TS and AI respectively.

The organic efficiencies for the 10x25mm, 10x50mm, and 25x50mm size fractions were not desirable and can be attributed to the high amounts of near-density material present at the respective cut-point densities.

The organic efficiency for the 0x50mm material was at 89% due to the material that was separated at a cut-point density of 1.99, with a low amount of near-density material present at 4%. Desirable Epm values were achieved for the 10x25mm, 10x50mm, and 25x50mm particle size ratios as it ranged from 0.0911 to 0.1298.

Table 14: Efficiency test averages for a maximum upgrade of the feed for Coal 2

Size range	10x25mm	10x50mm	25x50mm	0x50mm
Product yield (%)	44	53	34	80
D50 (Cut-point density (SG))	1.65	1.73	1.56	1.99
Epm	0.1264	0.1298	0.0911	0.2377
Organic Efficiency (%)	58	66	42	89
Sink in Float (%)	6.6	5.8	11.3	4.7
Float in Sink (%)	27.2	21.3	18.1	10.4
Total Misplaced (%)	33.7	27.1	29.4	15.2
Near Density (%)	19.5	14.5	21.0	4.0

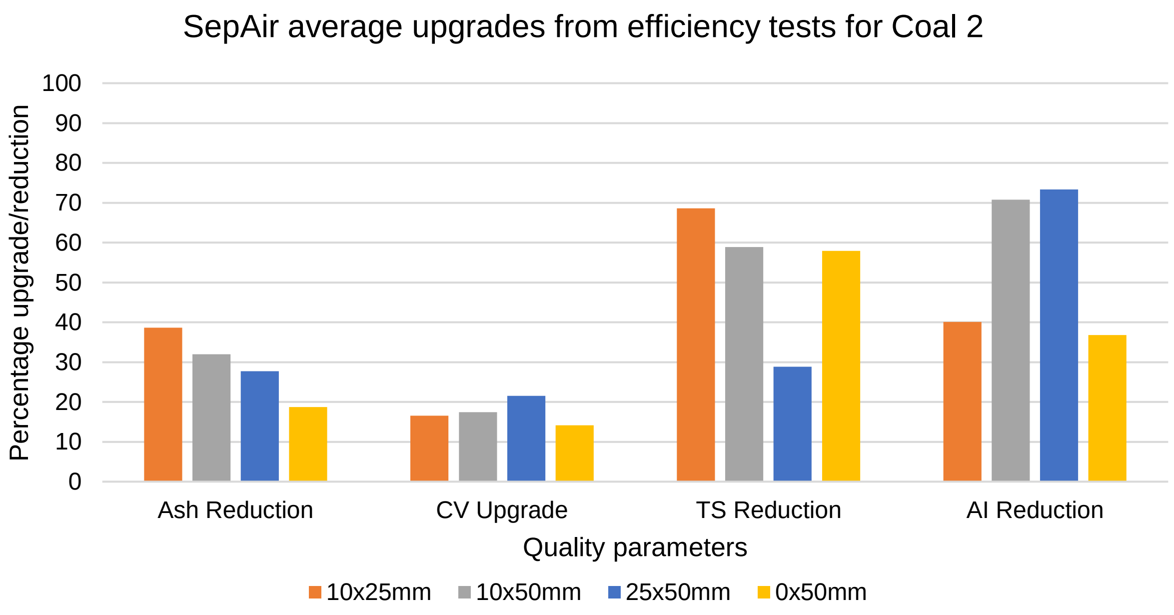

Figure 28: Average feed quality upgrades from efficiency tests for Coal 2

The efficiency test results for Coal 4 are indicated in Table 15. The product yields for the size fractions tested for Coal 4 all indicated positive product yields at relatively high cut-point densities of 1.69 (10x25mm), 1.77 (25x50mm), and 1.75 (0x50mm). The Epm values were as high as 0.5886 for the 25x50mm size fraction and as low as 0.2388 for the 0x50mm size range material. These Epm values were not favourable and may be ascribed to the challenging conditions during the Coal 4 test work. The SepAir became blocked numerous times due the nature of the five seam material.

Table 15: Efficiency test averages for a maximum upgrade of the feed for Coal 4

Size range	10x25mm	10x50mm	25x50mm	0x50mm
Product yield (%)	52	NA	60	53
D50 (Cut-point density (SG))	1.69		1.77	1.75
Epm	0.3186		0.5886	0.2388
Organic Efficiency (%)	76		78	68
Sink in Float (%)	12.8		12.0	8.4
Float in Sink (%)	11.8		12.9	19.8
Total Misplaced (%)	24.5		24.9	28.2
Near Density (%)	22.6		12.8	9.0

Although there were many challenges during the Coal 4 test work, the feed quality upgrade results were favourable as illustrated in Figure 29. Ash and TS reductions of 19.05% and 67.19% were achieved for the 10x25mm size fraction respectively. Ash and TS reductions of 28.49% and 34.59% were observed for the 25x50mm size ratio and 23.24% and 41.09% for 0x50mm respectively. The CV upgrade achieved for 10x25mm, 25x50mm, and 0x50mm was 27.33%, 19.77%, and 24.27% respectively. Irrespective of the low Epm values discussed, the feed for Coal 4 for 10x25mm was upgraded from an ash value of 35% to 28% and the CV was upgraded from 17.6MJ/kg to 22.41MJ/kg. The feed quality for the 25x50mm particle size fraction was upgraded from 41.6% to 29.75% for ash and from 17.7MJ/kg to 21.2MJ/kg for CV. Both these products were upgraded to achieve domestic and export market specifications as indicated in Table 2 and Table 3. However, the feed quality for the 0x50mm size ratio was not upgraded sufficiently to comply to the specific market specifications as it was upgraded from an ash value of 45.4% to an ash value of 34.85% and a feed CV of 15.86MJ/kg to a product CV of 19.71MJ/kg.

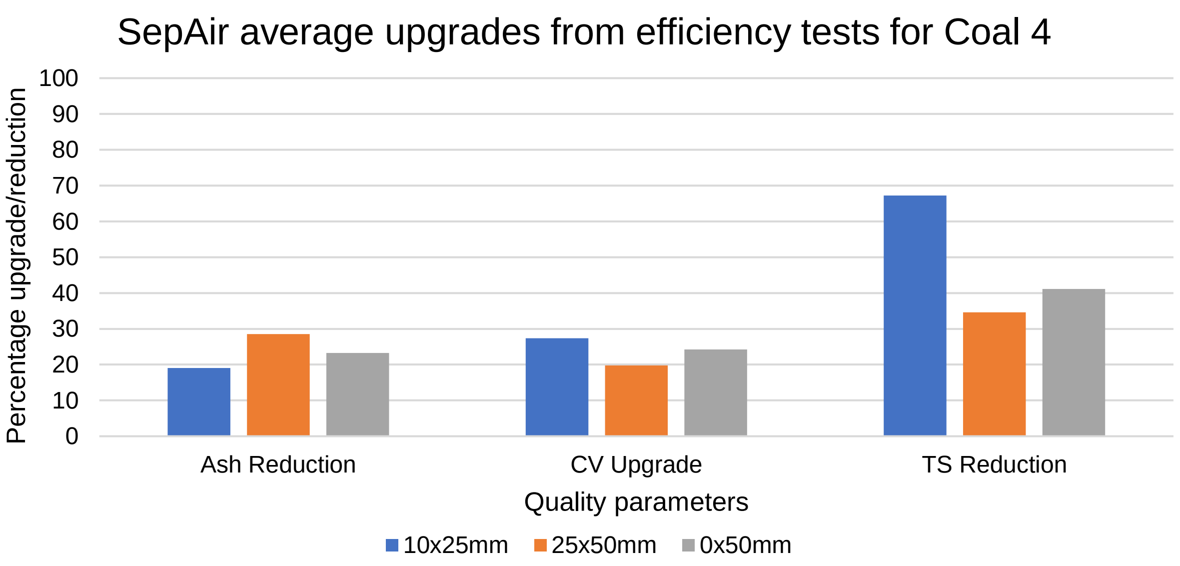

Figure 29: Average feed quality upgrades from efficiency tests for Coal 4

The results obtained from the spot and efficiency tests clearly indicate the SepAir's ability to upgrade Southern Hemisphere coal to acceptable market qualities with an average yield of 40%. When considering the particle size fractions treated, the 1:2 size ratios performed better when comparing the percentage ash reduction and CV upgrade of the feed quality for Coal 1 and Coal 2, but not for Coal 4. No conclusion could be drawn for the 1:2 and 1:5 size ratios for the percentage TS and AI reduction. The Epm was lower for the 1:2 size ratios for Coal 1 and Coal 2, but the opposite can be said for Coal 4. It can therefore not be concluded that a specific size ratio enhanced the performance of the SepAir.

High amounts of misplacement were present, especially referring to the clean coal in the discard for Coal 1 and Coal 2. Based on these results, it was decided to test the SepAir's capabilities to beneficiate the feed material with a two-stage process. This is discussed in detail in Chapter 6.1.

The -10mm material for Coal 1 and Coal 2 were analysed to determine if the raw material can be blended in to increase the yield. The raw quality results are available in Table 16. The -10mm material for Coal 1 can be blended in for the 10x25mm and 10x50mm products to obtain a final product compliant with the domestic market specifications. It is, however, advisable to avoid blending for the 25x50mm product for Coal 1 due to both products having a CV of below 21 MJ/kg. It can, however, be blended in when targeting a market for low grade export, such as RB4. The -10mm material for Coal 2 had very good raw qualities with CV results of above 22MJ/kg, and can thus be blended in for any of the SepAir products.

Table 16: Raw quality results for the -10mm samples for Coal 1 and Coal 2

Analysis on an Air Dry Basis.			CALORIFIC VALUE	VOLATILE MATTER	ASH %	MIAS %	SULPHUR %	FIXED CARBON %
			AVG	AVG	AVG	AVG	AVG	AVG
DATE	LAB	TRAIN	LAB	LAB	LAB	LAB	LAB	LAB
RAILED	ID NO.	NO.	CV	VOL	ASH	MIAS	TS	FC
04,01,2022	17520	Coal 1 (10mm)	20.13	22.1	31.2	4.0	0.59	42.7
07,01,2022	17521	Coal 2 (10mm)	22.28	23.0	23.5	4.4	0.46	49.1

5.1.2 The effect of feed rate

One of the objectives of this research was to test the performance of the SepAir at different feed to plant rates. As discussed in Chapter 3.4, the two feed rates selected for testing were 20tph and 40tph. The comparison was done only for Coal 1 and Coal 2, as tests conducted on Coal 3 had a different objective and Coal 4 was too difficult to process at a higher feed rate because it was five seam coal, which contains high amounts of clay. More information is available in section 3.4.2 regarding the nature of five seam.

The feed quality upgrade comparison for each size fraction per feed rate is as depicted in Figure 30, Figure 31, and Figure 32.

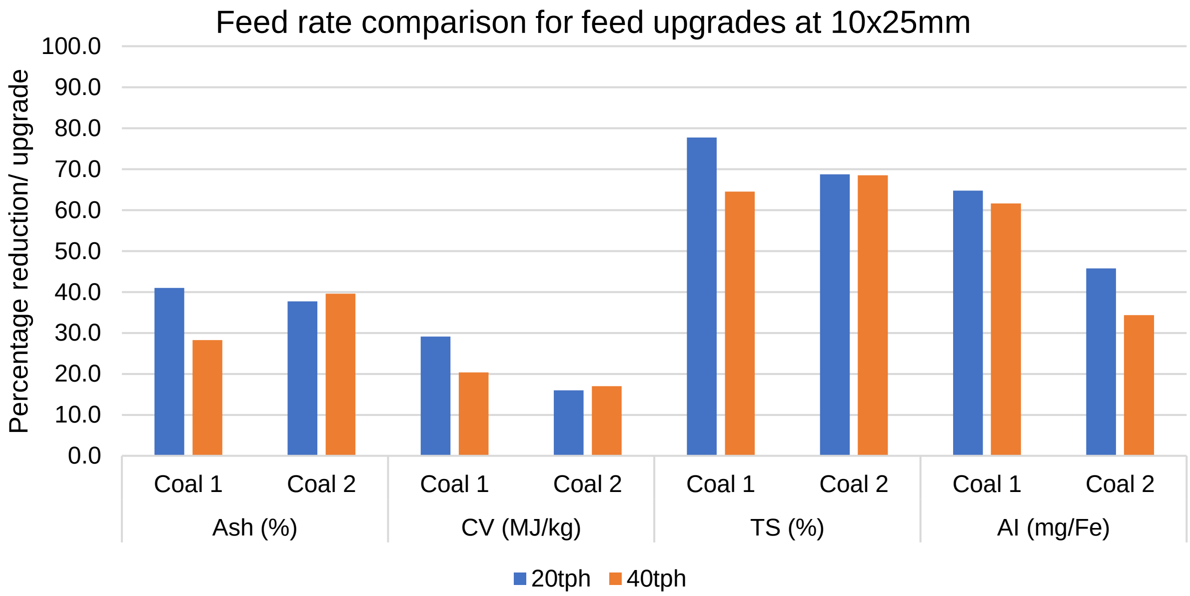

Figure 30: Feed rate comparison for 10x25mm

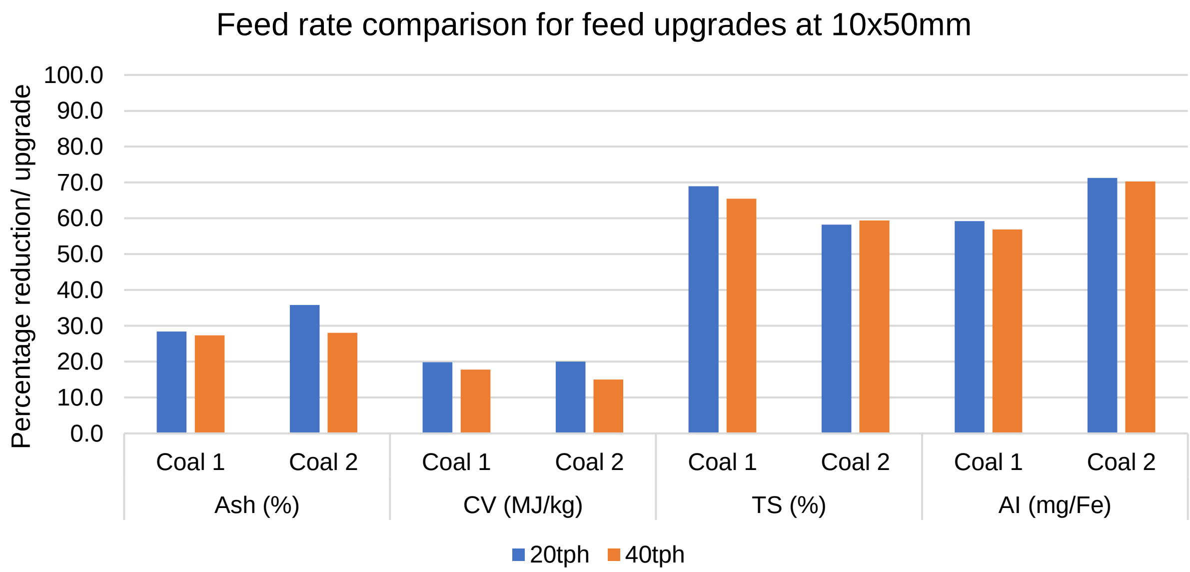

Figure 31: Feed rate comparison for 10x50mm

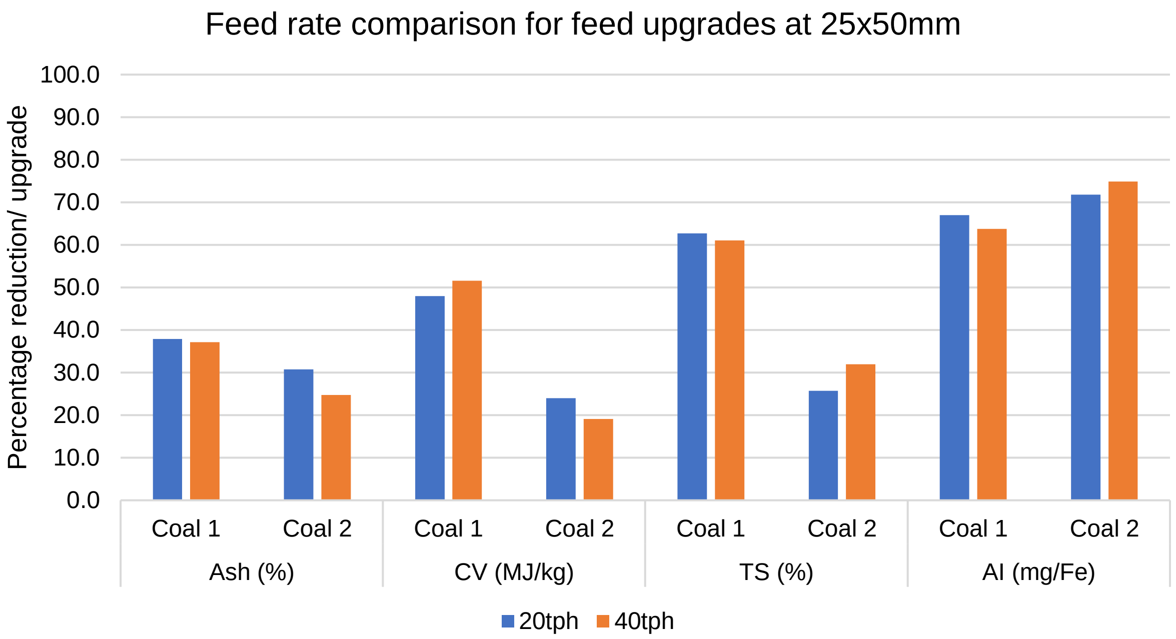

Figure 32: Feed rate comparison for 25x50mm

The feed quality upgrades at 20tph for Coal 1 were generally better than for 40tph. However, the CV upgrade for the 25x50mm particle size ratio performed slightly better at 40tph, but the remaining parameters (ash, TS, and AI) reduced more at a feed rate of 20tph. The feed upgrade for Coal 2 was not as consistent with a specific feed rate as that of Coal 1. The 20tph feed rate was the preferred feed rate for an ash reduction and CV upgrade for both the 10x50mm and 25x50mm size fractions. The TS reductions performed better at 40tph for the 10x50mm, and 25x50mm particle size ratios and AI was reduced more at 20tph at 10x25mm and 10x50mm. For Coal 2, the 20tph feed rate outperformed the 40tph feed rate only 58% of the time.

The results shown in Table 17 reveal that when running the SepAir at 20tph, the product yield, organic efficiency, and Epm values were higher. Higher product yields and organic efficiencies are favourable, but lower Epm values are desired. Th Epm values were lower at a feed rate of 40tph for all the size fractions. An analysis of variance (ANOVA) was done on Coal 1 and Coal 2 which also indicated that the feed rate has a significant effect on the product yield, Epm, and organic efficiency. The ANOVA results for Coal 1 and Coal 2 are based on p-values, which is an indication of the significance of the independent variables and should be below 0.05 to have a significant impact on the dependent variable. The p-values for product yield, organic efficiency, and Epm when comparing the effect of feed rate were all below 0.05, which indicates a significant impact. The raw data for the ANOVA are available in Annexure E.

Table 17: Coal 1 and Coal 2 feed rate comparison

	10x25mm		10x50mm		25x50mm	
	20tph	40tph	20tph	40tph	20tph	40tph
Product yield (%)	35	22	52	51	33	24
D50 (Cut-point density (SG))	1.57	1.51	1.75	1.76	1.62	1.48
Epm	0.0895	0.0608	0.2025	0.1373	0.1202	0.0553
Organic Efficiency (%)	47	29	66	63	47	32
Sink in Float (%)	8.6	5.5	6.8	7.5	10.2	11.5
Float in Sink (%)	17.8	19.9	20.3	22.9	18.9	12.9
Total Misplaced (%)	26.4	25.3	27.0	30.4	29.2	24.4
Near Density (%)	22.8	27.3	13.8	17.0	17.0	24.3

Box plots were plotted to summarise the effect of the feed rate on product yield (Figure 33), Epm (Figure 34), and organic efficiency (Figure 35) as the ANOVA indicated that the feed rate has a significant effect on these dependent variables. The box plots are a summary of all the data used for the research project and will therefore not be identical to the results available in Table 17. The effect of feed rate on product yield as displayed in Figure 33, indicates that the product yield tends to be higher at 20tph compared to 40tph, with a mean of approximately 50% at 20tph and 38% for 40tph.

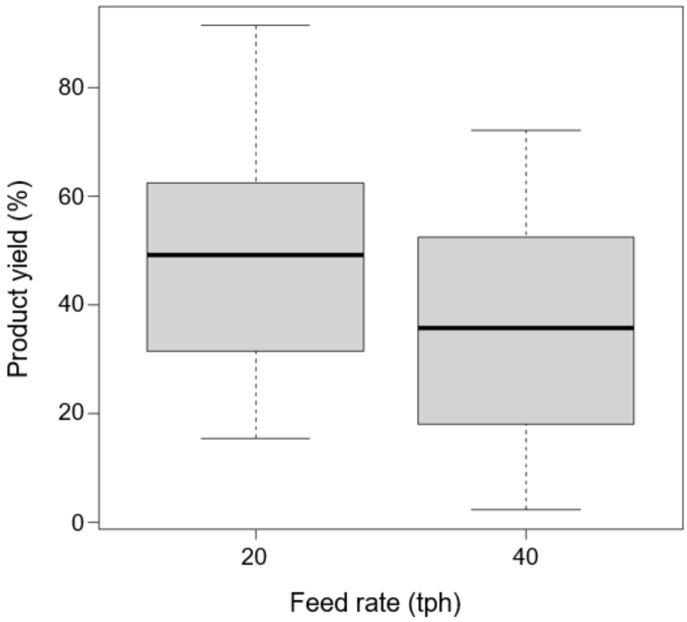

Figure 33: Effect of feed rate on product yield

The effect of feed rate on the performance of the SepAir in terms of the Epm values was as illustrated in Figure 34. A mean Epm value of about 0.08 was obtained at 40tph and a higher mean value of 0.15 for a feed rate of 20tph. The lower the Epm value, the more desirable the performance of the SepAir.

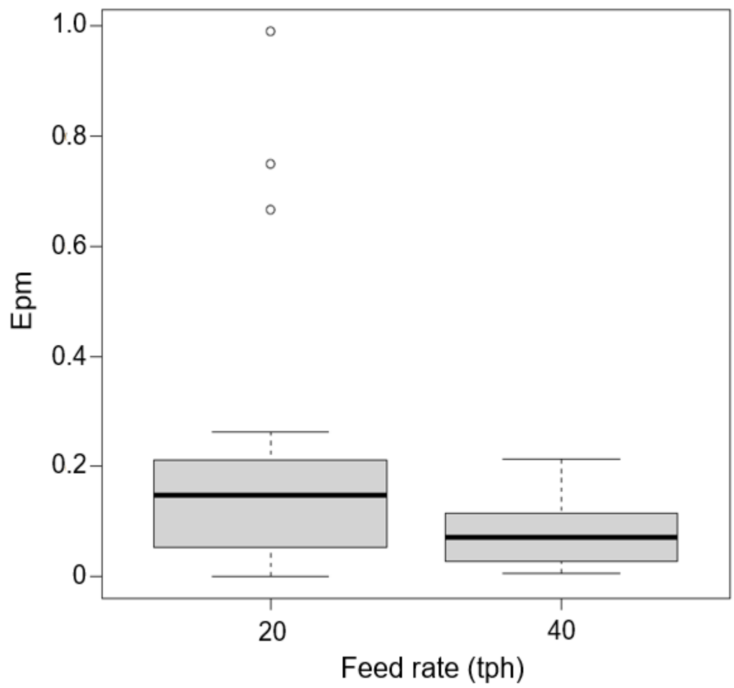

Figure 34: Effect of feed rate on Epm

The organic efficiency had a mean value of approximately 65% at 20tph and 45% at a feed rate of 40tph, as indicated in Figure 35. It is therefore clear that the lower feed rate is favoured with regard to organic efficiency.

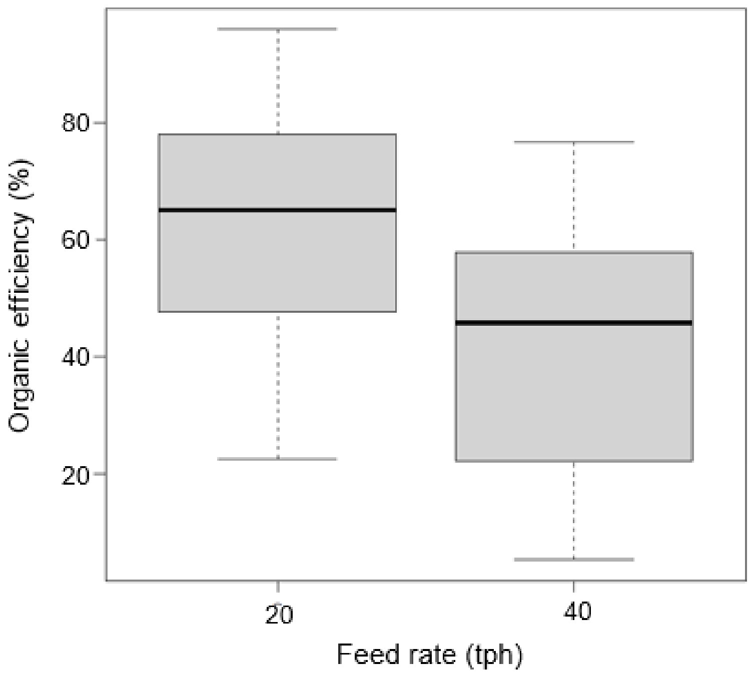

Figure 35: Effect of feed rate on organic efficiency

It is clear from all the graphs, the data available from the ANOVA, and Table 17 that a feed rate of 20tph is beneficial for the product yield and organic efficiency, while 40tph is better for obtaining lower Epm values.

5.1.3 The effect of mesh conveyor speed

Similar to the previous section, the mesh conveyor speed formed part of the objectives to determine the variables effecting the SepAir's performance. The mesh conveyor speed was tested to establish if the bed depth of the material has an influence on the performance of the SepAir. Tests were conducted with 30Hz and 60Hz mesh conveyor speeds, further details are available in Chapter 3.4. The same coal sources were tested as discussed in the previous section.

The feed quality upgrade comparisons for the different mesh conveyor speeds for each size fraction are as illustrated in Figure 36, Figure 37, and Figure 38. The graphs for the conveyor speed comparisons does not indicate a specific correlation between mesh conveyor speed and performance of the SepAir. The 60Hz mesh conveyor speed performed better for the 10x50mm and 25x50mm size fractions for Coal 1. For Coal 2; the 60Hz conveyor speed resulted in a greater upgrade for ash, CV, and sulphur for the 10x25mm and 10x50mm size fractions. The AI upgrades for all three size fractions for Coal 2 were better when running at 30Hz. It is thus unclear if mesh conveyor speed has a significant influence on upgrading the feed quality when treating coal with the SepAir technology.

