Methods to Optimise Underground Mine Production

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ABSTRACT

The focus of this study was to investigate the current underground conventional mining systems used in the platinum mining industry and to design a mine production planning system to optimise the conventional operations – Anglo Platinum specific. The maximum steady state micro output levels of underground mines were determined from a mining and engineering perspective and the GAP, or output potential compared to the current output levels, was established. All the production facility's requirements with regard to services, equipment and infrastructure to achieve optimum production levels were calculated from first principles and a modelling tool for technical and mining optimisation evaluations was designed for use by the operations. Furthermore, an analysis of the main infrastructure or so-called "ongoing capital development" was done as a means to determine the maximum sustainable shaft capacities.

With the main objective being to determine the existing production GAP and thus the requirements to fill this GAP, a picture of the current conditions, equipment capacities and output levels were determined. For this purpose, specific checklists were designed to capture all the relevant information. It was sub-divided in such a way that inputs could be made in a logical sequence to prevent backtracking exercises. The existing infrastructure and equipment were rated on a scale ranging from zero to ten with zero meaning non-existent and ten being brand new. The involvement of the site personnel throughout the entire process is a crucial part of the exercise as buy-in and ownership are probably the most important aspects of any implementation process. This buy-in was achieved through planning workshops and presentations where real examples from the audience where modelled. Members were allowed to change parameters and outcomes were debated. The systematic logical approach and the suite of practical outputs sold the system during every session held. Support came from all functions including mine design specialists and ore resource managers using different systems.

The mining industry is the largest source of foreign income for South Africa and it is also the main source of employment with Anglo Platinum employing in the region of forty thousand employees[1] and contractors. Reef deposits are not

replaceable and it is in the interest of all stakeholders to extract every unit in the most efficient manner. Mines require vast