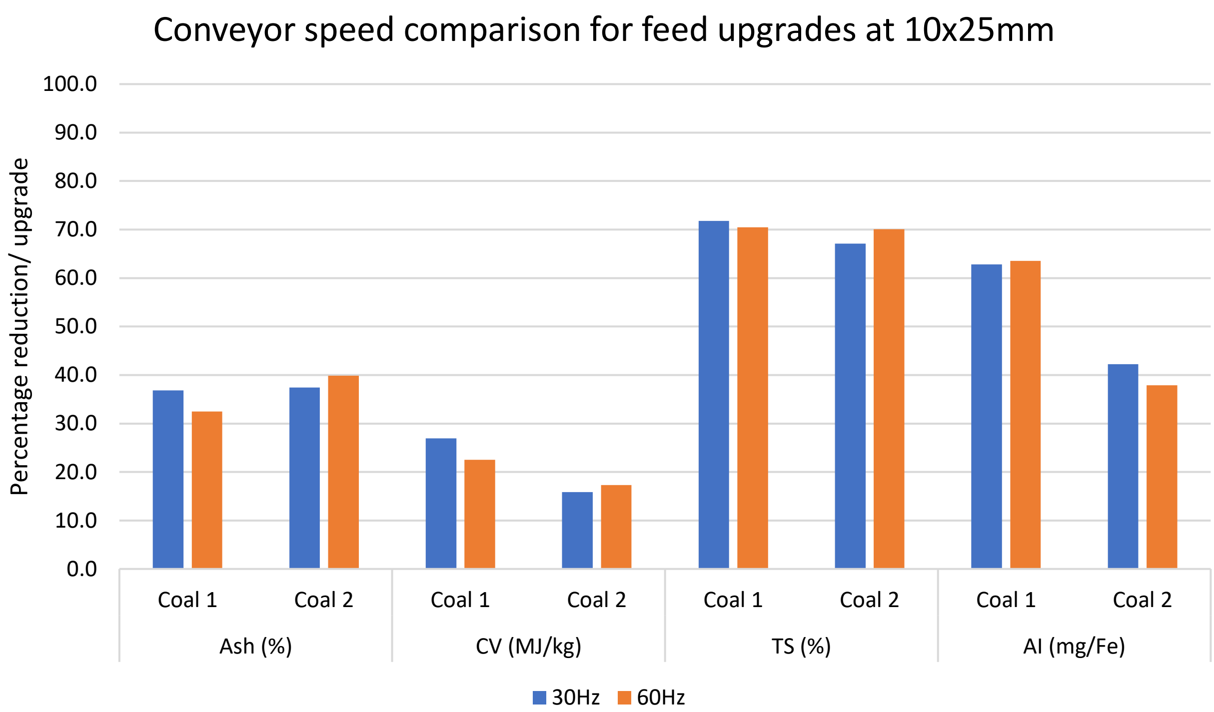

Figure 36: Conveyor speed comparison for 10x25mm

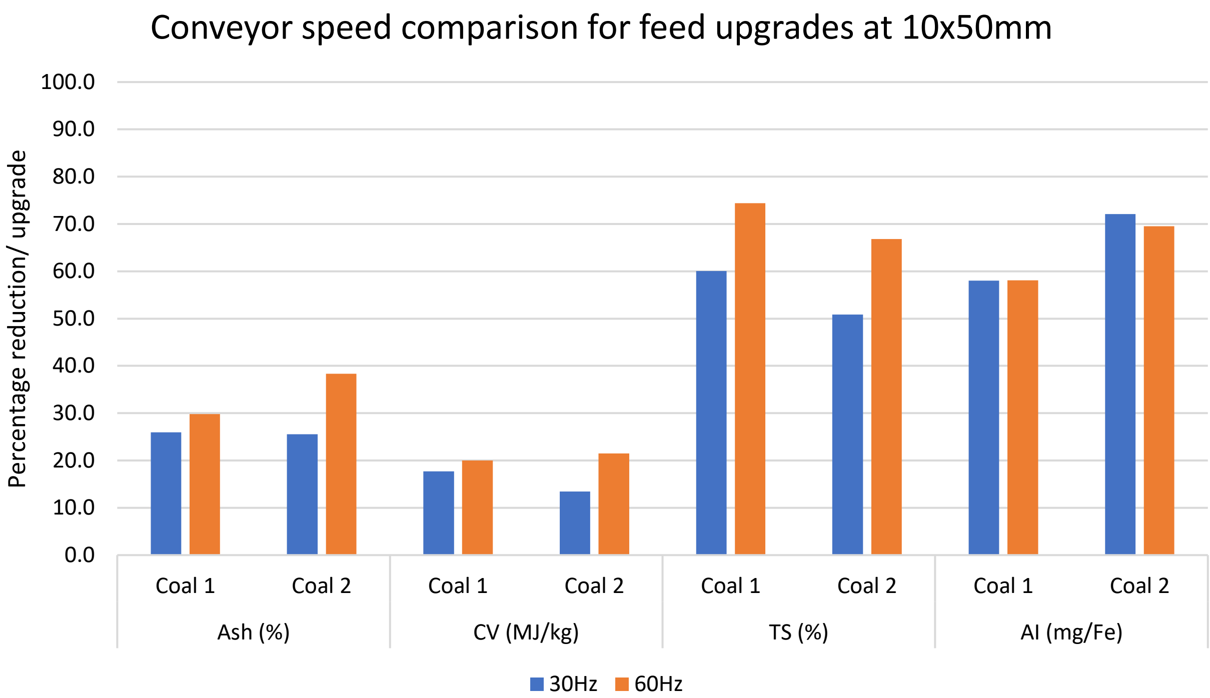

Figure 37: Conveyor speed comparison for 10x50mm

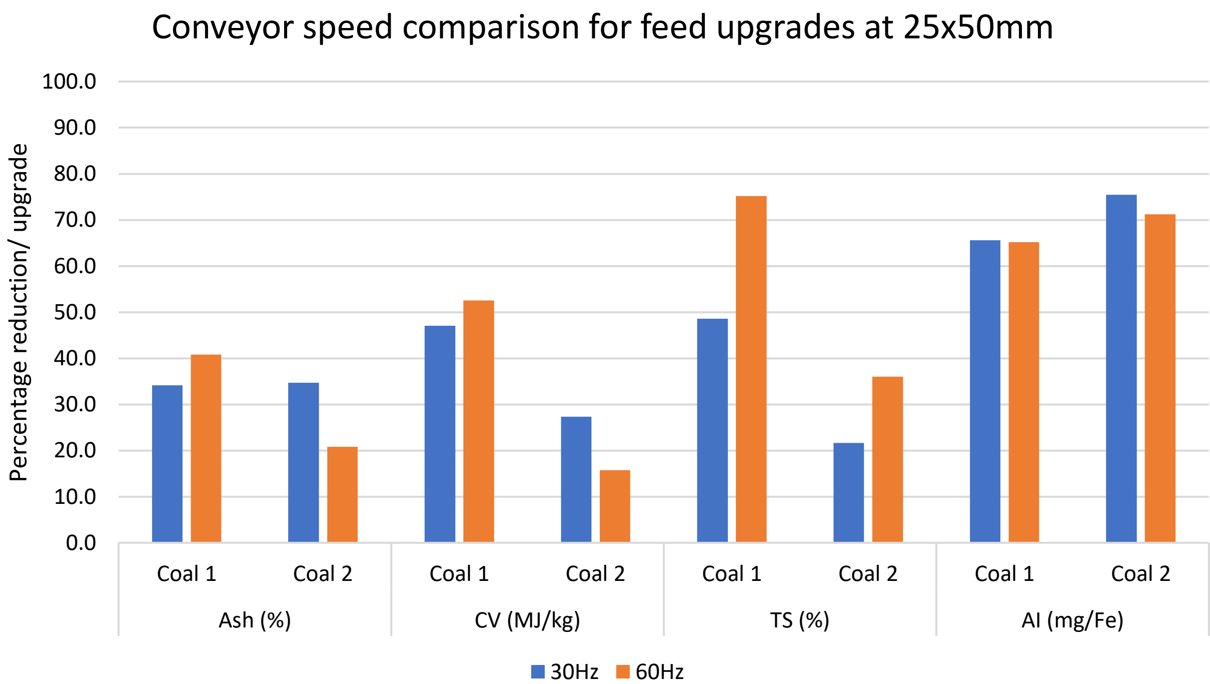

Figure 38: Conveyor speed comparison for 25x50mm

The results available in Table 18 do not indicate any major difference between the two mesh conveyor speeds. The ANOVA analysis (see Annexure E for raw data) done on Coal 1 and Coal 2 also indicated that the mesh conveyor speed does not have any significant effect on the dependent variables i.e., the SepAir's performance.

It was assumed that since a minimum top size is allowed underneath the suction valve, the different feed rates did not change the profile of the feed enough to influence the bed depth underneath the suction valve. More test work will be required to test the influence of the bed depth when the suction valve height is varied.

Table 18: Coal 1 and Coal 2 conveyor speed comparison

	10x25mm		10x50mm		25x50mm	
	30Hz	60Hz	30Hz	60Hz	30Hz	60Hz
Product yield (%)	29	28	50	52	27	30
D50 (Cut-point density (SG))	1.54	1.54	1.75	1.77	1.54	1.56
Epm	0.0764	0.0739	0.1706	0.1692	0.0837	0.0918
Organic Efficiency (%)	39	37	61	67	37	42
Sink in Float (%)	8.4	5.6	7.7	6.5	10.5	11.3
Float in Sink (%)	19.6	18.1	24.0	19.1	15.5	16.4
Total Misplaced (%)	28.0	23.7	31.8	25.7	25.9	27.6
Near Density (%)	26.0	24.0	17.3	13.5	21.5	19.8

5.1.4 The effect of fan speed

The effect of fan speed on the performance of the SepAir was discussed in Chapter 4.2, but an in-depth analysis was done to indicate the impact of the fan speed. The results are based on the spot test results and the efficiency tests for Coal 4. The feed quality upgrade results for the spot tests conducted with Coal 2 for the different size ranges are as illustrated in Figure 39, Figure 40, and Figure 41. The results for Coal 4 are depicted in Figure 42, Figure 43, and Figure 44. The results from the efficiency tests conducted on Coal 1, Coal 2, and Coal 3, could not be used for this section due to the fan speed that was used as a constant independent variable.

The results from the spot tests for Coal 2 indicated that when fan speed was increased, the percentage upgrade of the feed quality decreased, which is to be expected due to the cut-point density ($D50_{density}$) increasing as the fan speed goes up. A higher cut-point results in a lower feed upgrade. The feed quality upgrades for the 10x25mm particles size range for Coal 2, Figure 39, indicate that the product ash, TS, and AI increase as the fan speed goes up, resulting in a lower percentage reduction. The gradient of the graphs is therefore on a decline with the increasing fan speed. The CV trend line also shows a decline due to the CV upgrade decreasing with the increasing fan speed. The product CV results will therefore decrease with an increasing fan speed.

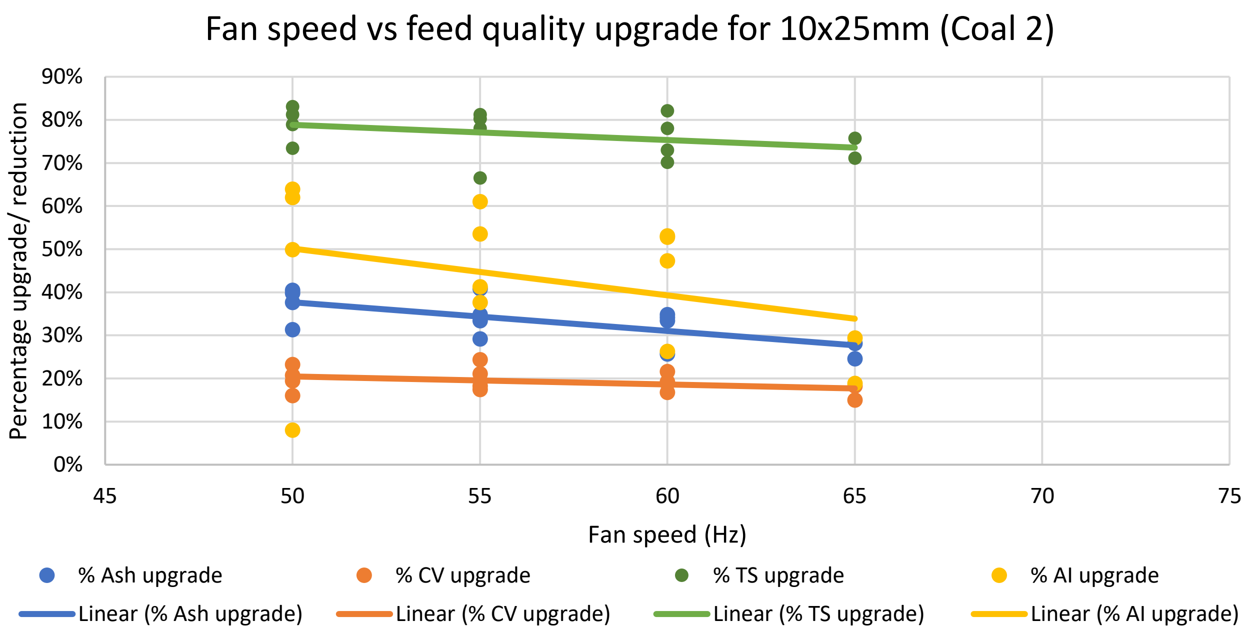

Figure 39: Fan speed vs feed quality upgrade for 10x25mm (Coal 2)

The ash, TS, and AI feed quality reduction and the CV upgrade for the 10x50mm and 25x50mm particle size fractions depicted in Figure 40 and Figure 41 also illustrate a decrease with an increase in the fan speed. The increase in fan speed consequently causes an increase in the cut-point density.

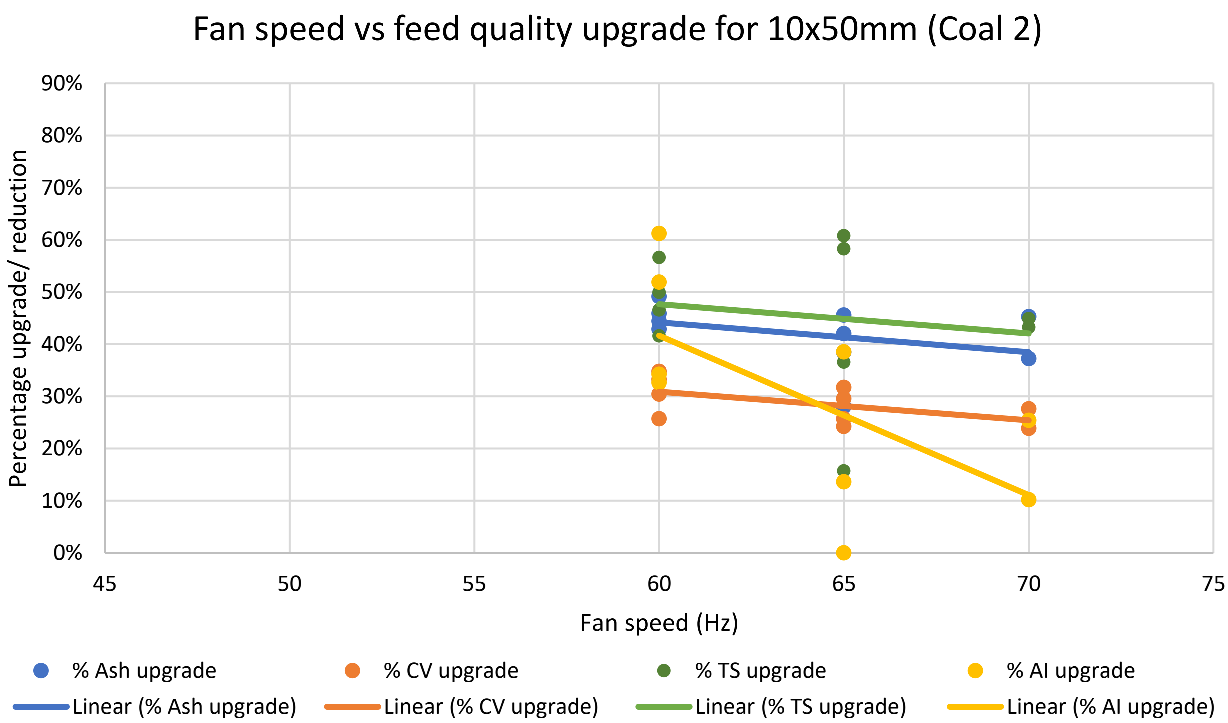

Figure 40: Fan speed vs feed quality upgrade for 10x50mm (Coal 2)

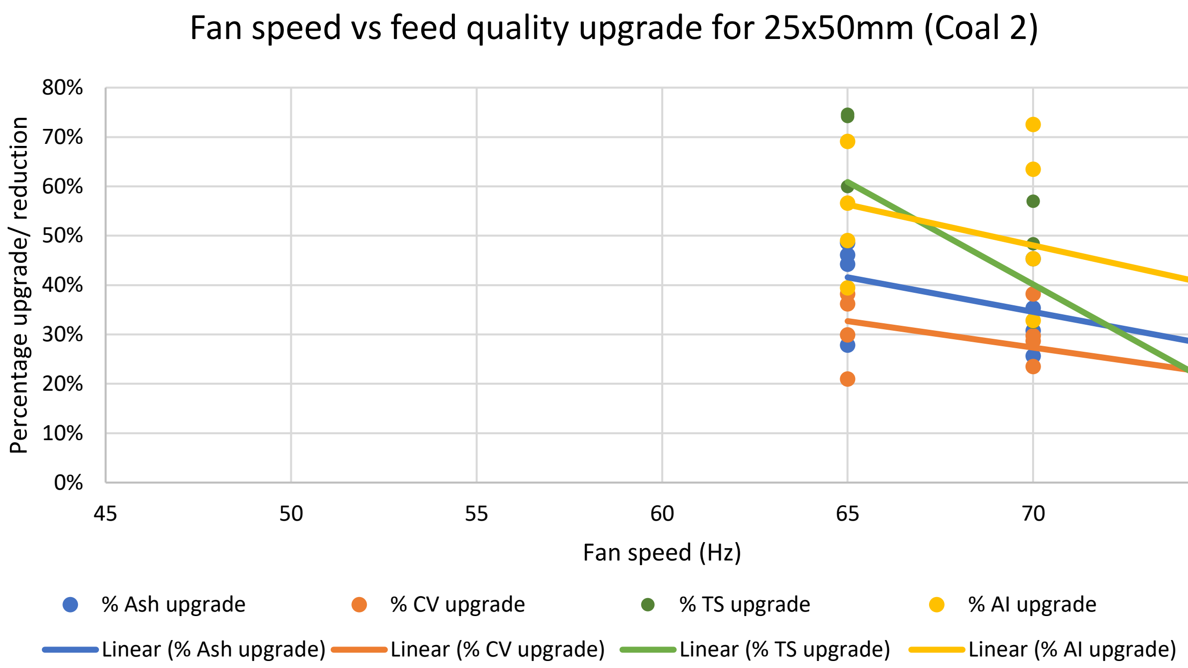

Figure 41: Fan speed vs feed quality upgrade for 25x50mm (Coal 2)

However, the results for Coal 4 indicated the opposite. The feed upgrade increased with an increased fan speed for the reduction of sulphur for the 10x25mm fraction (Figure 42), all the parameters for the 25x50mm fraction (Figure 43), and the ash reduction and CV upgrade for the 0x50mm (Figure 44) size fraction.

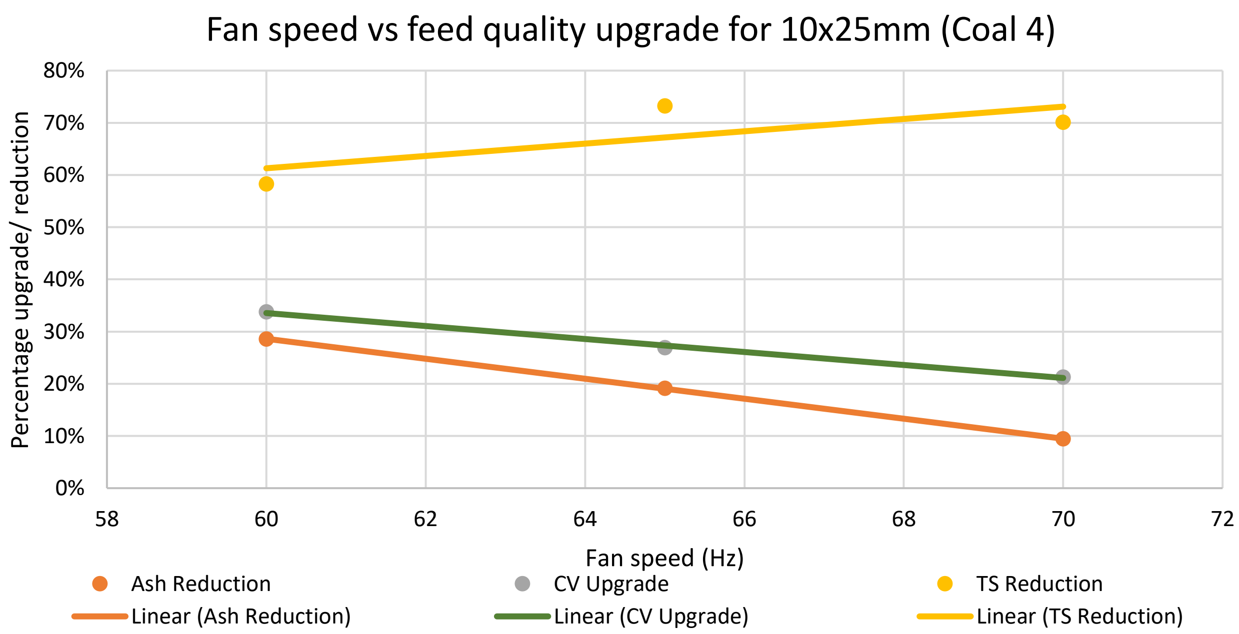

Figure 42: Fan speed vs feed quality upgrade for 10x25mm (Coal 4)

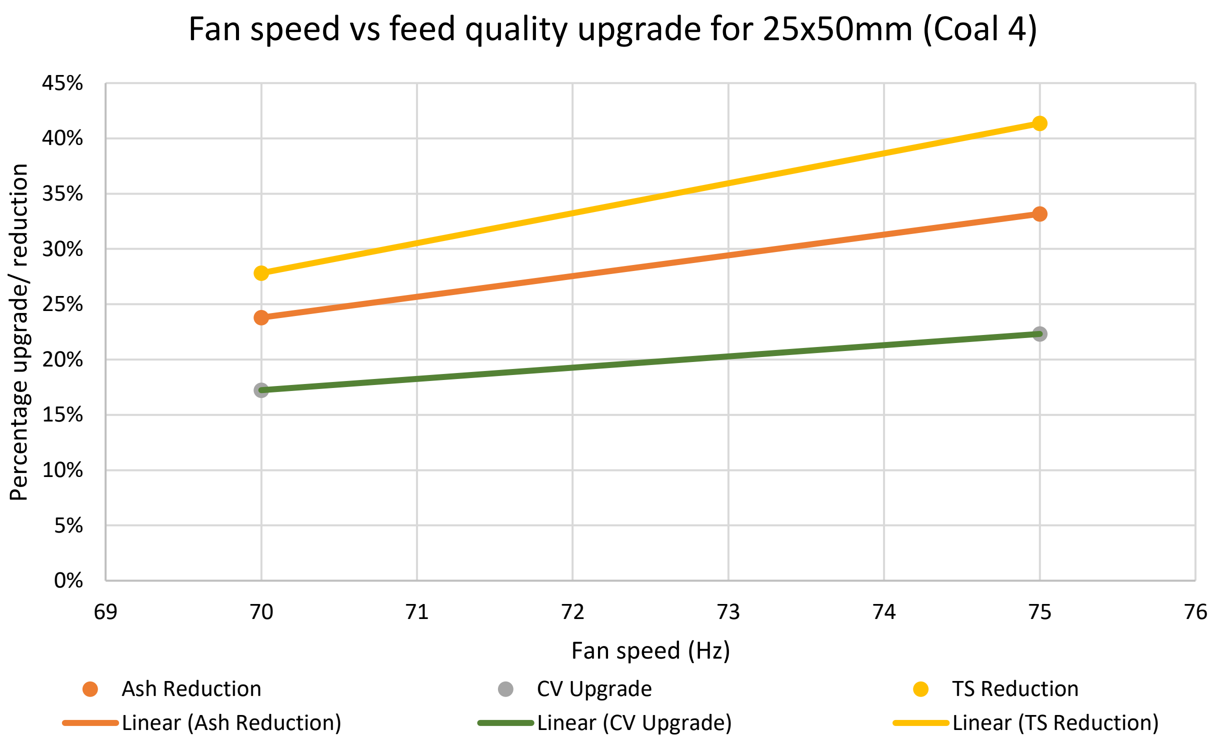

Figure 43: Fan speed vs feed quality upgrade for 25x50mm (Coal 4)

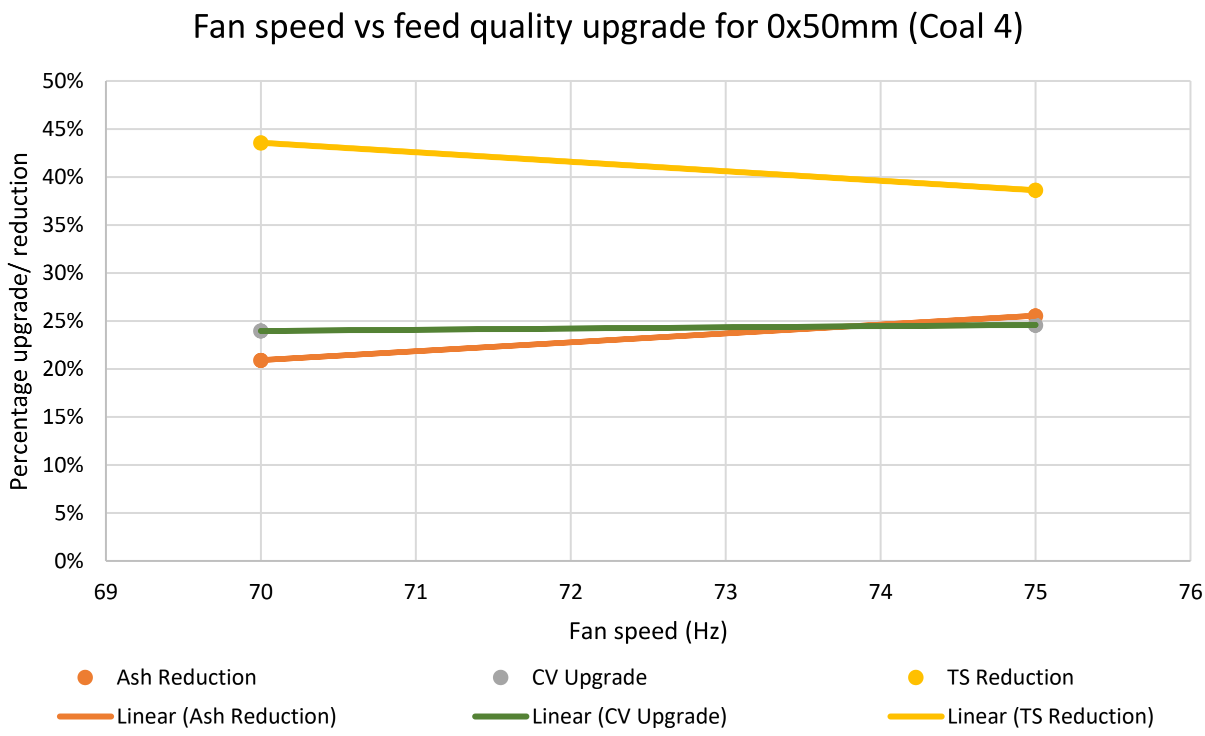

Figure 44: Fan speed vs feed quality upgrade for 0x50mm (Coal 4)

The results available in Table 19, however, indicate that the SepAir achieved higher cut-points at the increased fan speeds, but the upgrades for 25x50mm and 0x50mm were better at the higher cut-point densities. The discrepancies in the Coal 4 analysis can be due to the operational issues observed during the test work, such as the SepAir becoming blocked numerous times from the high clay content in the material.

Table 19: Coal 4 fan speed comparison

	10x25mm		25x50mm			0x50mm	
	T1	T2	T3	T4	T5	T6	T7
Fan speed	60	65	70	70	75	70	75
Product yield (%)	29.1	38.0	89.6	55.8	64.8	50.5	55.2
D50 (Cut-point density (SG))	1.43	1.44	2.20	1.74	1.79	1.71	1.80
Epm	0.0263	0.6665	0.2629	0.1865	0.9907	0.2397	0.2379
Organic Efficiency (%)	68.2	63.4	95.9	69.5	85.5	62.6	72.7
Sink in Float (%)	13.35	18.75	6.25	16.2	7.74	9.32	7.41
Float in Sink (%)	11.57	18.04	5.64	16.58	9.2	22.89	16.68
Total Misplaced (%)	24.92	36.79	11.89	32.78	16.94	32.21	24.09
Near Density (%)	29.7	30	8	13.44	12.18	11.08	6.96

An ANOVA, linear model, and Tukey Honest(ly) Significant Difference (HSD) analysis were done to determine the influence of the fan speed. The results indicated that the fan speed has a significant effect on the product yield, cut-point density ($D50_{density}$), organic efficiency, product ash, product CV, product sulphur, and product AI. The fan speed has no effect on the Epm, which is justifiable as the near-gravity material influences the Epm. The detailed results for the statistical analysis are available in Annexure E.

The graphs in Figure 45, Figure 46, and Figure 47 show that the product yield, cut-point, and organic efficiency change substantially when varying the fan speed. The Epm values in Figure 48, however, does not change significantly with the varying fan speed, which correlates with the statistical analysis conducted. A linear trendline cannot be drawn for these graphs as they include the data for all the test work as discussed. The feed rate and amount of near-density material varied for the different tests, and this will also influence the results.

The data presented in Figure 45 shows that product yield is generally higher at high fan speeds, ranging from 55Hz to 75Hz. The fan speeds were varied across the different size fractions for all the coal sources. A Tukey HSD statistical analysis was done to determine the significance of the different fan speeds. The results indicated that the effect of a fan speed of 50Hz and 55Hz has no significance, which can be seen in Figure 45, but between the fan speeds 50Hz and 70Hz the difference is significant. The results for the Tukey HSD analysis can be found in Annexure E.

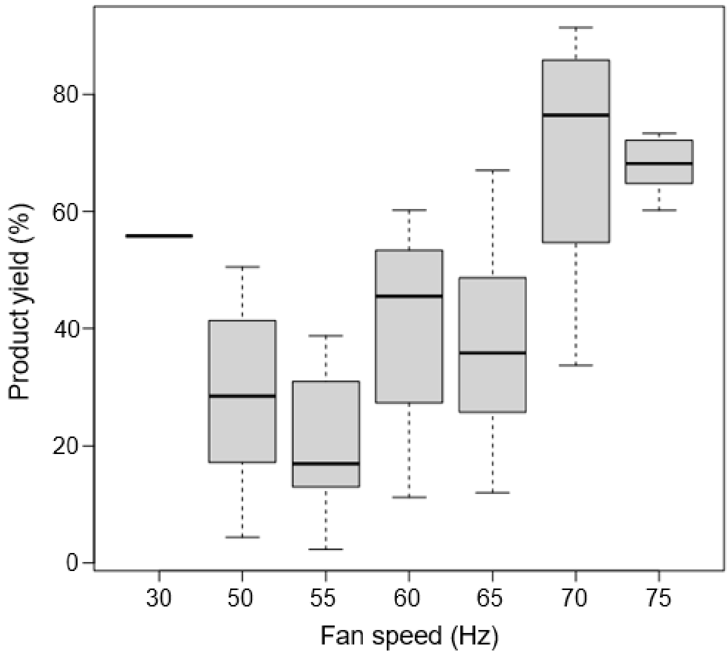

Figure 45: Effect of fan speed on product yield

The cut-point densities increased with an increasing fan speed as indicated in Figure 46. However, a linear trend cannot be deduced as discussed previously as the data points used for the box plots are from all the test work done. The Tukey HSD analysis, Annexure E, showed that the difference in the cut-point density between a fan speed of 50Hz and 70Hz is significant, which is clear from the box plots available in Figure 46.

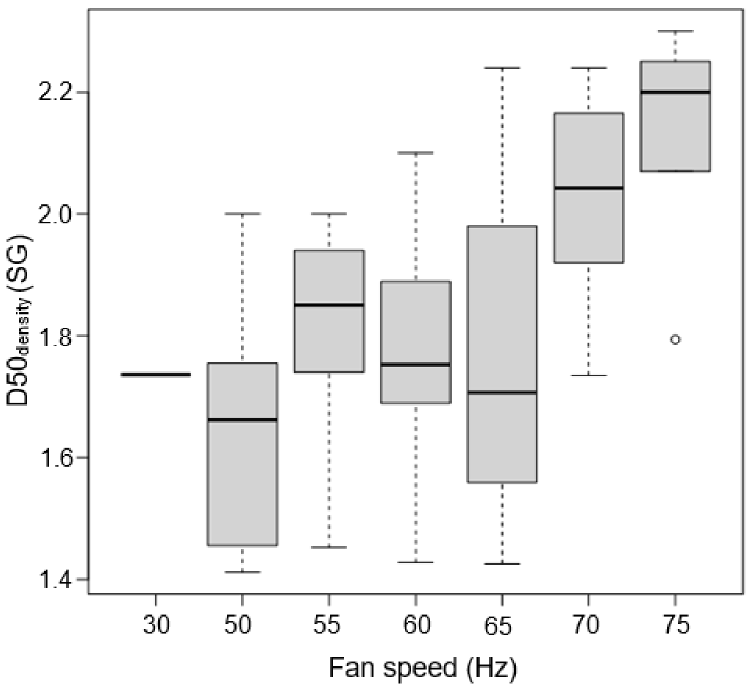

Figure 46: Effect of fan speed on cut-point

The effect the fan speed has on the organic efficiency is as illustrated in Figure 47. It cannot be concluded that the organic efficiency will increase as the fan speed increases, but the cut-point will increase proportionally to the fan speeds (Figure 46) which will reduce the amount of near-density material present, and therefore an increase in the organic efficiency is expected.

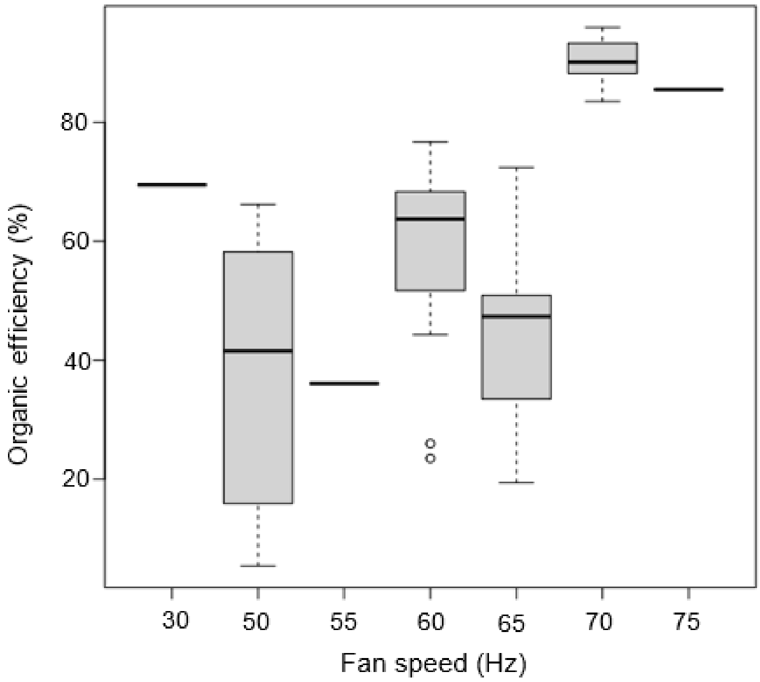

Figure 47: Effect of fan speed on organic efficiency

The results available in Figure 48 shows a minimal difference in Epm values between the different fan speeds. The Tukey HSD analysis indicated that the various fan speeds had no significant effect on the Epm values obtained.

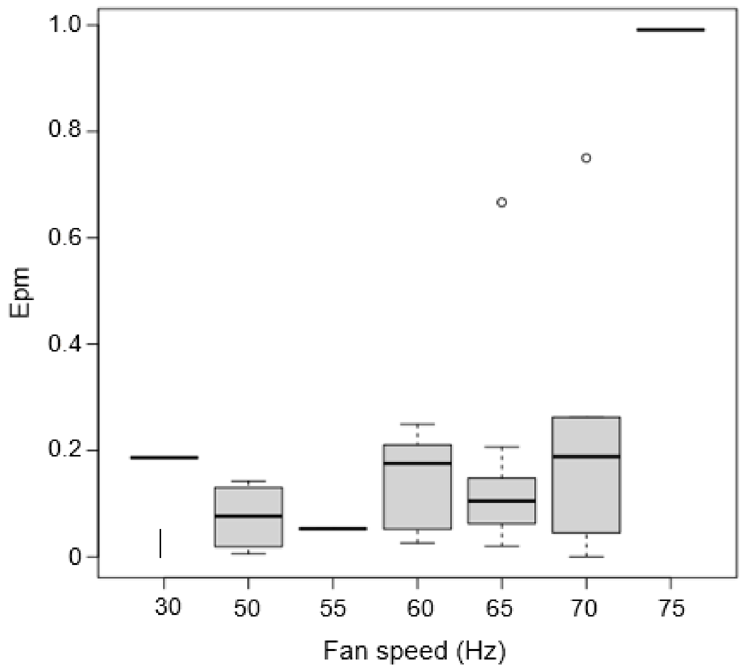

Figure 48: Effect of fan speed on Epm

5.1.5 The effect of near-density material

An ANOVA was conducted to determine the effect near-density material has on the performance parameters of the SepAir. The results showed that the amount of near-density material has a significant effect on the product yield, cut-point density ($D50_{density}$), Epm, and organic efficiency. The raw daw data are available in Annexure E.

CHAPTER 6 ADDITIONAL TESTING

6.1 Phase 3 results: Double stage beneficiation

The results from the efficiency tests as discussed in Chapter 5 indicated that there was generally more misplacement of coal to the discard (sinks) than in the product (floats) as illustrated in Figure 49. The high misplacement to the discard material made it possible to test if the SepAir has the ability to beneficiate the coal in two stages, namely primary and secondary stage. If the SepAir can perform double stage processing it can either be used to produce and sell two different product qualities and/or the overall yield can be increased. The coal used for the double stage beneficiation test was Coal 3.

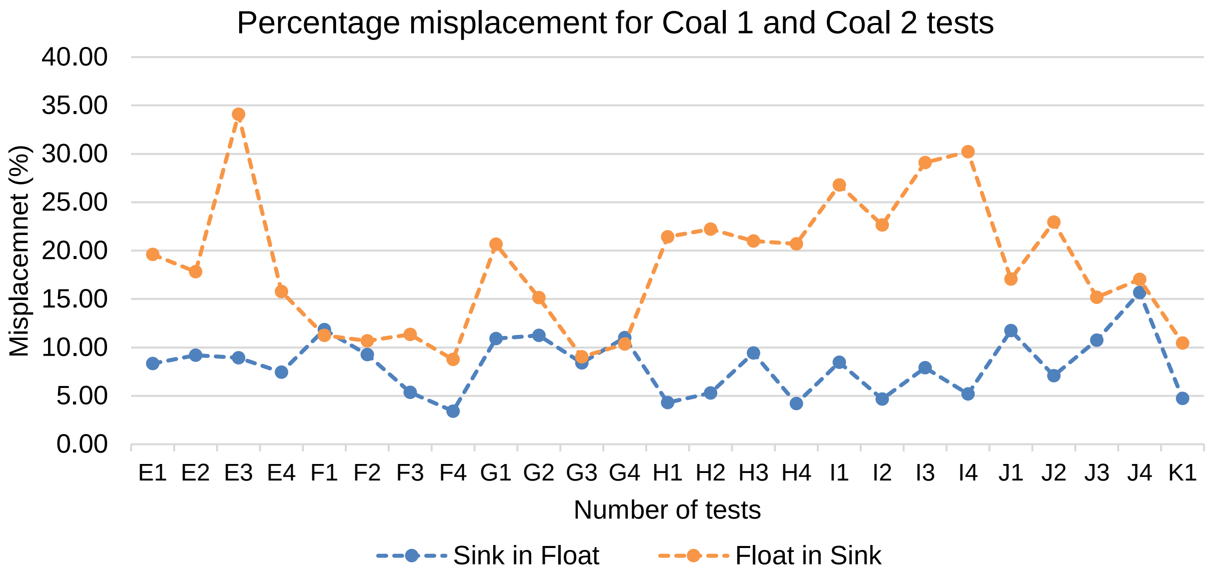

Figure 49: Amount of misplacement from efficiency test results

The results for the double stage beneficiation are available in Table 20. The average primary ash results across the size fractions were 23%, with an average CV of 24MJ/kg. The average ash and CV results for the secondary stage were 30% and 22MJ/kg respectively. The average yield for the primary stage was 35% and for the secondary stage 80%. The overall yields across the different size fractions were 86%. The primary product can be exported as RB3 and the secondary product as RB4. RB specifications are available in Table 2. The two products can also be sold to the domestic market as both products meet the required specifications.

The efficiency of the plant showed that the SepAir performed as expected with respect to the cut-point densities ($D50_{density}$). They were lower for the primary stage than the secondary stage and higher amounts of near-density material were therefore present at the primary stages.

The Epm values ranged from 0.0316 to 0.2134, which is relatively good as dry beneficiation processes generally have Epm values of 0.12-0.27 as specified in Table 4. The organic efficiencies were higher for the secondary stage as the cut-points were slightly higher with less near-density material present.

Table 20: Double stage beneficiation results

Coal 3	10x25mm		10x50mm		25x50mm	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Fan Speed (Hz)	55	70	60	70	60	65
CVR Speed (Hz)	30	30	30	30	30	30
Feed rate (tph)	20	20	20	20	20	20
Feed % Ash	29.4	32	28.1	34.3	27.6	28.9
Product % Ash	23.6	29.7	22.8	33.1	22.5	25.9
Discard % Ash	32	43.7	34.3	43.2	28.9	35
Ash Reduction (%)	20	7	19	3	18	10
Feed CV (MJ/kg)	21.8	20.9	22.5	20.6	22.9	22.4
Product CV (MJ/kg)	24.4	22.2	23	21.7	24.3	23.3
Discard CV (MJ/kg)	20.9	17.6	20.6	16.9	22.4	19.1
CV Upgrade (%)	12	6	2	5	6	4
Product Yield (%)	31	83.6	53.9	88.1	20.3	67
Overall Yield (%)	88.7		94.5		73.7	
D50 (Cut-point density (SG))	1.45	2.15	1.7	2.18	1.44	1.86
Epm	0.0529	0.0449	0.2134	0.1473	0.0316	0.2066
Organic Efficiency (%)	36.1	89	62.4	91.2	23.5	72.4
Sink in Float (%)	21.92	0.38	9.52	0.76	13.64	5.51
Float in Sink (%)	12.13	15.48	27.59	11.09	8.3	25.41
Total Misplaced (%)	34.06	15.86	37.11	11.85	21.94	30.93
Near Density (%)	36.41	5.1	27.04	6.8	28.32	17.37

6.2 Phase 4 results: Maximum organic efficiency

The first three phases focused on testing the SepAir's ability to upgrade the feed qualities to a maximum, i.e., low cut-points. This resulted in the plant producing low organic efficiencies, which indicated that the SepAir was not as efficient as initially anticipated. However, when operating the plant in such a way that the organic efficiency is maximised, the objectives of the tests were to determine the feed quality upgrade, cut-point densities, and the efficiency of the SepAir in terms of the Epm values.

Efficiency tests were first done on the feed for Coal 3 for a maximum upgrade of the feed quality, after which the same feed was fed to the SepAir, but at a higher fan speed, to achieve a higher cut-point. This was done for the 10x25mm, 10x50mm, and 25x50mm size fractions. At the higher cut-points the amount of near-density material was lower when compared with the lower cut-points, which subsequently increased the organic efficiency of the SepAir as the material was easier to beneficiate as a result of the lower amount of near-density material present.

The cut-points for the maximum upgrade varied from 1.44 to 1.70 with organic efficiencies of 23.5% to 62.4% and the amount of near-density material of 27.04% to 36.41%. The cut-point results for the maximum organic efficiencies tests ranged from 1.79 to 2.04, with organic efficiency results of 83.5% to 93.3% and the amount of near-density material of 3.41% to 14.94%.

The results available in Table 4 for the All-air jig and FGX technologies indicate that the All-air jig can achieve cut-points of 1.95 to 2.20 and the FGX 1.90 to 2.03. The results from Table 21 show that the SepAir can efficiently separate the material at cut-points of 1.79 to 2.04, which is competitive with the All-air jig and FGX technologies.

Table 21: Maximum upgrade vs maximum organic efficiency for Coal 3

Coal 3	10x25mm		10x50mm		25x50mm	
	Max Upgrade	Max Organic Efficiency	Max Upgrade	Max Organic Efficiency	Max Upgrade	Max Organic Efficiency
Fan Speed (Hz)	55	70	60	70	60	70
CVR Speed (Hz)	30	30	30	30	30	30
Feed rate (tph)	20	20	20	20	20	20
Feed % Ash	29.4	29.4	28.1	28.1	27.6	27.6
Product % Ash	23.6	26.3	22.8	25.9	22.5	26.4
Discard % Ash	32	42.6	34.3	36.7	28.9	40.3
Ash Reduction (%)	19.73	10.54	18.86	7.83	18.48	4.35
Feed CV (MJ/kg)	21.8	21.8	22.5	22.5	22.9	22.9
Product CV (MJ/kg)	24.4	22.6	23	23.2	24.3	23.5
Discard CV (MJ/kg)	20.9	18	20.6	20.7	22.4	18
CV Upgrade (%)	11.93	3.67	2.22	3.11	6.11	2.62
Product Yield (%)	31	81	53.9	79.6	20.3	91.4
D50 (Cut-point density (SG))	1.45	1.79	1.70	2.01	1.44	2.04
Epm	0.0529	0.0004	0.2134	0.2301	0.0316	0.7497
Organic Efficiency (%)	**36.1**	**88.2**	**62.4**	**83.5**	**23.5**	**93.3**
Sink in Float (%)	21.92	11.85	9.52	3.03	13.64	11.2
Float in Sink (%)	12.13	9.57	27.59	17.76	8.3	21.95
Total Misplaced (%)	34.06	21.42	37.11	20.78	21.94	33.15
Near Density (%)	36.41	14.94	27.04	4.83	28.32	3.41

CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusions

The results indicate that the SepAir can process South African coal and therefore by implication Southern hemisphere coal. The SepAir was tested with one and two seam open cast coal, two seam underground coal, and five seam open cast coal. The size ratios treated can be either 1:2 or 1:5, with both fractions resulting in high ash reductions and calorific value (CV) upgrades, as well as significant reductions in sulphur and abrasive index.

The SepAir is able to produce products for different quality specifications. The fan speed determines the cut-point density at which the SepAir will separate the feed material and consequently the quality of the product produced. The fan speed was found to be the independent variable that has the biggest influence on the performance of the SepAir. It affects the product yield, cut-point density, and organic efficiency. The fan speed does, however, not affect the Epm.

The efficiency of the SepAir with respect to the Epm and organic efficiency, is largely dependent on the amount of near-density material treated when treating coal for a low ash specification. For lower cut-point densities, higher amounts of near-density material were observed which in effect caused the organic efficiency to be lower than desired.

Although the pilot plant is a 40tph plant, it performed better when reducing the feed rate to 20tph when treating large amounts of near-density material. The feed rate influenced the product yield, Epm, and organic efficiency of the material treated. However, the mesh conveyor speed did not have any significant impact on the performance of the SepAir.

A high amount of misplacement was observed for all the test work conducted, especially with more clean coal reporting to the discard stream, which led to test work for double stage beneficiation. It was found that the SepAir can be used for double stage beneficiation when processing high amounts of near-density material to produce products that can be compliant with both the export and domestic markets. The yields increased from 31% to 89% for the 10x25mm size fraction, 54% to 95% for the 10x50mm particle size ratio, and from 20% to 74% for the 0x50mm fraction.

The SepAir was tested with two seam underground coal to determine if the plant will be able to upgrade the feed quality while obtaining a maximum organic efficiency. The fan speeds were increased across the various size fractions, which decreased the amount of near-density material present.

From what was seen from the results, the near-density material is indirectly proportional to the organic efficiency. The organic efficiency therefore increased with the increase in cut-point densities.

7.2 Recommendations

It is recommended to do further test work at high cut-point densities (1.9 to 2.0) to determine the effectiveness of the SepAir to destone the feed material. If the results are beneficial, the SepAir is a low-cost technology to use as the primary unit for destoning the run-of-mine (ROM) material to obtain a specific market specification. It can also be used upstream from the main coal handling processing plant to ensure most of the stones are removed before the feed qualities are upgraded for a specific market grade.

Another recommendation is to conduct tests using the SepAir technology on a smaller lab scale unit. The results of the lab scale unit can then be compared to existing data obtained from the pilot scale unit. A lab scale test unit can be used to conduct test work at a significant lower price. A lower operating cost thus also means more funds will be available for more tests to be conducted.

A third recommendation is to utilize the SepAir pilot plant in a more real-world environment, meaning running the plant for more than a few minutes at a time but rather for a complete shift of 12 hours. This will create an opportunity to see what the SepAir is capable of in terms of operability, durability, and workload.

During this 12-hour shift, several smaller operational changes can be made to test the response of the SepAir. These changes can include

- Introducing different ROM feeds and trying to obtain one product specification. This in effect will test the SepAir's ability to rapidly change the cut-point densities to obtain the specific product specification.
- The SepAir's ability to run when it is raining and beneficiate a feed of a total moisture for above desired moisture levels.

Another aspect of this recommendation is the impact of environmental factors such as dust generation at mining sites and personnel health considerations.

CHAPTER 8 REFERENCES

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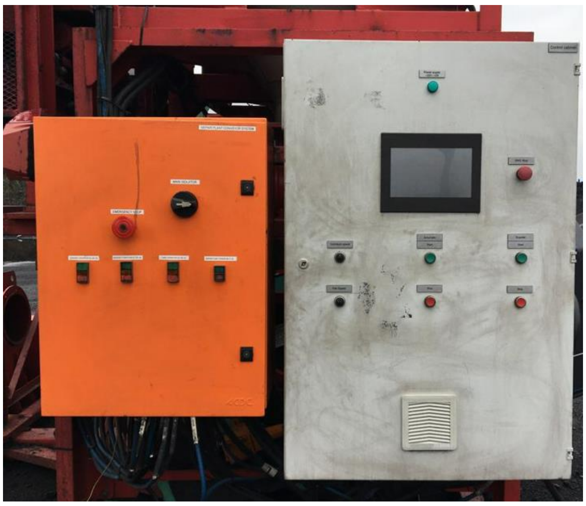
ANNEXURE A

SepAir unit



Uptake nozzle

Feeder

Separation of feed material

SepAir in operation during Coal 2 test work

ANNEXURE B

Coal 2 spot tests results

Test #	Coal Size	Tph	Fan (Hz)	CVR (Hz)	Product Yield (%)	D50	Feed Ash	Product Ash	Discard Ash	Feed CV	Product CV	Discard CV	Feed TS	Product TS	Discard TS	Feed AI	Product AI	% Ash upgrade	% CV upgrade	% TS upgrade	% AI upgrade
A1	10x50	20	60	30	47.2	1.82	33.6	18.2	47.4	19.09	24.00	13.70	1.20	0.60	3.08	374	252	46%	26%	50%	33%
A2	10x50	20	65	30	54.7	2.24	33.6	24.2	45.0	19.09	23.99	14.93	1.20	0.76	3.67	374	374	28%	26%	37%	0%
A4	10x50	20	60	60	32.0	1.93	33.6	19.2	40.4	19.09	25.73	16.50	1.20	0.52	1.57	374	246	43%	35%	57%	34%
A5	10x50	20	65	60	35.8	1.95	33.6	19.5	41.5	19.09	25.14	15.58	1.20	0.50	2.28	374	230	42%	32%	58%	39%
A7	10x50	40	60	60	11.2	1.88	33.6	18.7	35.5	19.09	24.90	18.33	1.20	0.70	2.05	374	180	44%	30%	42%	52%
A8	10x50	40	65	60	36.4	2.01	33.6	20.7	41.0	19.09	23.72	16.02	1.20	1.01	3.04	374	323	38%	24%	16%	14%
A9	10x50	40	70	60	52.4	1.84	33.6	18.4	50.4	19.09	24.36	11.96	1.20	0.66	3.19	374	279	45%	28%	45%	25%
A10	10x50	40	60	30	25.6	1.75	33.6	17.1	39.3	19.09	25.44	17.43	1.20	0.64	1.72	374	145	49%	33%	47%	61%
A11	10x50	40	65	30	24.9	1.82	33.6	18.3	38.7	19.09	24.73	16.36	1.20	0.47	1.93	374	396	46%	30%	61%	-6%
A12	10x50	40	70	30	57.0	2.05	33.6	21.1	50.2	19.09	23.65	13.14	1.20	0.68	1.60	374	336	37%	24%	43%	10%
Ave					37.7	1.93	33.6	19.5	42.9	19.09	24.57	15.40	1.20	0.65	2.41	374	276	42%	29%	45%	26%
B1	10x25	20	50	30	28.5	2.00	28.4	19.5	31.9	20.64	23.95	19.10	2.18	0.58	2.93	415	208	31%	16%	73%	50%
B2	10x25	20	55	30	38.8	1.74	28.4	16.8	35.7	20.64	25.66	19.07	2.18	0.41	3.11	415	259	41%	24%	81%	38%
B3	10x25	20	60	30	48.8	1.90	28.4	18.7	37.6	20.64	24.60	16.61	2.18	0.59	2.97	415	195	34%	19%	73%	53%
B4	10x25	20	50	60	18.9	1.77	28.4	17.1	31.0	20.64	24.91	20.26	2.18	0.37	1.72	415	150	40%	21%	83%	64%
B5	10x25	20	55	60	16.9	1.94	28.4	18.9	30.3	20.64	24.24	20.10	2.18	0.43	2.34	415	162	33%	17%	80%	61%
B6	10x25	20	60	60	-4.1	1.94	28.4	18.9	28.0	20.64	25.09	20.10	2.18	0.39	1.50	415	196	33%	22%	82%	53%
B7	10x25	40	50	30	40.7	1.80	28.4	17.7	35.7	20.64	25.43	18.43	2.18	0.46	2.30	415	382	38%	23%	79%	8%
B8	10x25	40	55	30	2.3	1.85	28.4	18.5	28.6	20.64	24.41	21.45	2.18	0.73	1.70	415	193	35%	18%	66%	53%
B9	10x25	40	60	30	35.7	2.10	28.4	21.1	32.4	20.64	24.10	19.08	2.18	0.65	3.20	415	306	26%	17%	70%	26%
B10	10x25	40	50	60	-49.0	1.74	28.4	16.9	24.6	20.64	24.65	23.00	2.18	0.41	1.13	415	158	40%	19%	81%	62%
B11	10x25	40	55	60	13.0	2.00	28.4	20.1	29.6	20.64	24.98	20.76	2.18	0.48	1.31	415	244	29%	21%	78%	41%
B12	10x25	40	60	60	21.7	1.85	28.4	18.5	31.1	20.64	24.53	20.49	2.18	0.48	2.61	415	219	35%	19%	78%	47%
B13	10x25	20	65	30	65.2	2.15	28.4	21.4	41.4	20.64	23.73	16.28	2.18	0.53	3.69	415	337	25%	15%	76%	19%
B14	10x25	20	65	60	53.1	2.05	28.4	20.4	37.4	20.64	24.40	16.95	2.18	0.63	4.45	415	293	28%	18%	71%	29%
Ave					23.6	1.92	28.4	18.9	32.5	20.64	24.62	19.41	2.18	0.51	2.50	415	236	33%	19%	77%	43%
C1	25x50	20	65	30	53.2	1.73	37.1	20.0	56.6	17.63	22.90	10.20	2.33	0.59	3.00	408	208	46%	30%	75%	49%
C2	25x50	20	70	30	73.3	2.24	37.1	27.6	63.3	17.63	21.77	8.01	2.33	2.46	2.56	408	223	26%	24%	-6%	45%
C3	25x50	20	75	30	73.3	2.25	37.1	27.8	62.8	17.63	19.33	5.75	2.33	2.04	4.12	408	218	25%	10%	12%	47%
C4	25x50	20	65	60	25.6	2.20	37.1	26.8	40.7	17.63	21.33	16.12	2.33	1.19	1.41	408	126	28%	21%	49%	69%
C5	25x50	20	70	60	51.1	2.00	37.1	24.0	50.9	17.63	22.87	14.60	2.33	1.00	1.53	408	112	35%	30%	57%	73%
C6	25x50	20	75	60	60.2	2.07	37.1	24.6	56.1	17.63	22.84	10.17	2.33	1.43	2.79	408	296	34%	30%	39%	27%
C7	25x50	40	65	30	44.3	1.75	37.1	20.7	50.2	17.63	24.01	12.69	2.33	0.93	2.32	408	247	44%	36%	60%	39%
C8	25x50	40	70	30	61.9	2.14	37.1	25.7	55.7	17.63	22.69	10.20	2.33	1.20	2.52	408	149	31%	29%	48%	63%
C9	25x50	40	75	30	68.2	2.20	37.1	26.8	59.3	17.63	22.35	9.81	2.33	1.90	2.75	408	272	28%	27%	18%	33%
C10	25x50	40	65	60	18.0	1.69	37.1	19.1	41.1	17.63	24.36	16.12	2.33	0.60	2.76	408	177	49%	38%	74%	57%
C11	25x50	40	70	60	33.7	1.74	37.1	20.3	45.7	17.63	24.37	14.76	2.33	1.57	3.91	408	274	45%	38%	33%	33%
C12	25x50	40	75	60	72.1	2.30	37.1	28.2	60.3	17.63	20.53	8.84	2.33	1.80	2.14	408	242	24%	16%	23%	41%
Ave					50.8	2.02	35.9	23.6	50.9	18.06	22.74	12.40	2.30	1.28	2.77	409	219	34%	26%	45%	46%
D1	0x50	20	70	30	65.1	2.00	31.4	25.5	42.4	20.68	22.09	15.20	1.30	0.97	1.69	579	220	19%	7%	25%	62%

ANNEXURE C

Coal 1 and Coal 2 efficiency tests results

Coal 1 10x50mm

Efficiency Analysis : **TEST E 1 17/02/2022**

Feed % Ash : 36.3
Product % Ash : 27.1
Discard % Ash : 48.9
Product Yield : **57.8**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	14.48	6.29	8.37	2.65	11.02	1.40	100.0	14.0	11.9	13.5	14.0	11.9	13.5	8.4	2.7	11.0
F @ 1.50	25.83	6.39	14.93	2.70	17.63	1.45	84.7	14.4	15.3	14.6	14.3	13.6	14.1	23.3	5.4	28.7
F @ 1.60	22.77	7.52	13.16	3.18	16.34	1.55	80.6	18.3	22.8	19.2	15.7	17.0	16.0	36.5	8.5	45.0
F @ 1.70	12.30	10.86	7.11	4.58	11.70	1.65	60.8	29.5	27.1	28.5	18.0	20.5	18.6	43.6	13.1	56.7
F @ 1.80	6.76	10.84	3.91	4.57	8.48	1.75	46.1	38.8	28.7	33.3	19.7	22.6	20.5	47.5	17.7	65.2
F @ 1.90	4.79	6.00	2.77	2.53	5.30	1.85	52.2	46.3	44.0	45.2	21.2	25.3	22.3	50.3	20.2	70.5
F @ 2.00	3.50	3.56	2.02	1.50	3.52	1.95	57.4	52.8	49.7	51.5	22.4	27.0	23.7	52.3	21.7	74.0
F @ 2.10	2.99	2.86	1.73	1.20	2.93	2.05	58.9	62.0	57.8	60.3	23.6	28.6	25.1	54.0	22.9	76.9
F @ 2.20	3.40	4.79	1.96	2.02	3.99	2.15	49.3	72.7	63.3	67.9	25.4	31.4	27.2	56.0	24.9	80.9
S @ 2.20	3.16	40.89	1.83	17.26	19.08	2.20	9.6	78.8	74.0	74.5	27.1	48.9	36.3	57.8	42.2	100.0
Whole Coal	100.00	100.00	57.80	42.20	100.00											

Efficiency Analysis : **TEST E 2 17/02/2022**

Feed % Ash : 36.3
Product % Ash : 24.9
Discard % Ash : 45.8
Product Yield : **45.5**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	23.01	6.51	10.46	3.55	14.01	1.40	100.0	10.4	10.1	10.3	10.4	10.1	10.3	10.5	3.6	14.0
F @ 1.50	24.34	9.94	11.06	5.42	16.48	1.45	67.1	16.5	16.2	16.4	13.5	13.8	13.6	21.5	9.0	30.5
F @ 1.60	22.53	6.81	10.24	3.72	13.96	1.55	73.4	21.7	20.3	21.3	16.1	15.7	16.0	31.8	12.7	44.4
F @ 1.70	11.57	12.30	5.26	6.71	11.96	1.65	43.9	31.8	20.5	25.5	18.4	17.4	18.0	37.0	19.4	56.4
F @ 1.80	7.23	13.63	3.29	7.43	10.72	1.75	30.7	41.5	33.7	36.0	20.2	21.9	20.9	40.3	26.8	67.1
F @ 1.90	4.10	4.64	1.86	2.53	4.40	1.85	42.4	46.5	39.3	42.3	21.4	23.4	22.2	42.2	29.4	71.5
F @ 2.00	1.93	1.90	0.88	1.04	1.91	1.95	45.8	59.8	54.1	56.7	22.2	24.4	23.1	43.0	30.4	73.4
F @ 2.10	1.57	2.09	0.71	1.14	1.85	2.05	38.4	65.3	55.2	59.1	22.9	25.5	24.0	43.8	31.5	75.3
F @ 2.20	2.41	5.82	1.10	3.18	4.27	2.15	25.6	76.2	70.1	71.7	24.2	29.6	26.6	44.9	34.7	79.6
S @ 2.20	1.33	36.35	0.60	19.83	20.43	2.20	2.9	80.9	74.2	74.4	24.9	45.8	36.3	45.5	54.5	100.0
Whole Coal	100.00	100.00	45.45	54.55	100.00											

Efficiency Analysis : **TEST E 3 17/02/2022**

Feed % Ash : 36.3
Product % Ash : 26.7
Discard % Ash : 41.7
Product Yield : **36.0**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	21.40	14.25	7.71	9.12	16.83	1.40	100.0	11.3	11.1	11.2	11.3	11.1	11.2	7.7	9.1	16.8
F @ 1.50	24.88	17.82	8.96	11.41	20.36	1.45	44.0	15.0	17.1	16.2	13.3	14.4	13.9	16.7	20.5	37.2
F @ 1.60	17.60	13.36	6.34	8.55	14.89	1.55	42.6	21.5	18.2	19.6	15.6	15.6	15.6	23.0	29.1	52.1
F @ 1.70	13.55	9.23	4.88	5.91	10.79	1.65	45.2	30.0	34.6	32.5	18.1	18.8	18.5	27.9	35.0	62.9
F @ 1.80	6.28	3.01	2.26	1.93	4.19	1.75	54.0	40.3	41.2	40.7	19.7	19.9	19.9	30.1	36.9	67.1
F @ 1.90	5.79	3.01	2.08	1.93	4.01	1.85	52.0	49.3	45.7	47.5	21.7	21.2	21.4	32.2	38.8	71.1
F @ 2.00	2.40	3.37	0.86	2.15	3.02	1.95	28.6	56.8	55.1	55.6	22.6	23.0	22.8	33.1	41.0	74.1
F @ 2.10	2.98	4.39	1.07	2.81	3.88	2.05	27.6	66.6	63.6	64.4	23.9	25.6	24.9	34.2	43.8	78.0
F @ 2.20	2.64	5.20	0.95	3.33	4.28	2.15	22.2	75.4	68.3	69.8	25.3	28.6	27.2	35.1	47.1	82.2
S @ 2.20	2.48	26.36	0.89	16.87	17.77	2.20	5.0	80.3	78.3	78.4	26.7	41.7	36.3	36.0	64.0	100.0
Whole Coal	100.00	100.00	36.00	64.00	100.00											

Efficiency Analysis : **TEST E 4 17/02/2022**

Feed % Ash : 36.3
Product % Ash : 26.0
Discard % Ash : 51.9
Product Yield : **60.2**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	21.16	5.80	12.74	2.31	15.05	1.40	100.0	12.2	10.9	12.0	12.2	10.9	12.0	12.7	2.3	15.1
F @ 1.50	31.55	5.83	19.00	2.32	21.32	1.45	89.1	13.1	13.9	13.1	12.7	12.4	12.7	31.7	4.6	36.4
F @ 1.60	15.80	6.91	9.52	2.75	12.27	1.55	77.6	24.1	19.5	23.0	15.3	15.0	15.3	41.3	7.4	48.6
F @ 1.70	9.85	8.80	5.93	3.50	9.43	1.65	62.9	33.2	25.2	30.2	17.6	18.3	17.7	47.2	10.9	58.1
F @ 1.80	6.06	9.46	3.65	3.76	7.41	1.75	49.2	40.0	27.0	33.4	19.2	20.5	19.5	50.8	14.6	65.5
F @ 1.90	3.33	2.88	2.00	1.14	3.15	1.85	63.7	47.2	47.3	47.2	20.3	22.5	20.8	52.8	15.8	68.6
F @ 2.00	4.11	2.17	2.48	0.86	3.34	1.95	74.2	55.6	50.4	54.3	21.8	23.9	22.3	55.3	16.6	72.0
F @ 2.10	1.19	1.51	0.72	0.60	1.32	2.05	54.4	63.2	56.9	60.3	22.4	25.1	23.0	56.0	17.2	73.3
F @ 2.20	4.57	4.92	2.75	1.96	4.71	2.15	58.5	72.8	59.9	67.4	24.7	28.6	25.7	58.8	19.2	78.0
S @ 2.20	2.38	51.72	1.43	20.57	22.00	2.20	6.5	79.4	73.7	74.1	26.0	51.9	36.3	60.2	39.8	100.0
Whole Coal	100.00	100.00	60.23	39.77	100.00											

Coal 1 10x25mm

Efficiency Analysis : **TEST F 1 17/02/2022**

Feed % Ash : 37.1
Product % Ash : 22.1
Discard % Ash : 41.9
Product Yield : **24.2**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	20.50	7.22	4.97	5.47	10.44	1.40	100.0	11.8	10.7	11.2	11.8	10.7	11.2	5.0	5.5	10.4
F @ 1.50	39.27	10.49	9.52	7.94	17.47	1.45	54.5	14.5	15.0	14.8	13.6	13.3	13.4	14.5	13.4	27.9
F @ 1.60	18.10	12.70	4.39	9.62	14.01	1.55	31.3	23.4	19.5	20.7	15.9	15.9	15.9	18.9	23.0	41.9
F @ 1.70	9.61	15.30	2.33	11.59	13.92	1.65	16.7	32.9	25.5	26.7	17.7	19.1	18.6	21.2	34.6	55.8
F @ 1.80	4.86	10.39	1.18	7.87	9.05	1.75	13.0	41.0	36.3	36.9	19.0	22.3	21.1	22.4	42.5	64.9
F @ 1.90	2.18	7.32	0.53	5.54	6.07	1.85	8.7	46.6	44.8	44.9	19.6	24.9	23.2	22.9	48.0	71.0
F @ 2.00	2.07	4.25	0.50	3.22	3.72	1.95	13.5	57.0	51.5	52.3	20.4	26.5	24.6	23.4	51.3	74.7
F @ 2.10	0.84	2.92	0.20	2.21	2.42	2.05	8.4	63.8	60.5	60.8	20.8	27.9	25.7	23.6	53.5	77.1
F @ 2.20	1.96	3.76	0.47	2.85	3.32	2.15	14.3	72.1	65.2	66.2	21.8	29.8	27.4	24.1	56.3	80.4
S @ 2.20	0.61	25.66	0.15	19.44	19.59	2.20	0.8	77.2	76.9	76.9	22.1	41.9	37.1	24.2	75.8	100.0
Whole Coal	100.00	100.00	24.24	75.76	100.00											

Efficiency Analysis : **TEST F 2 17/02/2022**

Feed % Ash : 37.1
Product % Ash : 21.7
Discard % Ash : 39.9
Product Yield : **15.4**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	26.17	8.90	4.03	7.53	11.56	1.40	100.0	9.8	11.1	10.6	9.8	11.1	10.6	4.0	7.5	11.6
F @ 1.50	33.75	10.65	5.19	9.01	14.20	1.45	36.6	15.8	14.6	15.0	13.1	13.0	13.0	9.2	16.5	25.8
F @ 1.60	17.93	13.94	2.76	11.80	14.55	1.55	19.0	22.8	19.7	20.3	15.4	15.8	15.7	12.0	28.3	40.3
F @ 1.70	9.04	14.84	1.39	12.56	13.95	1.65	10.0	33.1	20.8	22.1	17.2	17.3	17.3	13.4	40.9	54.3
F @ 1.80	4.74	11.64	0.73	9.85	10.58	1.75	6.9	41.2	35.3	35.7	18.5	20.8	20.3	14.1	50.7	64.8
F @ 1.90	5.03	6.25	0.77	5.29	6.06	1.85	12.8	48.2	49.8	49.6	20.0	23.6	22.8	14.9	56.0	70.9
F @ 2.00	1.24	2.58	0.19	2.18	2.37	1.95	8.0	62.8	55.6	56.2	20.5	24.8	23.9	15.1	58.2	73.3
F @ 2.10	1.09	3.36	0.17	2.84	3.01	2.05	5.6	70.0	56.8	57.5	21.1	26.3	25.2	15.2	61.1	76.3
F @ 2.20	1.02	4.12	0.16	3.48	3.64	2.15	4.3	78.3	61.5	62.2	21.7	28.2	26.9	15.4	64.5	79.9
S @ 2.20	0.00	23.72	0.00	20.07	20.07	2.20	0.0	0.0	77.5	77.5	0.0	39.9	37.1	15.4	84.6	100.0
Whole Coal	100.00	100.00	15.38	84.62	100.00											

Efficiency Analysis : **TEST F 3 17/02/2022**

Feed % Ash : 37.1
Product % Ash : 24.8
Discard % Ash : 38.0
Product Yield : **6.8**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	15.98	9.96	1.09	9.28	10.37	1.40	100.0	11.2	12.5	12.4	11.2	12.5	12.4	1.1	9.3	10.4
F @ 1.50	32.92	14.58	2.24	13.58	15.83	1.45	14.2	13.3	15.5	15.2	12.6	14.3	14.1	3.3	22.9	26.2
F @ 1.60	21.47	17.05	1.46	15.89	17.35	1.55	8.4	22.2	18.8	19.0	15.5	16.1	16.1	4.8	38.8	43.6
F @ 1.70	10.54	14.33	0.72	13.35	14.07	1.65	5.1	32.3	27.3	27.6	17.7	19.0	18.9	5.5	52.1	57.6
F @ 1.80	5.55	8.34	0.38	7.77	8.15	1.75	4.6	39.2	37.9	38.0	19.1	21.5	21.2	5.9	59.9	65.8
F @ 1.90	5.55	3.84	0.38	3.58	3.96	1.85	9.5	49.5	48.5	48.6	20.9	23.0	22.8	6.3	63.5	69.7
F @ 2.00	2.09	1.95	0.14	1.81	1.96	1.95	7.3	54.2	56.4	56.2	21.7	23.9	23.7	6.4	65.3	71.7
F @ 2.10	1.81	2.55	0.12	2.37	2.50	2.05	4.9	64.0	56.8	57.1	22.5	25.1	24.8	6.5	67.6	74.2
F @ 2.20	1.57	7.81	0.11	7.28	7.39	2.15	1.4	75.0	61.3	61.4	23.3	28.6	28.1	6.6	74.9	81.6
S @ 2.20	2.53	19.60	0.17	18.26	18.43	2.20	0.9	81.0	76.4	76.5	24.8	38.0	37.1	6.8	93.2	100.0
Whole Coal	100.00	100.00	6.82	93.18	100.00											

Efficiency Analysis : **TEST F 4 17/02/2022**

Feed % Ash : 37.1
Product % Ash : 28.5
Discard % Ash : 37.5
Product Yield : **4.4**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	21.76	8.42	0.97	8.04	9.01	1.40	100.0	10.5	12.8	12.6	10.5	12.8	12.6	1.0	8.0	9.0
F @ 1.50	14.93	7.64	0.66	7.30	7.96	1.45	8.3	13.6	15.2	15.1	11.8	13.9	13.7	1.6	15.3	17.0
F @ 1.60	24.86	14.87	1.10	14.21	15.31	1.55	7.2	22.2	18.6	18.9	16.0	16.2	16.2	2.7	29.5	32.3
F @ 1.70	13.84	21.98	0.62	21.00	21.62	1.65	2.8	32.3	22.8	23.1	19.0	18.9	18.9	3.4	50.5	53.9
F @ 1.80	6.15	11.54	0.27	11.03	11.30	1.75	2.4	38.7	33.9	34.0	20.4	21.6	21.6	3.6	61.6	65.2
F @ 1.90	2.69	4.83	0.12	4.62	4.73	1.85	2.5	44.5	47.0	47.0	21.2	23.4	23.3	3.7	66.2	69.9
F @ 2.00	5.10	4.35	0.23	4.16	4.39	1.95	5.2	53.7	51.7	51.8	23.1	25.1	25.0	4.0	70.4	74.3
F @ 2.10	2.05	3.07	0.09	2.93	3.02	2.05	3.0	67.2	56.5	56.8	24.1	26.3	26.2	4.1	73.3	77.3
F @ 2.20	4.69	5.38	0.21	5.14	5.35	2.15	3.9	70.3	67.7	67.8	26.3	29.0	28.9	4.3	78.4	82.7
S @ 2.20	3.94	17.93	0.18	17.14	17.31	2.20	1.0	80.6	76.5	76.6	28.5	37.5	37.1	4.4	95.6	100.0
Whole Coal	100.00	100.00	4.44	95.56	100.00											

Coal 1 25x50mm

Efficiency Analysis : **TEST G 1 17/02/2022**

Feed % Ash : 47.2
Product % Ash : 31.0
Discard % Ash : 55.3
Product Yield : 33.3

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	13.35	10.92	4.45	7.28	11.73	1.40	100.0	12.2	15.1	14.0	12.2	15.1	14.0	4.5	7.3	11.7
F @ 1.50	20.58	6.82	6.86	4.54	11.41	1.45	60.2	15.1	26.3	19.6	14.0	19.4	16.7	11.3	11.8	23.1
F @ 1.60	22.51	8.96	7.50	5.97	13.48	1.55	55.7	17.7	31.2	23.6	15.4	23.3	19.3	18.8	17.8	36.6
F @ 1.70	11.78	4.98	3.93	3.32	7.24	1.65	54.2	31.0	33.0	31.9	18.1	24.9	21.4	22.7	21.1	43.9
F @ 1.80	6.85	8.42	2.28	5.61	7.89	1.75	28.9	41.4	41.0	41.1	20.2	28.3	24.4	25.0	26.7	51.8
F @ 1.90	6.18	5.01	2.06	3.34	5.40	1.85	38.2	50.8	48.3	49.3	22.6	30.5	26.7	27.1	30.1	57.1
F @ 2.00	5.54	4.60	1.85	3.07	4.91	1.95	37.6	51.8	55.7	54.2	24.4	32.8	28.9	28.9	33.1	62.1
F @ 2.10	1.25	3.20	0.42	2.13	2.55	2.05	16.4	63.4	65.4	65.1	25.0	34.8	30.3	29.3	35.3	64.6
F @ 2.20	8.43	4.07	2.81	2.71	5.52	2.15	50.8	71.9	66.5	69.3	29.1	37.1	33.4	32.2	38.0	70.1
S @ 2.20	3.53	43.03	1.18	28.69	29.86	2.20	3.9	83.0	79.3	79.5	31.0	55.3	47.2	33.3	66.7	100.0
Whole Coal	100.00	100.00	33.33	66.67	100.00											

Efficiency Analysis : **TEST G 2 17/02/2022**

Feed % Ash : 47.2
Product % Ash : 27.7
Discard % Ash : 55.8
Product Yield : 30.6

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	17.48	9.10	5.35	6.31	11.67	1.40	100.0	11.0	17.1	14.3	11.0	17.1	14.3	5.4	6.3	11.7
F @ 1.50	28.83	5.45	8.82	3.78	12.60	1.45	70.0	13.7	17.1	14.7	12.7	17.1	14.5	14.2	10.1	24.3
F @ 1.60	18.67	8.12	5.71	5.64	11.35	1.55	50.3	22.5	25.0	23.7	15.5	19.9	17.4	19.9	15.7	35.6
F @ 1.70	12.36	6.50	3.78	4.51	8.29	1.65	45.6	32.8	34.5	33.7	18.2	23.2	20.5	23.7	20.2	43.9
F @ 1.80	5.08	6.97	1.56	4.84	6.40	1.75	24.3	41.1	39.2	39.7	19.7	26.3	23.0	25.2	25.1	50.3
F @ 1.90	3.33	5.88	1.02	4.08	5.10	1.85	20.0	48.5	51.4	50.8	20.8	29.8	25.5	26.2	29.2	55.4
F @ 2.00	4.73	5.45	1.45	3.78	5.23	1.95	27.7	54.7	53.6	53.9	22.5	32.5	28.0	27.7	32.9	60.6
F @ 2.10	1.84	3.96	0.56	2.75	3.31	2.05	17.0	63.0	64.5	64.3	23.4	35.0	29.8	28.3	35.7	63.9
F @ 2.20	4.86	5.02	1.49	3.48	4.97	2.15	30.0	75.9	72.5	73.5	26.0	38.3	33.0	29.7	39.2	68.9
S @ 2.20	2.80	43.56	0.86	30.23	31.09	2.20	2.8	85.4	78.3	78.5	27.7	55.8	47.2	30.6	69.4	100.0
Whole Coal	100.00	100.00	30.60	69.40	100.00											

Efficiency Analysis : **TEST G 3 17/02/2022**

Feed % Ash : 47.2
Product % Ash : 31.1
Discard % Ash : 49.4
Product Yield : 12.0

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	26.02	9.03	3.13	7.95	11.08	1.40	100.0	11.4	15.2	14.2	11.4	15.2	14.2	3.1	7.9	11.1
F @ 1.50	16.63	6.47	2.00	5.69	7.69	1.45	26.0	18.3	19.0	18.8	14.1	16.8	16.1	5.1	13.6	18.8
F @ 1.60	16.74	12.49	2.01	10.99	13.00	1.55	15.5	24.2	20.3	20.9	16.9	18.4	18.0	7.1	24.6	31.8
F @ 1.70	9.85	8.84	1.18	7.78	8.96	1.65	13.2	33.0	29.4	29.8	19.2	21.0	20.6	8.3	32.4	40.7
F @ 1.80	7.03	5.46	0.85	4.81	5.65	1.75	15.0	39.9	38.4	38.7	21.1	23.2	22.8	9.2	37.2	46.4
F @ 1.90	5.34	5.94	0.64	5.22	5.86	1.85	11.0	44.5	44.4	44.4	22.7	25.8	25.2	9.8	42.4	52.2
F @ 2.00	4.61	6.03	0.55	5.31	5.86	1.95	9.4	54.8	60.9	60.3	24.4	29.7	28.8	10.4	47.7	58.1
F @ 2.10	1.27	2.66	0.15	2.34	2.50	2.05	6.1	64.9	64.6	64.6	25.0	31.4	30.3	10.5	50.1	60.6
F @ 2.20	8.12	4.52	0.98	3.97	4.95	2.15	19.7	67.5	71.8	71.0	28.6	34.3	33.3	11.5	54.1	65.5
S @ 2.20	4.40	38.56	0.53	33.93	34.46	2.20	1.5	87.2	73.3	73.5	31.1	49.4	47.2	12.0	88.0	100.0
Whole Coal	100.00	100.00	12.02	87.98	100.00											

Efficiency Analysis : **TEST G 4 17/02/2022**

Feed % Ash : 47.2
Product % Ash : 28.2
Discard % Ash : 50.6
Product Yield : 15.2

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	17.27	8.74	2.62	7.41	10.03	1.40	100.0	12.6	13.0	12.9	12.6	13.0	12.9	2.6	7.4	10.0
F @ 1.50	26.20	8.71	3.98	7.39	11.37	1.45	35.0	13.9	21.1	18.6	13.3	17.1	15.9	6.6	14.8	21.4
F @ 1.60	19.90	7.64	3.02	6.48	9.50	1.55	31.8	22.2	21.9	22.0	16.1	18.5	17.8	9.6	21.3	30.9
F @ 1.70	11.37	10.34	1.73	8.77	10.49	1.65	16.4	32.2	32.2	32.2	18.6	22.5	21.4	11.3	30.1	41.4
F @ 1.80	7.21	8.02	1.09	6.80	7.90	1.75	13.8	40.0	33.1	34.1	20.4	24.5	23.5	12.4	36.9	49.3
F @ 1.90	4.64	7.21	0.70	6.12	6.82	1.85	10.3	47.5	43.1	43.6	21.9	27.1	25.9	13.1	43.0	56.1
F @ 2.00	4.10	4.16	0.62	3.53	4.15	1.95	15.0	55.3	54.6	54.7	23.4	29.2	27.9	13.8	46.5	60.3
F @ 2.10	1.33	3.34	0.20	2.83	3.03	2.05	6.6	65.0	60.8	61.1	24.0	31.0	29.5	14.0	49.3	63.3
F @ 2.20	5.25	2.89	0.80	2.46	3.25	2.15	24.5	73.8	65.5	67.5	26.7	32.7	31.3	14.8	51.8	66.5
S @ 2.20	2.74	38.95	0.42	33.04	33.46	2.20	1.2	81.7	78.7	78.7	28.2	50.6	47.2	15.2	84.8	100.0
Whole Coal	100.00	100.00	15.18	84.82	100.00											

Coal 2 10x50mm

Efficiency Analysis : **TEST H 1 17/02/2022**

Feed % Ash : 31.1
Product % Ash : 20.9
Discard % Ash : 43.2
Product Yield : **54.3**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	39.04	12.17	21.18	5.57	26.75	1.40	100.0	14.3	10.2	13.5	14.3	10.2	13.5	21.2	5.6	26.7
F @ 1.50	25.87	15.07	14.04	6.89	20.93	1.45	67.1	14.8	15.0	14.9	14.5	12.8	14.1	35.2	12.5	47.7
F @ 1.60	14.30	11.14	7.76	5.10	12.86	1.55	60.3	21.8	19.2	20.8	15.8	14.7	15.5	43.0	17.6	60.5
F @ 1.70	11.22	7.15	6.09	3.27	9.36	1.65	65.0	28.2	25.8	27.4	17.4	16.4	17.1	49.1	20.8	69.9
F @ 1.80	3.42	4.41	1.86	2.02	3.88	1.75	47.9	40.5	36.6	38.5	18.2	18.2	18.2	50.9	22.8	73.8
F @ 1.90	0.95	5.12	0.52	2.34	2.86	1.85	18.1	45.6	45.6	45.6	18.5	20.8	19.2	51.4	25.2	76.6
F @ 2.00	1.43	3.52	0.78	1.61	2.39	1.95	32.5	51.8	54.4	53.5	19.0	22.8	20.3	52.2	26.8	79.0
F @ 2.10	0.91	4.29	0.49	1.96	2.46	2.05	20.1	56.9	62.4	61.3	19.3	25.5	21.5	52.7	28.8	81.5
F @ 2.20	1.39	4.47	0.75	2.04	2.80	2.15	26.9	70.9	67.5	68.4	20.1	28.3	23.1	53.5	30.8	84.3
S @ 2.20	1.47	32.65	0.80	14.94	15.74	2.20	5.1	76.6	74.0	74.1	20.9	43.2	31.1	54.3	45.7	100.0
Whole Coal	100.00	100.00	54.26	45.74	100.00											

Efficiency Analysis : **TEST H 2 17/02/2022**

Feed % Ash : 31.1
Product % Ash : 19.1
Discard % Ash : 42.8
Product Yield : **49.4**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	37.57	11.10	18.55	5.62	24.17	1.40	100.0	8.8	9.6	9.0	8.8	9.6	9.0	18.5	5.6	24.2
F @ 1.50	28.13	13.65	13.89	6.91	20.80	1.45	66.8	15.0	14.1	14.7	11.5	12.1	11.6	32.4	12.5	45.0
F @ 1.60	12.26	10.32	6.05	5.22	11.28	1.55	53.7	21.0	20.2	20.6	13.0	14.5	13.4	38.5	17.8	56.2
F @ 1.70	9.70	7.66	4.79	3.88	8.67	1.65	55.3	28.7	26.3	27.6	14.7	16.6	15.3	43.3	21.6	64.9
F @ 1.80	4.00	4.82	1.97	2.44	4.42	1.75	44.7	38.5	35.1	36.6	15.7	18.5	16.7	45.3	24.1	69.3
F @ 1.90	2.95	9.64	1.46	4.88	6.34	1.85	23.0	45.4	44.2	44.5	16.7	22.8	19.0	46.7	29.0	75.7
F @ 2.00	2.49	2.83	1.23	1.43	2.66	1.95	46.2	54.0	58.3	56.3	17.6	24.5	20.3	47.9	30.4	78.3
F @ 2.10	0.85	2.91	0.42	1.47	1.89	2.05	22.2	63.7	58.4	59.6	18.0	26.1	21.2	48.4	31.9	80.2
F @ 2.20	1.51	4.48	0.74	2.27	3.01	2.15	24.7	67.7	63.2	64.4	18.8	28.5	22.8	49.1	34.1	83.2
S @ 2.20	0.52	32.60	0.26	16.51	16.77	2.20	1.5	71.6	72.3	72.3	19.1	42.8	31.1	49.4	50.6	100.0
Whole Coal	100.00	100.00	49.37	50.63	100.00											

Efficiency Analysis : **TEST H 3 17/02/2022**

Feed % Ash : 31.1
Product % Ash : 25.4
Discard % Ash : 37.6
Product Yield : **53.3**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	8.78	6.42	4.68	3.00	7.68	1.40	100.0	11.3	9.8	10.7	11.3	9.8	10.7	4.7	3.0	7.7
F @ 1.50	34.68	16.17	18.48	7.55	26.03	1.45	71.0	14.4	12.2	13.8	13.8	11.5	13.1	23.2	10.6	33.7
F @ 1.60	19.78	14.10	10.54	6.59	17.13	1.55	61.5	16.6	16.5	16.6	14.7	13.4	14.3	33.7	17.1	50.8
F @ 1.70	17.77	7.22	9.47	3.37	12.84	1.65	73.7	31.5	21.0	28.7	18.4	14.7	17.2	43.2	20.5	63.7
F @ 1.80	7.48	12.88	3.99	6.02	10.01	1.75	39.8	42.3	30.7	35.3	20.4	18.3	19.6	47.1	26.5	73.7
F @ 1.90	0.79	6.64	0.42	3.10	3.52	1.85	12.0	47.3	46.1	46.2	20.6	21.2	20.8	47.6	29.6	77.2
F @ 2.00	2.45	3.59	1.30	1.68	2.98	1.95	43.7	54.8	51.0	52.7	21.5	22.8	22.0	48.9	31.3	80.2
F @ 2.10	3.17	3.24	1.69	1.51	3.20	2.05	52.7	65.1	54.9	60.2	23.0	24.3	23.5	50.6	32.8	83.4
F @ 2.20	2.88	3.21	1.53	1.50	3.03	2.15	50.5	69.5	62.6	66.1	24.3	26.0	25.0	52.1	34.3	86.4
S @ 2.20	2.23	26.53	1.19	12.39	13.58	2.20	8.7	72.9	69.7	69.9	25.4	37.6	31.1	53.3	46.7	100.0
Whole Coal	100.00	100.00	53.28	46.72	100.00											

Efficiency Analysis : **TEST H 4 17/02/2022**

Feed % Ash : 31.1
Product % Ash : 19.3
Discard % Ash : 44.7
Product Yield : **53.5**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	47.38	17.49	25.37	8.12	33.49	1.40	100.0	10.3	10.2	10.3	10.3	10.2	10.3	25.4	8.1	33.5
F @ 1.50	15.60	10.08	8.35	4.68	13.03	1.45	64.1	14.8	15.3	14.9	11.4	12.1	11.6	33.7	12.8	46.5
F @ 1.60	15.79	9.24	8.46	4.29	12.75	1.55	66.3	21.6	21.0	21.4	13.4	14.3	13.7	42.2	17.1	59.3
F @ 1.70	10.25	5.59	5.49	2.59	8.08	1.65	67.9	29.1	28.5	28.9	15.3	16.2	15.5	47.7	19.7	67.4
F @ 1.80	4.62	4.60	2.47	2.14	4.61	1.75	53.7	43.2	36.6	40.1	16.6	18.2	17.1	50.1	21.8	72.0
F @ 1.90	1.41	8.03	0.75	3.73	4.49	1.85	16.8	46.3	42.5	43.2	17.1	21.7	18.6	50.9	25.6	76.4
F @ 2.00	1.38	2.80	0.74	1.30	2.04	1.95	36.2	46.7	52.6	50.5	17.5	23.2	19.5	51.6	26.9	78.5
F @ 2.10	0.65	3.83	0.35	1.78	2.13	2.05	16.3	55.1	59.0	58.4	17.7	25.5	20.5	52.0	28.6	80.6
F @ 2.20	2.03	3.38	1.09	1.57	2.66	2.15	40.8	70.0	63.6	66.2	18.8	27.4	21.9	53.1	30.2	83.3
S @ 2.20	0.90	34.96	0.48	16.24	16.72	2.20	2.9	71.1	76.7	76.5	19.3	44.7	31.1	53.5	46.5	100.0
Whole Coal	100.00	100.00	53.54	46.46	100.00											

Coal 2: 10x25mm

Efficiency Analysis : **TEST I 1 17/02/2022**

Feed % Ash : 27.6
Product % Ash : 17.8
Discard % Ash : 37.0
Product Yield : **49.0**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	11.27	25.00	5.52	12.76	18.28	1.40	100.0	8.0	10.9	10.0	8.0	10.9	10.0	5.5	12.8	18.3
F @ 1.50	29.01	9.88	14.20	5.04	19.24	1.45	73.8	9.9	15.4	11.3	9.4	12.2	10.7	19.7	17.8	37.5
F @ 1.60	32.85	6.97	16.08	3.56	19.64	1.55	81.9	15.5	19.5	16.2	12.1	13.4	12.6	35.8	21.4	57.2
F @ 1.70	9.62	8.48	4.71	4.33	9.04	1.65	52.1	22.2	26.0	24.0	13.3	15.5	14.1	40.5	25.7	66.2
F @ 1.80	1.65	7.46	0.81	3.81	4.62	1.75	17.5	26.3	37.3	35.4	13.5	18.3	15.5	41.3	29.5	70.8
F @ 1.90	12.15	4.02	5.95	2.05	8.00	1.85	74.4	34.7	43.4	36.9	16.2	19.9	17.7	47.3	31.5	78.8
F @ 2.00	1.36	4.75	0.67	2.42	3.09	1.95	21.6	50.7	52.2	51.8	16.7	22.2	19.0	47.9	34.0	81.9
F @ 2.10	0.34	5.42	0.17	2.77	2.93	2.05	5.7	63.6	57.9	58.3	16.8	24.9	20.3	48.1	36.7	84.8
F @ 2.20	1.02	2.72	0.50	1.39	1.89	2.15	26.5	66.9	64.1	64.9	17.4	26.3	21.3	48.6	38.1	86.7
S @ 2.20	0.73	25.31	0.36	12.92	13.27	2.20	2.7	71.9	68.6	68.7	17.8	37.0	27.6	49.0	51.0	100.0
Whole Coal	100.00	100.00	48.96	51.04	100.00											

Efficiency Analysis : **TEST I 2 17/02/2022**

Feed % Ash : 27.6
Product % Ash : 16.6
Discard % Ash : 38.8
Product Yield : **50.5**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	47.16	17.19	23.79	8.52	32.31	1.40	100.0	8.9	11.2	9.5	8.9	11.2	9.5	23.8	8.5	32.3
F @ 1.50	21.89	15.04	11.04	7.45	18.50	1.45	59.7	14.8	14.7	14.7	10.8	12.8	11.4	34.8	16.0	50.8
F @ 1.60	15.62	8.74	7.88	4.33	12.21	1.55	64.5	21.8	20.4	21.3	12.8	14.5	13.3	42.7	20.3	63.0
F @ 1.70	9.94	8.86	5.01	4.39	9.40	1.65	53.3	31.0	27.5	29.4	14.7	16.8	15.4	47.7	24.7	72.4
F @ 1.80	3.53	7.26	1.78	3.60	5.38	1.75	33.1	44.4	38.3	40.3	15.8	19.5	17.1	49.5	28.3	77.8
F @ 1.90	0.36	5.05	0.18	2.50	2.68	1.85	6.8	50.4	46.5	46.8	15.9	21.7	18.1	49.7	30.8	80.5
F @ 2.00	0.72	2.76	0.36	1.37	1.73	1.95	21.0	57.6	55.4	55.8	16.2	23.1	18.9	50.1	32.2	82.2
F @ 2.10	0.79	3.22	0.40	1.60	2.00	2.05	20.0	69.3	59.1	61.1	16.6	24.8	19.9	50.5	33.8	84.2
F @ 2.20	0.00	3.83	0.00	1.90	1.90	2.15	0.0	0.0	63.9	63.9	0.0	26.9	20.9	50.5	35.7	86.1
S @ 2.20	0.00	28.04	0.00	13.89	13.89	2.20	0.0	0.0	69.2	69.2	0.0	38.8	27.6	50.5	49.5	100.0
Whole Coal	100.00	100.00	50.45	49.55	100.00											

Efficiency Analysis : **TEST I 3 17/02/2022**

Feed % Ash : 27.6
Product % Ash : 16.8
Discard % Ash : 33.5
Product Yield : **35.3**

Rel.Dens.		% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
		Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @	1.40	44.42	28.31	15.69	18.31	34.00	1.40	100.0	10.4	11.3	10.9	10.4	11.3	10.9	15.7	18.3	34.0
F @	1.50	27.13	13.47	9.59	8.71	18.30	1.45	52.4	14.0	17.7	15.8	11.8	13.4	12.6	25.3	27.0	52.3
F @	1.60	14.49	9.08	5.12	5.87	10.99	1.55	46.6	21.7	22.7	22.2	13.5	15.0	14.3	30.4	32.9	63.3
F @	1.70	8.90	10.24	3.15	6.62	9.77	1.65	32.2	29.4	30.3	30.0	14.9	17.6	16.4	33.5	39.5	73.1
F @	1.80	2.79	4.54	0.99	2.94	3.92	1.75	25.1	43.5	38.6	39.8	15.8	19.0	17.6	34.5	42.5	77.0
F @	1.90	0.53	4.64	0.19	3.00	3.18	1.85	5.8	53.1	46.5	46.9	16.0	20.8	18.7	34.7	45.4	80.2
F @	2.00	0.58	2.88	0.20	1.86	2.07	1.95	9.9	54.3	54.9	54.9	16.2	22.2	19.6	34.9	47.3	82.2
F @	2.10	0.53	2.57	0.19	1.66	1.85	2.05	10.1	62.1	55.1	55.8	16.4	23.3	20.4	35.1	49.0	84.1
F @	2.20	0.32	4.15	0.11	2.68	2.80	2.15	4.0	70.2	61.1	61.5	16.6	25.3	21.8	35.2	51.7	86.9
S @	2.20	0.32	20.12	0.11	13.01	13.12	2.20	0.9	76.6	66.3	66.4	16.8	33.5	27.6	35.3	64.7	100.0
Whole Coal		100.00	100.00	35.33	64.67	100.00											

Efficiency Analysis : **TEST I 4 17/02/2022**

Feed % Ash : 27.6
Product % Ash : 16.6
Discard % Ash : 35.6
Product Yield : **42.1**

Rel.Dens.		% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
		Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @	1.40	19.18	29.47	8.07	17.06	25.14	1.40	100.0	8.1	11.1	10.1	8.1	11.1	10.1	8.1	17.1	25.1
F @	1.50	27.99	9.08	11.79	5.25	17.04	1.45	69.2	10.1	16.4	12.0	9.2	12.4	10.9	19.9	22.3	42.2
F @	1.60	30.14	7.83	12.69	4.54	17.22	1.55	73.7	16.4	19.3	17.2	12.0	13.5	12.7	32.6	26.9	59.4
F @	1.70	12.86	8.23	5.42	4.76	10.18	1.65	53.2	23.4	26.3	24.7	13.6	15.5	14.5	38.0	31.6	69.6
F @	1.80	5.78	6.43	2.43	3.72	6.15	1.75	39.5	30.5	36.3	34.0	14.7	17.7	16.1	40.4	35.3	75.7
F @	1.90	1.97	5.04	0.83	2.92	3.75	1.85	22.1	55.0	45.3	47.5	15.5	19.8	17.5	41.2	38.3	79.5
F @	2.00	0.00	3.13	0.00	1.81	1.81	1.95	0.0	0.0	51.1	51.1	0.0	21.2	18.3	41.2	40.1	81.3
F @	2.10	0.83	3.33	0.35	1.93	2.28	2.05	15.4	63.6	59.4	60.0	15.9	22.9	19.4	41.6	42.0	83.6
F @	2.20	0.83	5.27	0.35	3.05	3.40	2.15	10.3	70.3	65.9	66.3	16.3	25.9	21.3	41.9	45.1	87.0
S @	2.20	0.42	22.19	0.18	12.84	13.02	2.20	1.3	74.0	70.0	70.1	16.6	35.6	27.6	42.1	57.9	100.0
Whole Coal		100.00	100.00	42.11	57.89	100.00											

Coal 2: 25x50mm

Efficiency Analysis : **TEST J 1 17/02/2022**

Feed % Ash : 34.8
Product % Ash : 22.3
Discard % Ash : 41.8
Product Yield : **35.9**

Rel.Dens.		% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
		Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @	1.40	42.54	13.89	15.27	8.90	24.17	1.40	100.0	10.8	9.2	10.2	10.8	9.2	10.2	15.3	8.9	24.2
F @	1.50	17.94	7.68	6.44	4.92	11.36	1.45	56.7	13.8	14.0	13.9	11.7	10.9	11.4	21.7	13.8	35.5
F @	1.60	13.02	9.56	4.67	6.13	10.80	1.55	43.3	21.2	17.8	19.2	13.4	13.0	13.2	26.4	20.0	46.3
F @	1.70	10.01	5.25	3.59	3.37	6.96	1.65	51.6	32.1	28.6	30.4	15.6	15.3	15.5	30.0	23.3	53.3
F @	1.80	5.67	17.11	2.04	10.97	13.00	1.75	15.7	41.2	30.5	32.1	17.2	20.1	18.7	32.0	34.3	66.3
F @	1.90	1.57	17.85	0.56	11.44	12.00	1.85	4.7	44.2	37.0	37.3	17.7	24.3	21.6	32.6	45.7	78.3
F @	2.00	1.47	6.34	0.53	4.06	4.59	1.95	11.5	50.5	50.2	50.2	18.2	26.4	23.2	33.1	49.8	82.9
F @	2.10	0.99	9.93	0.36	6.36	6.72	2.05	5.3	59.3	53.4	53.7	18.7	29.5	25.5	33.5	56.1	89.6
F @	2.20	5.23	6.20	1.88	3.98	5.85	2.15	32.1	69.1	70.7	70.2	21.3	32.2	28.2	35.3	60.1	95.5
S @	2.20	1.57	6.20	0.56	3.98	4.54	2.20	12.4	83.9	73.2	74.5	22.3	34.8	30.3	35.9	64.1	100.0
Whole Coal		100.00	100.00	35.90	64.10	100.00											

Efficiency Analysis : **TEST J 2 17/02/2022**

Feed % Ash : 37.4
Product % Ash : 29.4
Discard % Ash : 41.4
Product Yield : **33.3**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	9.73	15.34	3.24	10.22	13.47	1.40	100.0	12.0	12.1	12.1	12.0	12.1	12.1	3.2	10.2	13.5
F @ 1.50	41.34	8.44	13.78	5.63	19.41	1.45	71.0	22.1	18.8	21.1	20.2	14.5	17.4	17.0	15.8	32.9
F @ 1.60	21.30	8.39	7.10	5.59	12.69	1.55	55.9	28.1	21.7	25.2	22.5	16.3	19.6	24.1	21.4	45.6
F @ 1.70	12.06	5.48	4.02	3.65	7.67	1.65	52.4	37.6	23.2	30.8	24.7	17.3	21.2	28.1	25.1	53.2
F @ 1.80	5.93	12.65	1.98	8.43	10.41	1.75	19.0	41.7	28.4	30.9	25.8	20.1	22.8	30.1	33.5	63.6
F @ 1.90	2.24	10.03	0.75	6.69	7.43	1.85	10.0	53.9	41.8	43.0	26.5	23.7	24.9	30.9	40.2	71.1
F @ 2.00	3.11	4.55	1.04	3.03	4.07	1.95	25.5	61.4	49.5	52.5	27.6	25.5	26.4	31.9	43.2	75.1
F @ 2.10	0.97	3.93	0.32	2.62	2.94	2.05	11.0	67.9	57.8	58.9	28.0	27.4	27.6	32.2	45.9	78.1
F @ 2.20	3.31	2.59	1.10	1.73	2.83	2.15	38.9	71.4	61.3	65.2	29.4	28.6	29.0	33.3	47.6	80.9
S @ 2.20	0.00	28.62	0.00	19.08	19.08	2.20	0.0	0.0	73.2	73.2	0.0	41.4	37.4	33.3	66.7	100.0
Whole Coal	100.00	100.00	33.33	66.67	100.00											

Efficiency Analysis : **TEST J 3 17/02/2022**

Feed % Ash : 37.4
Product % Ash : 26.5
Discard % Ash : 41.2
Product Yield : **25.9**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	32.92	14.90	8.51	11.05	19.56	1.40	100.0	15.2	10.5	12.5	15.2	10.5	12.5	8.5	11.0	19.6
F @ 1.50	26.75	6.13	6.92	4.54	11.46	1.45	60.4	19.9	12.7	17.0	17.3	11.1	14.2	15.4	15.6	31.0
F @ 1.60	14.19	10.93	3.67	8.11	11.77	1.55	31.2	24.9	15.0	18.1	18.7	12.5	15.3	19.1	23.7	42.8
F @ 1.70	8.24	8.75	2.13	6.48	8.61	1.65	24.7	28.7	19.5	21.8	19.7	14.0	16.4	21.2	30.2	51.4
F @ 1.80	3.88	10.35	1.00	7.67	8.67	1.75	11.6	34.9	29.4	30.1	20.4	17.1	18.3	22.2	37.9	60.1
F @ 1.90	1.12	6.15	0.29	4.56	4.85	1.85	5.9	46.2	40.6	40.9	20.7	19.6	20.0	22.5	42.4	64.9
F @ 2.00	4.33	2.63	1.12	1.95	3.07	1.95	36.5	53.4	49.9	51.2	22.3	21.0	21.4	23.6	44.4	68.0
F @ 2.10	1.25	5.49	0.32	4.07	4.39	2.05	7.3	54.0	54.6	54.5	22.7	23.8	23.4	24.0	48.4	72.4
F @ 2.20	2.55	4.42	0.66	3.28	3.94	2.15	16.7	65.6	71.6	70.6	23.9	26.8	25.9	24.6	51.7	76.3
S @ 2.20	4.78	30.25	1.24	22.43	23.67	2.20	5.2	78.9	74.4	74.6	26.5	41.2	37.4	25.9	74.1	100.0
Whole Coal	100.00	100.00	25.85	74.15	100.00											

Efficiency Analysis : **TEST J 4 17/02/2022**

Feed % Ash : 37.4
Product % Ash : 29.8
Discard % Ash : 42.8
Product Yield : **41.5**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	39.96	15.16	16.60	8.86	25.46	1.40	100.0	10.2	10.1	10.2	10.2	10.1	10.2	16.6	8.9	25.5
F @ 1.50	13.97	8.06	5.80	4.71	10.51	1.45	55.2	17.0	18.3	17.6	12.0	13.0	12.4	22.4	13.6	36.0
F @ 1.60	11.22	7.99	4.66	4.67	9.33	1.55	49.9	22.1	21.7	21.9	13.7	15.2	14.3	27.1	18.2	45.3
F @ 1.70	6.62	5.83	2.75	3.41	6.16	1.65	44.7	29.0	24.0	26.2	15.1	16.6	15.7	29.8	21.7	51.5
F @ 1.80	4.18	10.84	1.74	6.34	8.08	1.75	21.5	38.5	31.9	33.4	16.4	20.1	18.1	31.5	28.0	59.5
F @ 1.90	0.86	7.43	0.36	4.34	4.70	1.85	7.6	46.4	40.9	41.3	16.8	22.9	19.8	31.9	32.3	64.2
F @ 2.00	1.33	5.62	0.55	3.28	3.84	1.95	14.4	53.6	50.8	51.2	17.4	25.4	21.6	32.5	35.6	68.1
F @ 2.10	0.76	4.02	0.32	2.35	2.66	2.05	11.9	59.8	59.6	59.6	17.8	27.6	23.0	32.8	38.0	70.7
F @ 2.20	4.63	4.10	1.92	2.40	4.32	2.15	44.5	69.4	64.9	66.9	20.6	29.8	25.6	34.7	40.4	75.1
S @ 2.20	16.48	30.95	6.84	18.09	24.94	2.20	27.4	76.2	72.0	73.2	29.8	42.8	37.4	41.5	58.5	100.0
Whole Coal	100.00	100.00	41.54	58.46	100.00											

Coal 2: 0x50mm

Efficiency Analysis : **TEST K 1 17/02/2022**

Feed % Ash : 28.4
Product % Ash : 23.1
Discard % Ash : 49.4
Product Yield : 79.8

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T0590

Rel.Dens.		% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
		Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @	1.40	39.81	0.00	31.79	0.00	31.79	1.40	100.0	11.3	0.0	11.3	11.3	0.0	11.3	31.8	0.0	31.8
F @	1.50	22.54	18.09	18.00	3.64	21.64	1.45	83.2	17.5	16.4	17.3	13.5	16.4	13.7	49.8	3.6	53.4
F @	1.60	14.51	8.17	11.58	1.65	13.23	1.55	87.6	24.9	20.9	24.4	15.7	17.8	15.8	61.4	5.3	66.7
F @	1.70	8.50	8.98	6.79	1.81	8.60	1.65	78.9	34.3	27.4	32.9	17.5	20.3	17.8	68.2	7.1	75.3
F @	1.80	5.91	8.28	4.72	1.67	6.39	1.75	73.9	44.0	39.6	42.9	19.2	23.9	19.8	72.9	8.8	81.6
F @	1.90	1.23	4.49	0.98	0.91	1.89	1.85	52.0	47.7	46.0	46.9	19.6	26.0	20.4	73.9	9.7	83.5
F @	2.00	1.73	4.21	1.38	0.85	2.23	1.95	61.9	54.6	54.2	54.4	20.3	28.3	21.2	75.2	10.5	85.8
F @	2.10	1.43	7.04	1.14	1.42	2.56	2.05	44.6	62.4	54.3	57.9	20.9	31.4	22.3	76.4	11.9	88.3
F @	2.20	1.96	6.20	1.56	1.25	2.81	2.15	55.6	68.0	69.2	68.6	21.8	35.0	23.7	77.9	13.2	91.1
S @	2.20	2.39	34.53	1.91	6.96	8.87	2.20	21.5	73.3	76.9	76.1	23.1	49.4	28.4	79.8	20.2	100.0
Whole Coal		100.00	100.00	79.85	20.15	100.00											

Feed quality upgrades for Coal 1 and Coal 2

	Test 2 Upgrades	Size	Ash content %			CV (MJ/kg)			TS content %			AI (mg/Fe)		Ash Reduction	CV Upgrade	TS Reduction	AI Reduction
			Feed	Product	Discard	Feed	Product	Discard	Feed	Product	Discard	Feed	Product				
1#	E1	10x50	36.3	27.1	48.9	18.7	22.0	13.7	1.4	0.6	0.8	1237	486	25.47	17.23	56.45	60.71
	E2	10x50	36.3	24.9	45.8	18.7	23.0	14.5	1.4	0.3	3.2	1237	523	31.30	22.48	81.50	57.72
	E3	10x50	36.3	26.7	41.7	18.7	22.1	16.3	1.4	0.5	1.8	1237	553	26.43	18.15	63.70	55.30
	E4	10x50	36.3	26.0	51.9	18.7	22.0	11.9	1.4	0.5	2.5	1237	513	28.29	17.51	67.26	58.53
	Ave	10x50	**36.3**	**26.2**	**47.1**	**18.7**	**22.3**	**14.1**	**1.4**	**0.5**	**2.1**	**1237**	**518.8**	**27.87**	**18.84**	**67.23**	**58.06**
	F1	10x25	37.1	22.1	41.9	18.3	23.6	16.3	1.4	0.4	0.6	1032	345	40.34	29.26	72.18	66.57
	F2	10x25	37.1	21.7	39.9	18.3	23.6	17.7	1.4	0.2	1.6	1032	382	41.59	29.01	83.27	62.98
	F3	10x25	37.1	24.8	38.0	18.3	22.8	17.7	1.4	0.4	1.6	1032	422	33.25	24.64	71.41	59.11
	F4	10x25	37.1	28.5	37.5	18.3	21.2	18.1	1.4	0.6	1.8	1032	370	23.31	16.08	57.64	64.15
	Ave	10x25	**37.1**	**24.3**	**39.3**	**18.3**	**22.8**	**17.4**	**1.4**	**0.4**	**1.4**	**1032**	**379.8**	**34.62**	**24.75**	**71.12**	**63.20**
	G1	25x50	47.2	31.0	55.3	13.9	20.1	12.2	1.7	0.9	3.1	1938	647	34.34	44.40	50.32	66.62
	G2	25x50	47.2	27.7	55.8	13.9	21.1	11.3	1.7	0.4	3.9	1938	632	41.41	51.52	75.08	67.39
	G3	25x50	47.2	31.1	49.4	13.9	20.9	13.6	1.7	0.9	1.1	1938	687	34.01	49.71	46.88	64.55
	G4	25x50	47.2	28.2	50.6	13.9	21.4	13.7	1.7	0.4	1.4	1938	718	40.25	53.52	75.22	62.95
	G5	25x50	47.2	30.2	54.6	13.9	20.1	11.7	1.7	0.8	2.0	1938	758	36.02	43.97	51.72	60.89
	Ave	25x50	**47.2**	**29.6**	**53.1**	**13.9**	**20.7**	**12.5**	**1.7**	**0.7**	**2.3**	**1938**	**688.4**	**37.21**	**48.63**	**59.84**	**64.48**
2#	H1	10x50	31.1	20.9	43.2	20.1	24.0	15.5	1.6	0.8	2.0	877	241	32.8	19	50	73
	H2	10x50	31.1	19.1	42.8	20.1	24.2	15.2	1.6	0.5	2.1	877	263	38.7	20	67	70
	H3	10x50	31.1	25.4	37.6	20.1	21.7	17.5	1.6	0.8	2.4	877	249	18.2	8	52	72
	H4	10x50	31.1	19.3	44.7	20.1	24.7	15.7	1.6	0.5	0.8	877	272	38.0	23	67	69
	Ave	10x50	**31.1**	**21.2**	**42.1**	**20.1**	**23.6**	**16.0**	**1.6**	**0.7**	**1.8**	**877**	**256.3**	**31.9**	**17.5**	**58.8**	**70.8**
	I1	10x25	27.6	17.8	37.0	21.8	24.7	18.2	1.5	0.5	3.0	568	288	35.7	13	64	49
	I2	10x25	27.6	16.6	38.8	21.8	26.1	17.1	1.5	0.4	2.3	568	328	39.7	20	74	42
	I3	10x25	27.6	16.8	33.5	21.8	25.8	19.2	1.5	0.4	1.8	568	368	39.2	18	71	35
	I4	10x25	27.6	16.6	35.6	21.8	25.1	18.1	1.5	0.5	2.6	568	378	40.0	15	66	33
	Ave	10x25	**27.6**	**16.9**	**36.3**	**21.8**	**25.4**	**18.2**	**1.5**	**0.5**	**2.4**	**568**	**340.5**	**38.6**	**16.6**	**68.6**	**40.1**
	J1	25x50	37.4	22.3	34.8	17.9	23.9	18.1	1.6	1.2	1.6	1233	293	40.3	33	21	76
	J2	25x50	37.4	29.4	41.4	17.9	20.5	16.3	1.6	1.1	2.4	1233	403	21.3	14	30	67
	J3	25x50	37.4	26.5	41.2	17.9	21.7	16.4	1.6	1.2	0.9	1233	313	29.1	21	22	75
	J4	25x50	37.4	29.8	42.8	17.9	20.9	16.2	1.6	0.9	2.8	1233	306	20.3	17	42	75
	Ave	25x50	**37.4**	**27.0**	**40.0**	**17.9**	**21.7**	**16.8**	**1.6**	**1.1**	**1.9**	**1233**	**328.8**	**27.8**	**21.5**	**28.8**	**73.3**
	K1	0x50	28.4	23.1	49.4	20.4	23.3	13.6	1.1	0.5	1.6	601	380	18.8	14	58	37

<u>Efficiency test results for Coal 1 and Coal 2</u>

	Coal 1- 1#												Coal 2- 2#												
Test 2	10X50				10X25				25X50				10X50				10X25				25X50				0x50
	E1	**E2**	**E3**	**E4**	**F1**	**F2**	**F3**	**F4**	**G1**	**G2**	**G3**	**G4**	**H1**	**H2**	**H3**	**H4**	**I1**	**I2**	**I3**	**I4**	**J1**	**J2**	**J3**	**J4**	**K1**
Fan Speed	60	60	60	60	50	50	50	50	65	65	65	65	60	60	60	60	50	50	50	50	65	65	65	65	70
CVR Speed	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30
Feed rate	20	20	40	40	20	20	40	40	20	20	40	40	20	20	40	40	20	20	40	40	20	20	40	40	20
Feed % Ash	36.3	36.3	36.3	36.3	37.1	37.1	37.1	36.3	47.2	47.2	47.2	47.2	31.1	31.1	31.1	31.1	27.6	27.6	27.6	27.6	37.4	37.4	37.4	37.4	28.4
Product % Ash	27.1	24.9	26.7	26.0	22.1	21.7	24.8	28.5	31.0	27.7	31.1	28.2	20.9	19.1	25.4	19.3	17.8	16.6	16.8	16.6	22.3	29.4	26.5	29.8	23.1
Ash Upgrade	25%	**31%**	26%	28%	40%	**42%**	33%	22%	34%	**41%**	34%	40%	33%	**39%**	18%	38%	36%	**40%**	39%	**40%**	**40%**	21%	29%	20%	19%
Discard % Ash	48.9	45.8	41.7	51.9	41.9	39.9	38.0	37.5	55.3	55.8	49.4	50.6	43.2	42.8	37.6	44.7	37.0	38.8	33.5	35.6	34.8	41.4	41.2	42.8	49.4
Product Yield	57.8	45.5	36.0	60.2	24.2	15.4	6.8	4.4	33.3	30.6	12.0	15.2	54.3	49.4	53.3	53.5	49.0	50.5	35.3	42.1	35.9	33.3	25.9	41.5	79.8
D50	1.8687	1.6803	1.6787	1.8975	1.4738	1.4374	1.4159	1.4116	1.6884	1.5893	1.4255	1.4378	1.7268	1.7270	1.7099	1.7554	1.7248	1.6536	1.5334	1.6697	1.5482	1.6470	1.4938	1.5699	1.9929
Ep	0.2490	0.1837	0.1948	0.2124	0.0516	0.0279	0.0101	0.0060	0.1480	0.1364	0.0199	0.0333	0.1679	0.2093	0.0708	0.0712	0.1422	0.1361	0.1016	0.1255	0.1044	0.0920	0.0624	0.1055	0.2377
Org Eff %	71.8	59.1	44.3	76.7	35.7	22.6	9.2	5.4	50.7	50.9	19.4	24.9	67.6	65.1	61.1	68.5	61.9	66.2	47.4	54.5	44.6	40.7	33.5	50.1	88.8
Sink in Float	8.32	9.20	8.94	7.44	11.83	9.26	5.35	3.42	10.91	11.25	8.40	11.00	4.30	5.29	9.43	4.20	8.46	4.66	7.91	5.18	11.75	7.07	10.76	15.68	4.72
Float in Sink	19.60	17.83	34.08	15.76	11.25	10.69	11.34	8.75	20.65	15.15	9.02	10.35	21.41	22.23	21.01	20.69	26.77	22.64	29.10	30.23	17.05	22.94	15.19	17.02	10.44
Total Misplaced	27.92	27.03	43.02	23.20	23.08	19.92	16.68	12.17	31.56	26.37	17.42	21.34	25.72	27.52	30.44	24.89	35.23	27.30	37.01	35.40	28.80	30.01	25.95	32.70	15.16
Near Density %	7.00	25.00	27.00	6.00	32.00	28.00	32.00	30.00	17.00	19.00	22.00	23.00	11.00	12.00	24.00	11.00	12.00	19.00	28.00	19.00	13.00	19.00	34.00	18.00	4.00

Coal 3 efficiency tests results

Coal 3: 10x50mm

Efficiency Analysis : **TEST AA 1 31/05/2022**

Feed % Ash : 28.1
Product % Ash : 22.8
Discard % Ash : 34.3
Product Yield : **53.9**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	28.37	12.07	15.29	5.56	20.86	1.40	100.0	9.8	11.9	10.4	9.8	11.9	10.4	15.3	5.6	20.9
F @ 1.50	22.14	12.44	11.93	5.73	17.67	1.45	67.6	15.1	15.9	15.3	12.1	13.9	12.7	27.2	11.3	38.5
F @ 1.60	17.76	17.39	9.58	8.02	17.59	1.55	54.4	21.8	24.4	23.0	14.6	18.3	15.9	36.8	19.3	56.1
F @ 1.70	14.32	18.34	7.72	8.45	16.17	1.65	47.7	29.2	31.0	30.1	17.2	22.1	19.1	44.5	27.8	72.3
F @ 1.80	7.91	14.12	4.26	6.51	10.77	1.75	39.6	39.7	38.0	38.7	19.1	25.2	21.6	48.8	34.3	83.1
F @ 1.90	1.20	1.25	0.65	0.58	1.23	1.85	52.9	50.7	50.9	50.8	19.5	25.6	22.0	49.4	34.8	84.3
F @ 2.00	2.03	5.23	1.09	2.41	3.50	1.95	31.2	58.3	53.3	54.9	20.4	27.4	23.3	50.5	37.3	87.8
F @ 2.10	1.87	6.36	1.01	2.93	3.94	2.05	25.6	58.3	57.3	57.6	21.1	29.6	24.8	51.5	40.2	91.7
F @ 2.20	3.88	5.68	2.09	2.62	4.71	2.15	44.5	59.6	59.2	59.4	22.6	31.4	26.5	53.6	42.8	96.4
S @ 2.20	0.52	7.11	0.28	3.28	3.56	2.20	7.8	63.7	72.4	71.8	22.8	34.3	28.1	53.9	46.1	100.0
Whole Coal	100.00	100.00	53.91	46.09	100.00											

Efficiency Analysis : **TEST AA 2 31/05/2022**

Feed % Ash : 34.3
Product % Ash : 33.1
Discard % Ash : 43.2
Product Yield : **88.1**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	8.35	0.90	7.36	0.11	7.47	1.40	100.0	13.8	15.2	13.8	13.8	15.2	13.8	7.4	0.1	7.5
F @ 1.50	10.04	1.51	8.85	0.18	9.03	1.45	98.0	15.1	16.8	15.1	14.5	16.2	14.5	16.2	0.3	16.5
F @ 1.60	19.79	4.78	17.44	0.57	18.00	1.55	96.8	18.0	22.1	18.2	16.3	20.1	16.4	33.6	0.9	34.5
F @ 1.70	21.24	8.59	18.72	1.02	19.74	1.65	94.8	27.1	27.6	27.1	20.2	24.2	20.3	52.4	1.9	54.2
F @ 1.80	13.09	19.48	11.54	2.31	13.85	1.75	83.3	36.5	29.4	35.3	23.1	27.1	23.4	63.9	4.2	68.1
F @ 1.90	8.27	9.47	7.29	1.12	8.41	1.85	86.6	45.6	31.0	43.6	25.4	27.9	25.6	71.2	5.3	76.5
F @ 2.00	8.26	11.47	7.28	1.36	8.64	1.95	84.2	58.2	48.2	56.6	28.5	32.0	28.7	78.5	6.7	85.1
F @ 2.10	7.87	25.53	6.94	3.03	9.97	2.05	69.6	69.5	56.3	65.4	31.8	39.6	32.6	85.4	9.7	95.1
F @ 2.20	2.52	13.71	2.22	1.63	3.85	2.15	57.7	74.6	56.8	67.1	32.9	42.1	33.9	87.6	11.3	99.0
S @ 2.20	0.56	4.58	0.49	0.54	1.04	2.20	47.5	78.8	66.6	72.4	33.1	43.2	34.3	88.1	11.9	100.0
Whole Coal	100.00	100.00	88.12	11.88	100.00											

Coal 3: 10x25mm

Efficiency Analysis : **TEST BB 1 31/05/2022**

Feed % Ash : 29.4
Product % Ash : 23.6
Discard % Ash : 32.0
Product Yield : **31.0**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	11.35	7.40	3.51	5.11	8.62	1.40	100.0	10.6	10.8	10.7	10.6	10.8	10.7	3.5	5.1	8.6
F @ 1.50	32.66	19.41	10.11	13.40	23.51	1.45	43.0	13.6	15.6	14.7	12.8	14.3	13.6	13.6	18.5	32.1
F @ 1.60	23.25	18.10	7.20	12.50	19.69	1.55	36.5	20.9	19.4	19.9	15.6	16.3	16.0	20.8	31.0	51.8
F @ 1.70	14.93	15.43	4.62	10.65	15.27	1.65	30.3	30.1	28.7	29.1	18.3	19.5	19.0	25.4	41.7	67.1
F @ 1.80	7.87	15.58	2.44	10.75	13.19	1.75	18.5	39.2	36.9	37.3	20.1	23.0	22.0	27.9	52.4	80.3
F @ 1.90	4.28	6.15	1.33	4.24	5.57	1.85	23.8	49.7	46.8	47.5	21.4	24.8	23.7	29.2	56.7	85.9
F @ 2.00	3.37	7.67	1.04	5.29	6.34	1.95	16.4	54.4	56.8	56.4	22.6	27.6	25.9	30.2	62.0	92.2
F @ 2.10	1.98	1.97	0.61	1.36	1.97	2.05	31.0	68.4	69.5	69.1	23.5	28.5	26.8	30.9	63.3	94.2
F @ 2.20	0.32	7.03	0.10	4.85	4.95	2.15	2.0	77.7	69.8	69.9	23.6	31.4	29.0	31.0	68.2	99.1
S @ 2.20	0.00	1.28	0.00	0.89	0.89	2.20	0.0	77.7	74.1	74.1	23.6	32.0	29.4	31.0	69.0	100.0
Whole Coal	100.00	100.00	30.95	69.05	100.00											

Efficiency Analysis : **TEST BB2 31/05/2022**

Feed % Ash : 32.0
Product % Ash : 29.7
Discard % Ash : 43.7
Product Yield : **83.6**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	7.94	1.25	6.64	0.20	6.84	1.40	100.0	10.1	14.1	10.2	10.1	14.1	10.2	6.6	0.2	6.8
F @ 1.50	22.01	4.07	18.40	0.67	19.07	1.45	96.5	15.6	14.8	15.6	14.1	14.7	14.2	25.0	0.9	25.9
F @ 1.60	19.01	8.68	15.89	1.43	17.31	1.55	91.8	21.5	21.0	21.5	17.0	18.6	17.1	40.9	2.3	43.2
F @ 1.70	19.30	16.27	16.13	2.67	18.80	1.65	85.8	29.1	28.7	29.0	20.4	24.0	20.7	57.0	5.0	62.0
F @ 1.80	13.00	20.23	10.86	3.32	14.19	1.75	76.6	38.9	34.4	37.9	23.4	28.2	23.9	67.9	8.3	76.2
F @ 1.90	8.74	28.09	7.31	4.61	11.92	1.85	61.3	53.8	54.9	54.2	26.3	37.8	28.0	75.2	12.9	88.1
F @ 2.00	4.40	4.77	3.68	0.78	4.46	1.95	82.4	54.3	55.7	54.5	27.6	38.8	29.3	78.9	13.7	92.6
F @ 2.10	4.22	7.75	3.53	1.27	4.80	2.05	73.5	62.8	63.9	63.1	29.1	40.9	31.0	82.4	15.0	97.4
F @ 2.20	1.38	5.53	1.15	0.91	2.06	2.15	55.9	72.5	71.9	72.2	29.7	42.7	31.8	83.6	15.9	99.4
S @ 2.20	0.00	3.36	0.00	0.55	0.55	2.20	0.0	72.5	73.2	73.2	29.7	43.7	32.0	83.6	16.4	100.0
Whole Coal	100.00	100.00	83.57	16.43	100.00											

Coal 3: 25x50mm

Efficiency Analysis : **TEST CC 1 31/05/2022**

Feed % Ash : 27.6
Product % Ash : 22.5
Discard % Ash : 28.9
Product Yield : **20.3**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	18.18	6.83	3.69	5.45	9.14	1.40	100.0	10.6	12.3	11.6	10.6	12.3	11.6	3.7	5.4	9.1
F @ 1.50	33.72	12.31	6.85	9.81	16.66	1.45	41.1	12.8	14.4	13.7	12.0	13.6	13.0	10.5	15.3	25.8
F @ 1.60	20.28	27.74	4.12	22.11	26.22	1.55	15.7	24.5	19.4	20.2	15.5	17.0	16.6	14.7	37.4	52.0
F @ 1.70	12.53	24.75	2.55	19.72	22.27	1.65	11.4	31.3	26.9	27.4	17.8	20.5	19.8	17.2	57.1	74.3
F @ 1.80	6.64	9.94	1.35	7.92	9.27	1.75	14.6	37.0	37.6	37.5	19.2	22.5	21.8	18.6	65.0	83.6
F @ 1.90	2.79	4.44	0.57	3.54	4.10	1.85	13.8	44.5	44.3	44.4	20.0	23.7	22.9	19.1	68.5	87.7
F @ 2.00	2.07	3.45	0.42	2.75	3.17	1.95	13.3	53.0	52.8	52.8	20.7	24.8	23.9	19.5	71.3	90.8
F @ 2.10	1.97	3.56	0.40	2.84	3.24	2.05	12.4	65.0	55.0	56.2	21.6	25.9	25.0	19.9	74.1	94.1
F @ 2.20	1.57	5.46	0.32	4.35	4.67	2.15	6.8	74.1	68.1	68.5	22.4	28.3	27.1	20.3	78.5	98.7
S @ 2.20	0.24	1.52	0.05	1.21	1.26	2.20	3.9	74.4	71.0	71.2	22.5	28.9	27.6	20.3	79.7	100.0
Whole Coal	100.00	100.00	20.31	79.69	100.00											

Efficiency Analysis : **TEST CC 2 31/05/2022**

Feed % Ash : 28.9
Product % Ash : 25.9
Discard % Ash : 35.0
Product Yield : **67.0**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	14.82	4.18	9.93	1.38	11.31	1.40	100.0	11.7	11.2	11.6	11.7	11.2	11.6	9.9	1.4	11.3
F @ 1.50	15.54	5.97	10.42	1.97	12.38	1.45	84.1	14.6	15.6	14.7	13.2	13.8	13.2	20.3	3.3	23.7
F @ 1.60	27.89	18.18	18.69	5.99	24.69	1.55	75.7	19.1	19.2	19.1	16.0	17.2	16.2	39.0	9.3	48.4
F @ 1.70	19.02	27.18	12.75	8.96	21.71	1.65	58.7	30.5	22.5	27.2	19.6	19.8	19.6	51.8	18.3	70.1
F @ 1.80	9.37	11.43	6.28	3.77	10.05	1.75	62.5	35.3	38.4	36.5	21.3	23.0	21.8	58.1	22.1	80.1
F @ 1.90	8.45	17.58	5.67	5.80	11.46	1.85	49.4	50.6	54.1	52.4	23.9	29.5	25.6	63.7	27.9	91.6
F @ 2.00	2.13	3.31	1.43	1.09	2.52	1.95	56.7	52.6	56.4	54.2	24.5	30.5	26.4	65.2	29.0	94.1
F @ 2.10	2.05	4.68	1.38	1.54	2.92	2.05	47.1	74.1	65.5	69.5	25.5	32.2	27.6	66.5	30.5	97.0
F @ 2.20	0.74	6.29	0.50	2.07	2.57	2.15	19.3	75.5	69.0	70.3	25.9	34.6	28.7	67.0	32.6	99.6
S @ 2.20	0.00	1.19	0.00	0.39	0.39	2.20	0.0	75.5	70.3	70.3	25.9	35.0	28.9	67.0	33.0	100.0
Whole Coal	100.00	100.00	67.03	32.97	100.00											

Efficiency Analysis : **TEST CC 3 31/05/2022**

Feed % Ash : 28.9
Product % Ash : 22.8
Discard % Ash : 30.5
Product Yield : **20.8**

sanas T0590

Rel.Dens.	% Weight Prod	% Weight Disc	% of Feed Prod	% of Feed Disc	Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash Prod	Fractional Ash Disc	Fractional Ash Feed	Cumulative Ash Prod	Cumulative Ash Disc	Cumulative Ash Feed	Cumulative Yield Prod	Cumulative Yield Disc	Cumulative Yield Feed
F @ 1.40	19.60	6.38	4.07	5.05	9.12	1.40	100.0	10.9	13.4	12.3	10.9	13.4	12.3	4.1	5.1	9.1
F @ 1.50	30.92	11.10	6.42	8.79	15.22	1.45	42.2	15.2	19.4	17.6	13.5	17.2	15.6	10.5	13.8	24.3
F @ 1.60	22.18	21.49	4.61	17.02	21.63	1.55	21.3	22.9	18.3	19.3	16.4	17.8	17.3	15.1	30.9	46.0
F @ 1.70	12.81	25.17	2.66	19.94	22.60	1.65	11.8	31.1	27.0	27.5	18.6	21.4	20.7	17.8	50.8	68.6
F @ 1.80	7.42	13.32	1.54	10.55	12.09	1.75	12.8	39.2	35.4	35.9	20.2	23.8	23.0	19.3	61.4	80.7
F @ 1.90	3.89	12.55	0.81	9.94	10.75	1.85	7.5	50.2	46.2	46.5	21.4	26.9	25.7	20.1	71.3	91.4
F @ 2.00	2.04	3.73	0.42	2.96	3.38	1.95	12.5	58.1	52.8	53.4	22.2	28.0	26.7	20.5	74.3	94.8
F @ 2.10	1.13	3.92	0.24	3.11	3.34	2.05	7.0	79.3	66.8	67.7	22.8	29.5	28.1	20.8	77.4	98.1
F @ 2.20	0.00	1.35	0.00	1.07	1.07	2.15	0.0	79.3	72.3	72.3	22.8	30.1	28.6	20.8	78.4	99.2
S @ 2.20	0.00	0.99	0.00	0.79	0.79	2.20	0.0	79.3	71.3	71.3	22.8	30.5	28.9	20.8	79.2	100.0
Whole Coal	100.00	100.00	20.78	79.22	100.00											

Feed quality upgrades for Coal 3

Test 3 Upgrades	Size	Ash content % Feed	Ash content % Product	Ash content % Discard	CV (MJ/kg) Feed	CV (MJ/kg) Product	CV (MJ/kg) Discard	TS content % Feed	TS content % Product	TS content % Discard	AI (mg/Fe) Feed	AI (mg/Fe) Product	Ash Reduction	CV Upgrade	TS Reduction	AI Reduction
AA1	10x50mm	28.1	**22.8**	34.3	22.5	23	20.6	1.74	0.91	1.49	238	131	18.86	2.22	47.70	44.96
AA2		34.3	**33.1**	43.2	20.6	21.7	16.9	1.49	1	3.66	74	62	3.50	5.34	32.89	16.22
BB1	10x25mm	29.4	**23.6**	32	21.8	24.4	20.9	1.26	0.61	1.57	143	57	19.73	11.93	51.59	60.14
BB2		32	**29.7**	43.7	20.9	22.2	17.6	1.57	1.5	3.97	141	137	7.19	6.22	4.46	2.84
CC1	25x50mm	27.6	**22.5**	28.9	22.9	24.3	22.4	1.3	0.75	1.68	354	161	18.48	6.11	42.31	54.52
CC2		28.9	**25.9**	35	22.4	23.3	19.1	1.68	0.77	3.87	363	58	10.38	4.02	54.17	84.02
CC3		28.9	**22.8**	30.5	22.4	24.7	21.4	1.68	1	2.89	363	222	21.11	10.27	40.48	38.84
DD1	10x50mm	28.1	**25.9**	36.7	22.5	23.2	20.7	1.74	1.08	1.96	238	300	7.83	3.11	37.93	-26.05
EE1	10x25mm	29.4	**26.3**	42.6	21.8	22.6	18	1.26	0.89	3.29	143	202	10.54	3.67	29.37	-41.26
FF1	25x50mm	27.6	**26.4**	40.3	22.9	23.5	18	1.3	1.05	3.81	354	194	4.35	2.62	19.23	45.20

Efficiency test results for Coal 3

Test 3	10x50mm AA1	10x50mm AA2	10x25mm BB1	10x25mm BB2	25x50mm CC1	25x50mm CC2	25x50mm CC3	10x50mm DD1	10x25mm EE1	25x50mm FF1
Fan Speed	60	70	55	70	60	65	60	70	70	70
CVR Speed	30	30	30	30	30	30	30	30	30	30
Feed rate	20	20	20	20	20	20	20	20	20	20
Feed % Ash	28.1	34.3	29.4	32	27.6	28.9	28.9	28.1	29.4	27.6
Product % Ash	**22.8**	**33.1**	**23.6**	**29.7**	**22.5**	**25.9**	**22.8**	**25.9**	**26.3**	**26.4**
Ash Reduction	18.86	3.50	19.73	7.19	18%	10%	21%	8%	11%	4%
Discard % Ash	34.3	43.2	32	43.7	28.9	35	30.5	36.7	42.6	40.3
Product Yield	53.9	88.1	31	83.6	20.3	67	20.8	79.6	81	91.4
D50	1.698	2.181	1.4522	2.1491	1.4403	1.8554	1.4446	2.0133	1.7887	2.0395
Ep	0.2134	0.1473	0.0529	0.0449	0.0316	0.2066	0.0332	0.2301	0.0004	0.7497
Org Eff	62.4	91.2	36.1	89	23.5	72.4	26	83.5	88.2	93.3
Sink in Float	9.52	0.76	21.92	0.38	13.64	5.51	13.71	3.03	11.85	11.2
Float in Sink	27.59	11.09	12.13	15.48	8.3	25.41	8.32	17.76	9.57	21.95
Total Misplaced	37.11	11.85	34.06	15.86	21.94	30.93	22.04	20.78	21.42	33.15
Near Density	27.04	6.8	36.41	5.1	28.32	17.37	26.02	4.83	14.94	3.41

Coal 4 efficiency tests results

Coal 4: 0x50mm

Efficiency Analysis : **TEST T1 01/12/2022**

Feed % Ash : 45.4
Product % Ash : 35.9
Discard % Ash : 55.1
Product Yield : **50.5**

T0590

Rel.Dens.	% Weight Prod	% Weight Disc	% of Feed Prod	% of Feed Disc	Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash Prod	Fractional Ash Disc	Fractional Ash Feed	Cumulative Ash Prod	Cumulative Ash Disc	Cumulative Ash Feed	Cumulative Yield Prod	Cumulative Yield Disc	Cumulative Yield Feed
F @ 1.40	40.55	23.39	20.49	11.57	32.06	1.40	100.0	16.6	16.6	16.6	16.6	16.6	16.6	20.5	11.6	32.1
F @ 1.50	20.04	6.90	10.12	3.42	13.54	1.45	74.8	28.2	30.2	28.7	20.4	19.7	20.2	30.6	15.0	45.6
F @ 1.60	12.83	6.44	6.48	3.19	9.66	1.55	67.0	39.6	34.2	37.8	23.8	22.3	23.3	37.1	18.2	55.3
F @ 1.70	7.60	9.02	3.84	4.46	8.30	1.65	46.3	55.4	40.1	47.2	26.7	25.8	26.4	40.9	22.6	63.6
F @ 1.80	4.25	2.60	2.15	1.29	3.43	1.75	62.5	58.5	50.0	55.3	28.3	27.1	27.9	43.1	23.9	67.0
F @ 1.90	0.51	1.99	0.26	0.98	1.24	1.85	20.7	63.2	51.0	53.5	28.5	28.0	28.3	43.3	24.9	68.2
F @ 2.00	0.89	1.13	0.45	0.56	1.01	1.95	44.7	67.4	52.5	59.2	28.9	28.6	28.8	43.8	25.5	69.3
F @ 2.10	0.93	1.84	0.47	0.91	1.38	2.05	34.1	70.8	67.9	68.9	29.4	29.9	29.6	44.3	26.4	70.6
F @ 2.20	3.82	8.92	1.93	4.41	6.34	2.15	30.4	81.1	81.7	81.5	31.5	37.4	33.9	46.2	30.8	77.0
S @ 2.20	8.58	37.76	4.33	18.69	23.02	2.20	18.8	82.3	84.3	83.9	35.9	55.1	45.4	50.5	49.5	100.0
Whole Coal	100.00	100.00	50.52	49.48	100.00											

Efficiency Analysis : **TEST T2 01/12/2022**

Feed % Ash : 45.4
Product % Ash : 33.8
Discard % Ash : 59.7
Product Yield : **55.2**

T0590

Rel.Dens.	% Weight Prod	% Weight Disc	% of Feed Prod	% of Feed Disc	Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash Prod	Fractional Ash Disc	Fractional Ash Feed	Cumulative Ash Prod	Cumulative Ash Disc	Cumulative Ash Feed	Cumulative Yield Prod	Cumulative Yield Disc	Cumulative Yield Feed
F @ 1.40	50.67	14.47	27.98	6.48	34.46	1.40	100.0	17.9	18.3	18.0	17.9	18.3	18.0	28.0	6.5	34.5
F @ 1.50	12.73	6.01	7.03	2.69	9.72	1.45	72.3	29.5	27.5	29.0	20.2	21.0	20.4	35.0	9.2	44.2
F @ 1.60	11.60	7.27	6.40	3.26	9.66	1.55	66.3	37.8	36.9	37.5	23.0	25.1	23.5	41.4	12.4	53.8
F @ 1.70	6.96	5.83	3.84	2.61	6.45	1.65	59.5	48.4	37.9	44.2	25.1	27.4	25.7	45.3	15.0	60.3
F @ 1.80	4.74	3.83	2.62	1.72	4.33	1.75	60.4	58.2	42.9	52.1	26.9	29.0	27.5	47.9	16.8	64.6
F @ 1.90	1.11	4.16	0.61	1.86	2.48	1.85	24.7	63.4	52.6	55.3	27.4	31.3	28.5	48.5	18.6	67.1
F @ 2.00	1.63	2.72	0.90	1.22	2.12	1.95	42.4	71.9	63.7	67.2	28.2	33.3	29.7	49.4	19.8	69.2
F @ 2.10	1.27	3.60	0.70	1.61	2.31	2.05	30.3	75.8	69.2	71.2	28.9	36.0	31.0	50.1	21.5	71.5
F @ 2.20	2.36	6.10	1.30	2.73	4.03	2.15	32.3	80.3	78.0	78.7	30.2	40.7	33.6	51.4	24.2	75.6
S @ 2.20	6.94	46.00	3.83	20.60	24.44	2.20	15.7	82.5	81.9	82.0	33.8	59.7	45.4	55.2	44.8	100.0
Whole Coal	100.00	100.00	55.21	44.79	100.00											

Coal 4: 25x50mm

Efficiency Analysis : **TEST T3 01/12/2022**

Feed % Ash : 41.6
Product % Ash : 27.8
Discard % Ash : 67.0
Product Yield : **64.8**

T0590

Rel.Dens.	% Weight Prod	% Weight Disc	% of Feed Prod	% of Feed Disc	Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash Prod	Fractional Ash Disc	Fractional Ash Feed	Cumulative Ash Prod	Cumulative Ash Disc	Cumulative Ash Feed	Cumulative Yield Prod	Cumulative Yield Disc	Cumulative Yield Feed
F @ 1.40	18.39	4.42	11.91	1.56	13.47	1.40	100.0	13.6	14.1	13.6	13.6	14.1	13.6	11.9	1.6	13.5
F @ 1.50	20.68	4.53	13.40	1.59	15.00	1.45	89.4	19.6	28.9	20.6	16.8	21.6	17.3	25.3	3.1	28.5
F @ 1.60	27.59	7.12	17.88	2.51	20.38	1.55	87.7	20.9	35.3	22.6	18.5	27.6	19.5	43.2	5.7	48.8
F @ 1.70	14.97	4.67	9.70	1.64	11.34	1.65	85.5	28.5	38.4	30.0	20.3	30.1	21.5	52.9	7.3	60.2
F @ 1.80	6.69	5.98	4.33	2.11	6.44	1.75	67.3	37.3	47.7	40.7	21.6	34.0	23.3	57.2	9.4	66.6
F @ 1.90	2.28	11.01	1.48	3.88	5.36	1.85	27.6	52.4	56.7	55.5	22.4	40.7	25.7	58.7	13.3	72.0
F @ 2.00	0.94	4.01	0.61	1.41	2.02	1.95	30.0	60.9	60.8	60.8	22.8	42.6	26.7	59.3	14.7	74.0
F @ 2.10	1.24	2.18	0.81	0.77	1.57	2.05	51.3	68.1	79.3	73.6	23.4	44.4	27.7	60.1	15.5	75.6
F @ 2.20	3.04	7.60	1.97	2.68	4.64	2.15	42.4	81.3	80.3	80.7	25.2	49.7	30.7	62.1	18.1	80.2
S @ 2.20	4.18	48.49	2.71	17.07	19.78	2.20	13.7	88.1	85.4	85.7	27.8	67.0	41.6	64.8	35.2	100.0
Whole Coal	100.00	100.00	64.80	35.20	100.00											

Efficiency Analysis :	**TEST T4 01/12/2022**
Feed % Ash :	41.6
Product % Ash :	31.7
Discard % Ash :	54.1
Product Yield :	**55.8**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	26.61	9.02	14.85	3.98	18.83	1.40	100.0	13.1	12.6	13.0	13.1	12.6	13.0	14.8	4.0	18.8
F @ 1.50	19.62	7.40	10.95	3.27	14.22	1.45	77.0	18.8	20.4	19.2	15.5	16.1	15.6	25.8	7.3	33.0
F @ 1.60	22.54	10.51	12.58	4.64	17.22	1.55	73.0	28.7	26.6	28.1	19.8	20.2	19.9	38.4	11.9	50.3
F @ 1.70	1.60	8.46	0.89	3.74	4.63	1.65	19.3	36.1	33.8	34.3	20.2	23.5	21.1	39.3	15.6	54.9
F @ 1.80	6.13	6.24	3.42	2.76	6.18	1.75	55.4	47.0	41.8	44.7	22.3	26.2	23.5	42.7	18.4	61.1
F @ 1.90	14.52	8.77	8.10	3.88	11.98	1.85	67.6	52.4	45.2	50.1	27.1	29.5	27.9	50.8	22.3	73.1
F @ 2.00	1.13	2.64	0.63	1.16	1.80	1.95	35.2	55.3	53.1	53.9	27.5	30.7	28.5	51.4	23.4	74.9
F @ 2.10	0.84	2.08	0.47	0.92	1.39	2.05	33.7	80.3	70.7	73.9	28.0	32.2	29.3	51.9	24.4	76.2
F @ 2.20	1.58	4.59	0.88	2.03	2.91	2.15	30.2	80.4	80.7	80.6	28.8	35.9	31.2	52.8	26.4	79.2
S @ 2.20	5.44	40.29	3.04	17.81	20.84	2.20	14.6	81.3	81.1	81.1	31.7	54.1	41.6	55.8	44.2	100.0
Whole Coal	100.00	100.00	55.80	44.20	100.00											

Coal 4: 10x25mm

Efficiency Analysis :	**TEST T5 01/12/2022**
Feed % Ash :	35.0
Product % Ash :	31.7
Discard % Ash :	63.4
Product Yield :	**89.6**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	39.55	6.62	35.43	0.69	36.12	1.40	100.0	15.6	15.7	15.6	15.6	15.7	15.6	35.4	0.7	36.1
F @ 1.50	14.80	3.51	13.26	0.37	13.63	1.45	97.3	20.8	21.3	20.8	17.0	17.6	17.0	48.7	1.1	49.7
F @ 1.60	14.33	4.55	12.84	0.47	13.31	1.55	96.4	30.4	27.6	30.3	19.8	20.7	19.8	61.5	1.5	63.1
F @ 1.70	11.42	6.89	10.23	0.72	10.95	1.65	93.4	38.1	35.4	37.9	22.4	25.4	22.5	71.8	2.2	74.0
F @ 1.80	5.32	4.36	4.77	0.45	5.22	1.75	91.3	49.2	35.9	48.1	24.1	27.2	24.2	76.5	2.7	79.2
F @ 1.90	1.02	9.45	0.92	0.98	1.90	1.85	48.3	54.5	44.7	49.4	24.4	31.9	24.8	77.4	3.7	81.1
F @ 2.00	1.61	3.54	1.44	0.37	1.81	1.95	79.6	60.3	60.8	60.4	25.1	34.5	25.5	78.9	4.1	82.9
F @ 2.10	1.29	3.57	1.15	0.37	1.52	2.05	75.6	70.6	67.3	69.7	25.7	37.2	26.3	80.0	4.4	84.5
F @ 2.20	3.89	12.39	3.49	1.29	4.78	2.15	73.0	81.5	81.5	81.5	28.1	47.2	29.3	83.5	5.7	89.2
S @ 2.20	6.76	45.13	6.06	4.70	10.76	2.20	56.3	81.8	83.0	82.3	31.7	63.4	35.0	89.6	10.4	100.0
Whole Coal	100.00	100.00	89.59	10.41	100.00											

Efficiency Analysis :	**TEST T6 01/12/2022**
Feed % Ash :	35.0
Product % Ash :	28.3
Discard % Ash :	39.1
Product Yield :	**38.0**

Rel.Dens.	% Weight		% of Feed		Calc. Feed	Mean RD	Part. Coeff.	Fractional Ash			Cumulative Ash			Cumulative Yield		
	Prod	Disc	Prod	Disc				Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @ 1.40	43.11	23.01	16.37	14.27	30.64	1.40	100.0	14.5	15.8	15.1	14.5	15.8	15.1	16.4	14.3	30.6
F @ 1.50	17.09	14.24	6.49	8.83	15.32	1.45	42.3	21.7	22.1	21.9	16.6	18.2	17.4	22.9	23.1	46.0
F @ 1.60	14.36	15.00	5.45	9.30	14.76	1.55	37.0	30.2	30.1	30.1	19.2	21.6	20.5	28.3	32.4	60.7
F @ 1.70	10.48	15.39	3.98	9.55	13.52	1.65	29.4	38.3	37.0	37.4	21.5	25.1	23.6	32.3	42.0	74.2
F @ 1.80	4.28	7.74	1.63	4.80	6.43	1.75	25.3	47.9	43.6	44.7	22.8	27.0	25.2	33.9	46.8	80.7
F @ 1.90	1.38	2.23	0.52	1.38	1.91	1.85	27.4	55.8	45.4	48.2	23.3	27.5	25.8	34.4	48.1	82.6
F @ 2.00	1.39	2.16	0.53	1.34	1.86	1.95	28.3	58.3	60.2	59.7	23.8	28.4	26.5	35.0	49.5	84.4
F @ 2.10	1.28	1.74	0.49	1.08	1.57	2.05	31.1	73.0	72.9	72.9	24.5	29.4	27.4	35.4	50.6	86.0
F @ 2.20	3.12	7.06	1.18	4.38	5.56	2.15	21.3	81.6	81.1	81.2	26.4	33.5	30.6	36.6	54.9	91.6
S @ 2.20	3.51	11.44	1.33	7.10	8.43	2.20	15.8	83.0	82.8	82.9	28.3	39.1	35.0	38.0	62.0	100.0
Whole Coal	100.00	100.00	37.96	62.04	100.00											

Efficiency Analysis : **TEST T7 01/12/2022**

Feed % Ash :	35.0
Product % Ash :	25.0
Discard % Ash :	39.1
Product Yield :	**29.1**

SANAS Testing Laboratory T0590

Rel.Dens.		% Weight		% of Feed		Calc.	Mean	Part.	Fractional Ash			Cumulative Ash			Cumulative Yield		
		Prod	Disc	Prod	Disc	Feed	RD	Coeff.	Prod	Disc	Feed	Prod	Disc	Feed	Prod	Disc	Feed
F @	1.40	50.66	12.05	14.73	8.55	23.28	1.40	100.0	13.3	13.9	13.5	13.3	13.9	13.5	14.7	8.5	23.3
F @	1.50	12.82	14.43	3.73	10.23	13.96	1.45	26.7	22.6	16.2	17.9	15.2	15.2	15.2	18.5	18.8	37.2
F @	1.60	13.99	13.24	4.07	9.39	13.46	1.55	30.2	29.2	24.0	25.6	17.7	18.1	17.9	22.5	28.2	50.7
F @	1.70	9.46	19.19	2.75	13.61	16.36	1.65	16.8	36.1	34.5	34.7	19.7	23.4	22.0	25.3	41.8	67.1
F @	1.80	5.75	6.79	1.67	4.82	6.49	1.75	25.8	46.6	44.7	45.2	21.4	25.6	24.1	26.9	46.6	73.5
F @	1.90	1.53	1.87	0.44	1.32	1.77	1.85	25.1	52.3	51.6	51.8	21.9	26.4	24.7	27.4	47.9	75.3
F @	2.00	0.61	3.11	0.18	2.21	2.39	1.95	7.4	56.9	52.5	52.9	22.1	27.5	25.6	27.6	50.1	77.7
F @	2.10	0.76	1.70	0.22	1.20	1.43	2.05	15.6	65.4	57.7	58.9	22.5	28.2	26.2	27.8	51.3	79.1
F @	2.20	0.41	2.15	0.12	1.53	1.64	2.15	7.2	76.6	62.7	63.7	22.7	29.2	27.0	27.9	52.9	80.8
S @	2.20	4.02	25.47	1.17	18.06	19.23	2.20	6.1	81.0	67.9	68.7	25.0	39.1	35.0	29.1	70.9	100.0
Whole Coal		100.00	100.00	29.08	70.92	100.00											

Feed quality upgrades for Coal 4

Test 4	0x50mm		25x50mm		10x25mm		
	T1	**T2**	**T4**	**T3**	**T7**	**T6**	**T5**
Fan Speed	70	75	70	75	60	65	70
CVR Speed	30	30	30	30	30	30	30
Feed rate	20	20	20	20	20	20	20
Feed % Ash	45.4	45.4	41.6	41.6	35	35	35
Product % Ash	35.9	33.8	31.7	27.8	25	28.3	31.7
Ash Reduction	21%	26%	24%	33%	29%	19%	9%
Discard % Ash	55.1	59.7	54.1	67	39.1	39.1	63.4
Product Yield	50.5	55.2	55.8	64.8	29.1	38.0	89.6
D50	1.71	1.80	1.74	1.79	1.43	1.44	2.20
Ep	0.2397	0.2379	0.1865	0.9907	0.0263	0.6665	0.2629
Org Eff	62.6	72.7	69.5	85.5	68.2	63.4	95.9
Sink in Float	9.32	7.41	16.2	7.74	13.35	18.75	6.25
Float in Sink	22.89	16.68	16.58	9.2	11.57	18.04	5.64
Total Misplaced	32.21	24.09	32.78	16.94	24.92	36.79	11.89
Near Density	11.08	6.96	13.44	12.18	29.7	30	8

<u>Efficiency test results for Coal 4</u>

TM (%)	Test 4 Upgrades	Size	Ash content %			CV (MJ/kg)			TS content %			AI (mg/Fe)		Ash Reduction	CV Upgrade	TS Reduction	AI Reduction
			Feed	Product	Discard	Feed	Product	Discard	Feed	Product	Discard	Feed	Product				
8.2	T1	0x50mm	45.4	35.9	55.1	15.86	19.66	13.1	1.01	0.57	0.72	1004		20.93	23.96	43.56	
	T2		45.4	33.8	59.7	15.86	19.76	10.46	1.01	0.62	2.36	1004		25.55	24.59	38.61	
7	T3	25x50mm	41.6	27.8	67	17.7	21.65	8.87	1.33	0.78	1.93	964		33.17	22.32	41.35	
	T4		41.6	31.7	54.1	17.7	20.75	11.97	1.33	0.96	0.55	964		23.80	17.23	27.82	
7.9	T5	10x25mm	35	31.7	63.4	17.6	21.35	9.37	1.27	0.38	0.59	600		9.43	21.31	70.08	
	T6		35	28.3	39.1	17.6	22.34	18.08	1.27	0.34	0.56	600		19.14	26.93	73.23	
	T7		35	25	39.1	17.6	23.54	17.39	1.27	0.53	0.9	600		28.57	33.75	58.27	

ANNEXURE D

Fractional analysis and particle size distribution (wet and dry) for Coal 4

Fraction	CV (MJ/Kg)	MIAS (%)	VM (%)	ASH (%)	FC (%)	TS (%)
Dry +50mm	17.63	3.2	18.1	43.4	35.4	1.61
Dry +25mm	22.90	3.3	24.3	27.8	44.6	0.99
Dry +10mm	21.72	3.4	24.3	30.4	41.9	1.21
Dry -10mm	18.95	3.9	21.8	36.6	37.7	0.66
Wet +50mm	21.78	3.4	24.0	30.5	42.1	0.61
Wet +25mm	21.50	3.1	23.9	31.6	41.4	0.83
Wet +10mm	21.55	3.5	24.0	31.1	41.5	0.88
Wet -10mm	17.54	3.9	20.1	39.9	36.1	0.75

SepAir blockages caused by Coal 4 material

Feeder blockages:



Uptake nozzle blockages- no separation (all material reporting to the discard conveyor):

ANNEXURE E

ANOVA results for Coal 1 and Coal 2 for Coal type, coal size, feed rate (tph), and mesh conveyor speed (CVR)

ANOVA Results Coal 1 and 2	Variable	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Coal	Product.Yield.Perc	1	1678.0	1678.0	7.51	0.01
Coal.Size	Product.Yield.Perc	2	2219.7	1109.9	4.96	0.01
Tph	**Product.Yield.Perc**	**1**	**1339.1**	**1339.1**	**5.99**	**0.02**
CVR..Hz.	Product.Yield.Perc	1	747.6	747.6	3.34	0.07
Coal:Coal.Size	Product.Yield.Perc	2	1986.4	993.2	4.44	0.02
Residuals	Product.Yield.Perc	50	11178.9	223.6	NA	NA
Coal 1	D50	1	0.8	0.8	21.26	0.00
Coal.Size 1	D50	2	0.1	0.0	0.97	0.38
Tph 1	D50	1	0.1	0.1	2.37	0.13
CVR..Hz. 1	D50	1	0.0	0.0	0.08	0.77
Coal:Coal.Size1	D50	2	0.2	0.1	2.46	0.10
Residuals 1	D50	52	2.0	0.0	NA	NA
Coal 2	Ep	1	0.0	0.0	0.52	0.48
Coal.Size 2	Ep	2	0.0	0.0	19.58	0.00
Tph 2	**Ep**	**1**	**0.0**	**0.0**	**15.53**	**0.00**
CVR..Hz. 2	Ep	1	0.0	0.0	0.01	0.92
Coal:Coal.Size2	Ep	2	0.0	0.0	15.43	0.00
Residuals 2	Ep	16	0.0	0.0	NA	NA
Coal 3	Organic.Efficiency	1	1512.4	1512.4	15.88	0.00
Coal.Size 3	Organic.Efficiency	2	3522.2	1761.1	18.49	0.00
Tph 3	**Organic.Efficiency**	**1**	**838.7**	**838.7**	**8.81**	**0.01**
CVR..Hz. 3	Organic.Efficiency	1	58.7	58.7	0.62	0.44
Coal:Coal.Size3	Organic.Efficiency	2	1652.3	826.2	8.68	0.00
Residuals 3	Organic.Efficiency	16	1523.8	95.2	NA	NA
Coal 4	Product.Ash	1	296.9	296.9	46.07	0.00
Coal.Size 4	Product.Ash	2	434.7	217.3	33.72	0.00
Tph 4	Product.Ash	1	0.0	0.0	0.00	0.99
CVR..Hz. 4	Product.Ash	1	4.1	4.1	0.63	0.43
Coal:Coal.Size4	Product.Ash	2	4.8	2.4	0.37	0.69
Residuals 4	Product.Ash	52	335.2	6.4	NA	NA
Coal 5	Product.CV	1	31.9	31.9	28.51	0.00
Coal.Size 5	Product.CV	2	66.2	33.1	29.57	0.00
Tph 5	Product.CV	1	0.0	0.0	0.03	0.87
CVR..Hz. 5	Product.CV	1	0.8	0.8	0.67	0.42
Coal:Coal.Size5	Product.CV	2	0.8	0.4	0.38	0.69

Residuals 5	Product.CV	52	58.2	1.1	NA	NA
Coal 6	Product.TS	1	1.0	1.0	11.34	0.00
Coal.Size 6	Product.TS	2	5.9	2.9	34.12	0.00
Tph 6	Product.TS	1	0.0	0.0	0.02	0.88
CVR..Hz. 6	Product.TS	1	0.3	0.3	3.75	0.06
Coal:Coal.Size6	Product.TS	2	0.6	0.3	3.27	0.05
Residuals 6	Product.TS	52	4.5	0.1	NA	NA
Coal 7	Product.AI	1	682986.7	682986.7	142.70	0.00
Coal.Size 7	Product.AI	2	20369.7	10184.9	2.13	0.13
Tph 7	Product.AI	1	7926.7	7926.7	1.66	0.20
CVR..Hz. 7	Product.AI	1	5940.2	5940.2	1.24	0.27
Coal:Coal.Size7	Product.AI	2	157079.6	78539.8	16.41	0.00
Residuals 7	Product.AI	52	248887.4	4786.3	NA	NA
Coal 8	Perc.Ash.upgrade	1	0.0	0.0	0.67	0.42
Coal.Size 8	Perc.Ash.upgrade	2	0.0	0.0	0.71	0.49
Tph 8	Perc.Ash.upgrade	1	0.0	0.0	0.02	0.88
CVR..Hz. 8	Perc.Ash.upgrade	1	0.0	0.0	0.67	0.42
Coal:Coal.Size8	Perc.Ash.upgrade	2	0.0	0.0	3.73	0.03
Residuals 8	Perc.Ash.upgrade	52	0.3	0.0	NA	NA
Coal 9	Perc.CV.upgrade	1	0.1	0.1	15.77	0.00
Coal.Size 9	Perc.CV.upgrade	2	0.1	0.1	15.54	0.00
Tph 9	Perc.CV.upgrade	1	0.0	0.0	0.12	0.73
CVR..Hz. 9	Perc.CV.upgrade	1	0.0	0.0	0.55	0.46
Coal:Coal.Size9	Perc.CV.upgrade	2	0.1	0.1	18.77	0.00
Residuals 9	Perc.CV.upgrade	52	0.2	0.0	NA	NA
Coal 10	Perc.TS.upgrade	1	0.1	0.1	6.46	0.01
Coal.Size 10	Perc.TS.upgrade	2	1.1	0.6	26.87	0.00
Tph 10	Perc.TS.upgrade	1	0.0	0.0	0.33	0.57
CVR..Hz. 10	Perc.TS.upgrade	1	0.1	0.1	4.06	0.05
Coal:Coal.Size10	Perc.TS.upgrade	2	0.1	0.1	3.33	0.04
Residuals 10	Perc.TS.upgrade	52	1.1	0.0	NA	NA
Coal 11	Perc.AI.upgrade	1	0.2	0.2	7.68	0.01
Coal.Size 11	Perc.AI.upgrade	2	0.1	0.1	2.38	0.10
Tph 11	Perc.AI.upgrade	1	0.0	0.0	0.63	0.43
CVR..Hz. 11	Perc.AI.upgrade	1	0.0	0.0	0.93	0.34
Coal:Coal.Size11	Perc.AI.upgrade	2	0.0	0.0	0.26	0.77
Residuals 11	Perc.AI.upgrade	51	1.6	0.0	NA	NA
Coal 12	D50	1	0.8	0.8	21.26	0.00
Coal.Size 12	D50	2	0.1	0.0	0.97	0.38
Tph 12	D50	1	0.1	0.1	2.37	0.13
CVR..Hz. 12	D50	1	0.0	0.0	0.08	0.77

Coal:Coal.Size12	D50	2	0.2	0.1	2.46	0.10
Residuals 12	D50	52	2.0	0.0	NA	NA
Coal 13	Ep	1	0.0	0.0	0.52	0.48
Coal.Size 13	Ep	2	0.0	0.0	19.58	0.00
Tph 13	**Ep**	**1**	**0.0**	**0.0**	**15.53**	**0.00**
CVR..Hz. 13	Ep	1	0.0	0.0	0.01	0.92
Coal:Coal.Size13	Ep	2	0.0	0.0	15.43	0.00
Residuals 13	Ep	16	0.0	0.0	NA	NA
Coal 14	Organic.Efficiency	1	1512.4	1512.4	15.88	0.00
Coal.Size 14	Organic.Efficiency	2	3522.2	1761.1	18.49	0.00
Tph 14	**Organic.Efficiency**	**1**	**838.7**	**838.7**	**8.81**	**0.01**
CVR..Hz. 14	Organic.Efficiency	1	58.7	58.7	0.62	0.44
Coal:Coal.Size14	Organic.Efficiency	2	1652.3	826.2	8.68	0.00
Residuals 14	Organic.Efficiency	16	1523.8	95.2	NA	NA
Coal 15	Product.Ash	1	296.9	296.9	46.07	0.00
Coal.Size 15	Product.Ash	2	434.7	217.3	33.72	0.00
Tph 15	Product.Ash	1	0.0	0.0	0.00	0.99
CVR..Hz. 15	Product.Ash	1	4.1	4.1	0.63	0.43
Coal:Coal.Size15	Product.Ash	2	4.8	2.4	0.37	0.69
Residuals 15	Product.Ash	52	335.2	6.4	NA	NA
Coal 16	Product.CV	1	31.9	31.9	28.51	0.00
Coal.Size 16	Product.CV	2	66.2	33.1	29.57	0.00
Tph 16	Product.CV	1	0.0	0.0	0.03	0.87
CVR..Hz. 16	Product.CV	1	0.8	0.8	0.67	0.42
Coal:Coal.Size16	Product.CV	2	0.8	0.4	0.38	0.69
Residuals 16	Product.CV	52	58.2	1.1	NA	NA
Coal 17	Product.TS	1	1.0	1.0	11.34	0.00
Coal.Size 17	Product.TS	2	5.9	2.9	34.12	0.00
Tph 17	Product.TS	1	0.0	0.0	0.02	0.88
CVR..Hz. 17	Product.TS	1	0.3	0.3	3.75	0.06
Coal:Coal.Size17	Product.TS	2	0.6	0.3	3.27	0.05
Residuals 17	Product.TS	52	4.5	0.1	NA	NA
Coal 18	Product.AI	1	682986.7	682986.7	142.70	0.00
Coal.Size 18	Product.AI	2	20369.7	10184.9	2.13	0.13
Tph 18	Product.AI	1	7926.7	7926.7	1.66	0.20
CVR..Hz. 18	Product.AI	1	5940.2	5940.2	1.24	0.27
Coal:Coal.Size18	Product.AI	2	157079.6	78539.8	16.41	0.00
Residuals 18	Product.AI	52	248887.4	4786.3	NA	NA
Coal 19	Perc.Ash.upgrade	1	0.0	0.0	0.67	0.42
Coal.Size 19	Perc.Ash.upgrade	2	0.0	0.0	0.71	0.49
Tph 19	Perc.Ash.upgrade	1	0.0	0.0	0.02	0.88

CVR..Hz. 19	Perc.Ash.upgrade	1	0.0	0.0	0.67	0.42
Coal:Coal.Size19	Perc.Ash.upgrade	2	0.0	0.0	3.73	0.03
Residuals 19	Perc.Ash.upgrade	52	0.3	0.0	NA	NA
Coal 20	Perc.CV.upgrade	1	0.1	0.1	15.77	0.00
Coal.Size 20	Perc.CV.upgrade	2	0.1	0.1	15.54	0.00
Tph 20	Perc.CV.upgrade	1	0.0	0.0	0.12	0.73
CVR..Hz. 20	Perc.CV.upgrade	1	0.0	0.0	0.55	0.46
Coal:Coal.Size20	Perc.CV.upgrade	2	0.1	0.1	18.77	0.00
Residuals 20	Perc.CV.upgrade	52	0.2	0.0	NA	NA
Coal 21	Perc.TS.upgrade	1	0.1	0.1	6.46	0.01
Coal.Size 21	Perc.TS.upgrade	2	1.1	0.6	26.87	0.00
Tph 21	Perc.TS.upgrade	1	0.0	0.0	0.33	0.57
CVR..Hz. 21	Perc.TS.upgrade	1	0.1	0.1	4.06	0.05
Coal:Coal.Size21	Perc.TS.upgrade	2	0.1	0.1	3.33	0.04
Residuals 21	Perc.TS.upgrade	52	1.1	0.0	NA	NA
Coal 22	Perc.AI.upgrade	1	0.2	0.2	7.68	0.01
Coal.Size 22	Perc.AI.upgrade	2	0.1	0.1	2.38	0.10
Tph 22	Perc.AI.upgrade	1	0.0	0.0	0.63	0.43
CVR..Hz. 22	Perc.AI.upgrade	1	0.0	0.0	0.93	0.34
Coal:Coal.Size22	Perc.AI.upgrade	2	0.0	0.0	0.26	0.77
Residuals 22	Perc.AI.upgrade	51	1.6	0.0	NA	NA

ANOVA results for Coal 2- fan speed

ANOVA results fan speed	**Variable**	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**
Fan..Hz.	Product.Yield.Perc	5	15265	3053	12.26	0.00
Residuals	Product.Yield.Perc	62	15445	249	NA	NA
Fan..Hz. 1	D50	5	1	0	7.55	0.00
Residuals 1	D50	64	3	0	NA	NA
Fan..Hz. 2	Ep	4	0	0	1.45	0.24
Residuals 2	Ep	29	0	0	NA	NA
Fan..Hz. 3	Organic.Efficiency	4	9677	2419	7.67	0.00
Residuals 3	Organic.Efficiency	29	9147	315	NA	NA
Fan..Hz. 4	Product.Ash	5	385	77	5.42	0.00
Residuals 4	Product.Ash	64	911	14	NA	NA
Fan..Hz. 5	Product.CV	5	52	10	5.83	0.00
Residuals 5	Product.CV	64	115	2	NA	NA
Fan..Hz. 6	Product.TS	5	8	2	20.95	0.00
Residuals 6	Product.TS	64	5	0	NA	NA
Fan..Hz. 7	Product.AI	5	230411	46082	2.54	0.04
Residuals 7	Product.AI	64	1162863	18170	NA	NA

Fan..Hz. 8	Perc.Ash.upgrade	5	0	0	2.40	0.05
Residuals 8	Perc.Ash.upgrade	64	1	0	NA	NA
Fan..Hz. 9	Perc.CV.upgrade	5	0	0	2.72	0.03
Residuals 9	Perc.CV.upgrade	64	1	0	NA	NA
Fan..Hz. 10	Perc.TS.upgrade	5	2	0	12.95	0.00
Residuals 10	Perc.TS.upgrade	64	2	0	NA	NA
Fan..Hz. 11	Perc.AI.upgrade	5	0	0	1.69	0.15
Residuals 11	Perc.AI.upgrade	61	2	0	NA	NA

Linear model for Coal 2- fan speed

Model results coal2

	Dependent variable:											
	Product.Yield.Perc	D50	Ep	Organic.Efficiency	Product.Ash	Product.CV	Product.TS	Product.AI	Perc.Ash.upgrade	Perc.CV.upgrade	Perc.TS.upgrade	Perc.AI.upgrade
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	28.71 (19.38, 38.04)	1.64 (1.52, 1.75)	.08 (-.01, .16)	37.86 (25.56, 50.17)	19.66 (17.53, 21.80)	24.32 (23.56, 25.07)	.44 (.28, .60)	314.92 (238.65, 391.18)	.37 (.31, .43)	.20 (.14, .26)	.73 (.64, .82)	.50 (.39, .60)
	p = 0.0000	p = 0.00	p = .11	p = 0.0000	p = 0.00	p = 0.00	p = 0.0000	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Fan..Hz.55	-8.32 (-25.01, 8.36)	.16 (-.05, .37)	-.02 (-.29, .25)	-1.76 (-38.68, 35.16)	-.08 (-4.02, 3.85)	.42 (-.97, 1.82)	.09 (-.20, .38)	-131.92 (-272.54, 8.71)	-.05 (-.16, .06)	-.02 (-.13, .09)	-.01 (-.18, .15)	.01 (-.19, .21)
	p = .34	p = .14	p = .88	p = .93	p = .97	p = .56	p = .54	p = .08	p = .35	p = .76	p = .87	p = .93
Fan..Hz.60	11.68 (-.15, 23.52)	.14 (-.001, .29)	.07 (-.04, .19)	19.05 (2.88, 35.23)	1.80 (-.92, 4.53)	-.42 (-1.39, .55)	.18 (-.02, .38)	-33.18 (-130.60, 64.24)	-.05 (-.12, .03)	-.01 (-.09, .06)	-.13 (-.25, -.02)	.04 (-.10, .17)
	p = .06	p = .06	p = .23	p = .03	p = .20	p = .40	p = .09	p = .51	p = .22	p = .76	p = .03	p = .61
Fan..Hz.65	8.44 (-3.28, 20.16)	.14 (.002, .29)	.03 (-.10, .15)	5.16 (-11.75, 22.07)	4.71 (1.98, 7.43)	-1.58 (-2.55, -.61)	.36 (.16, .56)	41.29 (-56.12, 138.71)	-.03 (-.10, .05)	.09 (.01, .17)	-.21 (-.32, -.09)	.03 (-.11, .17)
	p = .17	p = .06	p = .69	p = .56	p = .002	p = .003	p = .001	p = .41	p = .46	p = .03	p = .001	p = .65
Fan..Hz.70	39.75 (26.56, 52.94)	.38 (.22, .54)	.16 (.02, .30)	51.18 (31.33, 71.02)	5.65 (2.57, 8.74)	-1.33 (-2.42, -.23)	.75 (.52, .98)	-108.73 (-219.02, 1.55)	-.14 (-.22, -.05)	-.03 (-.12, .06)	-.42 (-.55, -.29)	-.15 (-.31, .02)
	p = 0.0000	p = .0001	p = .04	p = .0001	p = .001	p = .03	p = 0.0000	p = .06	p = .003	p = .52	p = 0.0000	p = .09
Fan..Hz.75	39.74 (21.68, 57.80)	.57 (.34, .79)			7.19 (2.92, 11.45)	-3.05 (-4.57, -1.54)	1.35 (1.04, 1.67)	-57.92 (-210.45, 94.62)	-.09 (-.21, .03)	.002 (-.12, .12)	-.50 (-.68, -.32)	-.13 (-.34, .09)
	p = .0001	p = 0.0000			p = .002	p = .0002	p = 0.00	p = .46	p = .14	p = .97	p = 0.0000	p = .25
Observations	68	70	34	34	70	70	70	70	70	70	70	67
R^2	.50	.37	.17	.51	.30	.31	.62	.17	.16	.18	.50	.12
Adjusted R^2	.46	.32	.05	.45	.24	.26	.59	.10	.09	.11	.46	.05
Residual Std. Error	15.78 (df = 62)	.20 (df = 64)	.13 (df = 29)	17.76 (df = 29)	3.77 (df = 64)	1.34 (df = 64)	.28 (df = 64)	134.80 (df = 64)	.10 (df = 64)	.11 (df = 64)	.16 (df = 64)	.19 (df = 61)
F Statistic	12.26^{***} (df = 5; 62)	7.55^{***} (df = 5; 64)	1.45 (df = 4; 29)	7.67^{***} (df = 4; 29)	5.42^{***} (df = 5; 64)	5.83^{***} (df = 5; 64)	20.95^{***} (df = 5; 64)	2.54^{**} (df = 5; 64)	2.40^{**} (df = 5; 64)	2.72^{**} (df = 5; 64)	12.95^{***} (df = 5; 64)	1.69 (df = 5; 61)
Note:												$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Tukey HSD results for Coal 2- fan speed

Tukey HSD results fan speed	Variable	Source	diff	lwr	upr	p adj
55-50	Product.Yield.Perc	Fan Hz	-8.32	-33.35	16.71	0.92
60-50	Product.Yield.Perc	Fan Hz	11.68	-6.08	29.45	0.39
65-50	Product.Yield.Perc	Fan Hz	8.44	-9.15	26.02	0.72
70-50	Product.Yield.Perc	Fan Hz	39.75	19.96	59.54	0.00
75-50	Product.Yield.Perc	Fan Hz	39.74	12.64	66.84	0.00
60-55	Product.Yield.Perc	Fan Hz	20.01	-3.46	43.47	0.14
65-55	Product.Yield.Perc	Fan Hz	16.76	-6.57	40.09	0.29
70-55	Product.Yield.Perc	Fan Hz	48.07	23.04	73.11	0.00
75-55	Product.Yield.Perc	Fan Hz	48.06	16.93	79.20	0.00
65-60	Product.Yield.Perc	Fan Hz	-3.25	-18.51	12.02	0.99
70-60	Product.Yield.Perc	Fan Hz	28.07	10.30	45.83	0.00
75-60	Product.Yield.Perc	Fan Hz	28.06	2.40	53.71	0.02
70-65	Product.Yield.Perc	Fan Hz	31.31	13.73	48.90	0.00
75-65	Product.Yield.Perc	Fan Hz	31.30	5.77	56.84	0.01
75-70	Product.Yield.Perc	Fan Hz	-0.01	-27.11	27.09	1.00
55-501	D50	Fan Hz	0.16	-0.15	0.47	0.65
60-501	D50	Fan Hz	0.14	-0.07	0.36	0.38
65-501	D50	Fan Hz	0.15	-0.07	0.36	0.36
70-501	D50	Fan Hz	0.38	0.14	0.62	0.00
75-501	D50	Fan Hz	0.57	0.23	0.91	0.00
60-551	D50	Fan Hz	-0.02	-0.31	0.27	1.00
65-551	D50	Fan Hz	-0.02	-0.31	0.28	1.00
70-551	D50	Fan Hz	0.22	-0.10	0.53	0.33
75-551	D50	Fan Hz	0.41	0.02	0.80	0.04
65-601	D50	Fan Hz	0.00	-0.19	0.19	1.00
70-601	D50	Fan Hz	0.24	0.02	0.46	0.03
75-601	D50	Fan Hz	0.43	0.11	0.75	0.00
70-651	D50	Fan Hz	0.23	0.01	0.46	0.03
75-651	D50	Fan Hz	0.42	0.10	0.74	0.00
75-701	D50	Fan Hz	0.19	-0.15	0.53	0.58
55-502	Ep	Fan Hz	-0.02	-0.42	0.37	1.00
60-502	Ep	Fan Hz	0.07	-0.10	0.25	0.73
65-502	Ep	Fan Hz	0.03	-0.16	0.21	0.99
70-502	Ep	Fan Hz	0.16	-0.05	0.37	0.22
60-552	Ep	Fan Hz	0.10	-0.29	0.49	0.95
65-552	Ep	Fan Hz	0.05	-0.35	0.44	1.00
70-552	Ep	Fan Hz	0.18	-0.23	0.59	0.70
65-602	Ep	Fan Hz	-0.05	-0.22	0.12	0.92

70-602	Ep	Fan Hz	0.09	-0.12	0.29	0.73
70-652	Ep	Fan Hz	0.13	-0.07	0.34	0.36
55-503	Organic.Efficiency	Fan Hz	-1.76	-56.52	52.99	1.00
60-503	Organic.Efficiency	Fan Hz	19.05	-4.93	43.04	0.17
65-503	Organic.Efficiency	Fan Hz	5.16	-19.92	30.24	0.97
70-503	Organic.Efficiency	Fan Hz	51.18	21.75	80.61	0.00
60-553	Organic.Efficiency	Fan Hz	20.82	-33.10	74.74	0.79
65-553	Organic.Efficiency	Fan Hz	6.92	-47.49	61.34	1.00
70-553	Organic.Efficiency	Fan Hz	52.94	-3.61	109.49	0.08
65-603	Organic.Efficiency	Fan Hz	-13.89	-37.10	9.31	0.43
70-603	Organic.Efficiency	Fan Hz	32.12	4.28	59.97	0.02
70-653	Organic.Efficiency	Fan Hz	46.02	17.22	74.81	0.00
55-504	Product.Ash	Fan Hz	-0.08	-5.98	5.81	1.00
60-504	Product.Ash	Fan Hz	1.80	-2.28	5.89	0.79
65-504	Product.Ash	Fan Hz	4.71	0.62	8.79	0.01
70-504	Product.Ash	Fan Hz	5.65	1.03	10.28	0.01
75-502	Product.Ash	Fan Hz	7.19	0.79	13.58	0.02
60-554	Product.Ash	Fan Hz	1.89	-3.68	7.46	0.92
65-554	Product.Ash	Fan Hz	4.79	-0.78	10.36	0.13
70-554	Product.Ash	Fan Hz	5.74	-0.24	11.72	0.07
75-552	Product.Ash	Fan Hz	7.27	-0.16	14.70	0.06
65-604	Product.Ash	Fan Hz	2.90	-0.69	6.50	0.18
70-604	Product.Ash	Fan Hz	3.85	-0.35	8.05	0.09
75-602	Product.Ash	Fan Hz	5.38	-0.71	11.48	0.11
70-654	Product.Ash	Fan Hz	0.95	-3.25	5.14	0.99
75-652	Product.Ash	Fan Hz	2.48	-3.62	8.57	0.84
75-702	Product.Ash	Fan Hz	1.53	-4.94	8.00	0.98
55-505	Product.CV	Fan Hz	0.42	-1.67	2.51	0.99
60-505	Product.CV	Fan Hz	-0.42	-1.87	1.03	0.96
65-505	Product.CV	Fan Hz	-1.58	-3.03	-0.13	0.02
70-505	Product.CV	Fan Hz	-1.33	-2.97	0.32	0.18
75-503	Product.CV	Fan Hz	-3.05	-5.32	-0.79	0.00
60-555	Product.CV	Fan Hz	-0.84	-2.82	1.13	0.81
65-555	Product.CV	Fan Hz	-2.00	-3.98	-0.03	0.05
70-555	Product.CV	Fan Hz	-1.75	-3.87	0.37	0.16
75-553	Product.CV	Fan Hz	-3.48	-6.11	-0.84	0.00
65-605	Product.CV	Fan Hz	-1.16	-2.44	0.11	0.09
70-605	Product.CV	Fan Hz	-0.91	-2.39	0.58	0.48
75-603	Product.CV	Fan Hz	-2.63	-4.80	-0.47	0.01
70-655	Product.CV	Fan Hz	0.25	-1.23	1.74	1.00
75-653	Product.CV	Fan Hz	-1.47	-3.64	0.69	0.35
75-703	Product.CV	Fan Hz	-1.73	-4.02	0.57	0.25

55-506	Product.TS	Fan Hz	0.09	-0.34	0.53	0.99
60-506	Product.TS	Fan Hz	0.18	-0.12	0.48	0.52
65-506	Product.TS	Fan Hz	0.36	0.06	0.66	0.01
70-506	Product.TS	Fan Hz	0.75	0.41	1.09	0.00
75-504	Product.TS	Fan Hz	1.35	0.88	1.82	0.00
60-556	Product.TS	Fan Hz	0.09	-0.33	0.50	0.99
65-556	Product.TS	Fan Hz	0.27	-0.15	0.68	0.41
70-556	Product.TS	Fan Hz	0.66	0.22	1.10	0.00
75-554	Product.TS	Fan Hz	1.26	0.71	1.81	0.00
65-606	Product.TS	Fan Hz	0.18	-0.09	0.45	0.36
70-606	Product.TS	Fan Hz	0.57	0.26	0.88	0.00
75-604	Product.TS	Fan Hz	1.17	0.72	1.62	0.00
70-656	Product.TS	Fan Hz	0.39	0.08	0.70	0.01
75-654	Product.TS	Fan Hz	0.99	0.54	1.45	0.00
75-704	Product.TS	Fan Hz	0.60	0.12	1.08	0.01
55-507	Product.AI	Fan Hz	-131.92	-342.71	78.87	0.45
60-507	Product.AI	Fan Hz	-33.18	-179.20	112.84	0.98
65-507	Product.AI	Fan Hz	41.29	-104.73	187.31	0.96
70-507	Product.AI	Fan Hz	-108.73	-274.04	56.57	0.39
75-505	Product.AI	Fan Hz	-57.92	-286.55	170.72	0.98
60-557	Product.AI	Fan Hz	98.74	-100.30	297.78	0.69
65-557	Product.AI	Fan Hz	173.21	-25.83	372.25	0.12
70-557	Product.AI	Fan Hz	23.18	-190.41	236.77	1.00
75-555	Product.AI	Fan Hz	74.00	-191.65	339.65	0.96
65-607	Product.AI	Fan Hz	74.47	-54.01	202.95	0.54
70-607	Product.AI	Fan Hz	-75.56	-225.59	74.48	0.68
75-605	Product.AI	Fan Hz	-24.74	-242.59	193.11	1.00
70-657	Product.AI	Fan Hz	-150.03	-300.06	0.00	0.05
75-655	Product.AI	Fan Hz	-99.21	-317.06	118.64	0.76
75-705	Product.AI	Fan Hz	50.82	-180.40	282.03	0.99
55-508	Perc.Ash.upgrade	Fan Hz	-0.05	-0.22	0.11	0.93
60-508	Perc.Ash.upgrade	Fan Hz	-0.05	-0.16	0.06	0.81
65-508	Perc.Ash.upgrade	Fan Hz	-0.03	-0.14	0.08	0.97
70-508	Perc.Ash.upgrade	Fan Hz	-0.14	-0.27	-0.01	0.03
75-506	Perc.Ash.upgrade	Fan Hz	-0.09	-0.27	0.09	0.66
60-558	Perc.Ash.upgrade	Fan Hz	0.00	-0.15	0.16	1.00
65-558	Perc.Ash.upgrade	Fan Hz	0.02	-0.13	0.18	1.00
70-558	Perc.Ash.upgrade	Fan Hz	-0.09	-0.25	0.08	0.65
75-556	Perc.Ash.upgrade	Fan Hz	-0.04	-0.24	0.17	0.99
65-608	Perc.Ash.upgrade	Fan Hz	0.02	-0.08	0.12	0.99
70-608	Perc.Ash.upgrade	Fan Hz	-0.09	-0.21	0.03	0.22
75-606	Perc.Ash.upgrade	Fan Hz	-0.04	-0.21	0.13	0.98

70-658	Perc.Ash.upgrade	Fan Hz	-0.11	-0.23	0.01	0.08
75-656	Perc.Ash.upgrade	Fan Hz	-0.06	-0.23	0.11	0.89
75-706	Perc.Ash.upgrade	Fan Hz	0.05	-0.13	0.23	0.97
55-509	Perc.CV.upgrade	Fan Hz	-0.02	-0.18	0.15	1.00
60-509	Perc.CV.upgrade	Fan Hz	-0.01	-0.13	0.10	1.00
65-509	Perc.CV.upgrade	Fan Hz	0.09	-0.02	0.20	0.20
70-509	Perc.CV.upgrade	Fan Hz	-0.03	-0.16	0.10	0.99
75-507	Perc.CV.upgrade	Fan Hz	0.00	-0.18	0.18	1.00
60-559	Perc.CV.upgrade	Fan Hz	0.01	-0.15	0.16	1.00
65-559	Perc.CV.upgrade	Fan Hz	0.11	-0.05	0.26	0.33
70-559	Perc.CV.upgrade	Fan Hz	-0.01	-0.18	0.16	1.00
75-557	Perc.CV.upgrade	Fan Hz	0.02	-0.19	0.23	1.00
65-609	Perc.CV.upgrade	Fan Hz	0.10	0.00	0.20	0.04
70-609	Perc.CV.upgrade	Fan Hz	-0.02	-0.13	0.10	1.00
75-607	Perc.CV.upgrade	Fan Hz	0.01	-0.16	0.19	1.00
70-659	Perc.CV.upgrade	Fan Hz	-0.12	-0.24	0.00	0.05
75-657	Perc.CV.upgrade	Fan Hz	-0.09	-0.26	0.08	0.66
75-707	Perc.CV.upgrade	Fan Hz	0.03	-0.15	0.21	1.00
55-5010	Perc.TS.upgrade	Fan Hz	-0.01	-0.26	0.23	1.00
60-5010	Perc.TS.upgrade	Fan Hz	-0.13	-0.30	0.04	0.21
65-5010	Perc.TS.upgrade	Fan Hz	-0.21	-0.38	-0.04	0.01
70-5010	Perc.TS.upgrade	Fan Hz	-0.42	-0.61	-0.22	0.00
75-508	Perc.TS.upgrade	Fan Hz	-0.50	-0.77	-0.23	0.00
60-5510	Perc.TS.upgrade	Fan Hz	-0.12	-0.35	0.11	0.66
65-5510	Perc.TS.upgrade	Fan Hz	-0.19	-0.42	0.04	0.16
70-5510	Perc.TS.upgrade	Fan Hz	-0.40	-0.65	-0.15	0.00
75-558	Perc.TS.upgrade	Fan Hz	-0.49	-0.80	-0.18	0.00
65-6010	Perc.TS.upgrade	Fan Hz	-0.07	-0.22	0.08	0.70
70-6010	Perc.TS.upgrade	Fan Hz	-0.28	-0.46	-0.11	0.00
75-608	Perc.TS.upgrade	Fan Hz	-0.37	-0.62	-0.11	0.00
70-6510	Perc.TS.upgrade	Fan Hz	-0.21	-0.38	-0.03	0.01
75-658	Perc.TS.upgrade	Fan Hz	-0.29	-0.55	-0.04	0.01
75-708	Perc.TS.upgrade	Fan Hz	-0.08	-0.35	0.19	0.94
55-5011	Perc.Al.upgrade	Fan Hz	0.01	-0.29	0.31	1.00
60-5011	Perc.Al.upgrade	Fan Hz	0.04	-0.17	0.24	1.00
65-5011	Perc.Al.upgrade	Fan Hz	0.03	-0.18	0.24	1.00
70-5011	Perc.Al.upgrade	Fan Hz	-0.15	-0.39	0.10	0.49
75-509	Perc.Al.upgrade	Fan Hz	-0.13	-0.45	0.19	0.85
60-5511	Perc.Al.upgrade	Fan Hz	0.03	-0.25	0.31	1.00
65-5511	Perc.Al.upgrade	Fan Hz	0.02	-0.26	0.30	1.00
70-5511	Perc.Al.upgrade	Fan Hz	-0.16	-0.47	0.15	0.67
75-559	Perc.Al.upgrade	Fan Hz	-0.14	-0.51	0.24	0.89

65-6011	Perc.AI.upgrade	Fan Hz	0.00	-0.19	0.18	1.00
70-6011	Perc.AI.upgrade	Fan Hz	-0.18	-0.41	0.04	0.17
75-609	Perc.AI.upgrade	Fan Hz	-0.16	-0.47	0.14	0.62
70-6511	Perc.AI.upgrade	Fan Hz	-0.18	-0.41	0.05	0.20
75-659	Perc.AI.upgrade	Fan Hz	-0.16	-0.47	0.15	0.65
75-709	Perc.AI.upgrade	Fan Hz	0.02	-0.31	0.36	1.00

ANOVA results for Coal 2- fan speed and near-density material

ANOVA results fan speed & near-density material	Variable	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Fan..Hz.	Product.Yield.Perc	4	11572	2893	21.04	0.00
Near.density	Product.Yield.Perc	1	2664	2664	19.37	0.00
Residuals	Product.Yield.Perc	28	3850	137	NA	NA
Fan..Hz. 1	D50	4	1	0	23.80	0.00
Near.density1	D50	1	0	0	29.59	0.00
Residuals 1	D50	28	0	0	NA	NA
Fan..Hz. 2	Ep	4	0	0	1.64	0.19
Near.density2	Ep	1	0	0	4.80	0.04
Residuals 2	Ep	28	0	0	NA	NA
Fan..Hz. 3	Organic.Efficiency	4	9677	2419	13.85	0.00
Near.density3	Organic.Efficiency	1	4256	4256	24.36	0.00
Residuals 3	Organic.Efficiency	28	4891	175	NA	NA
Fan..Hz. 4	Product.Ash	4	316	79	7.52	0.00
Near.density4	Product.Ash	1	26	26	2.43	0.13
Residuals 4	Product.Ash	28	294	11	NA	NA
Fan..Hz. 5	Product.CV	4	33	8	5.08	0.00
Near.density5	Product.CV	1	2	2	1.42	0.24
Residuals 5	Product.CV	28	45	2	NA	NA
Fan..Hz. 6	Product.TS	4	2	0	7.78	0.00
Near.density6	Product.TS	1	0	0	0.12	0.74
Residuals 6	Product.TS	28	2	0	NA	NA
Fan..Hz. 7	Product.AI	4	324731	81183	3.21	0.03
Near.density7	Product.AI	1	1444	1444	0.06	0.81
Residuals 7	Product.AI	28	707542	25269	NA	NA
Fan..Hz. 8	Perc.Ash.upgrade	4	0	0	12.46	0.00
Near.density8	Perc.Ash.upgrade	1	0	0	2.15	0.15
Residuals 8	Perc.Ash.upgrade	28	0	0	NA	NA
Fan..Hz. 9	Perc.CV.upgrade	4	0	0	5.80	0.00
Near.density9	Perc.CV.upgrade	1	0	0	0.12	0.73
Residuals 9	Perc.CV.upgrade	28	0	0	NA	NA

Fan..Hz. 10	Perc.TS.upgrade	4	1	0	8.22	0.00
Near.density10	Perc.TS.upgrade	1	0	0	0.33	0.57
Residuals 10	Perc.TS.upgrade	28	1	0	NA	NA
Fan..Hz. 11	Perc.AI.upgrade	4	1	0	10.19	0.00
Near.density11	Perc.AI.upgrade	1	0	0	0.28	0.60
Residuals 11	Perc.AI.upgrade	26	0	0	NA	NA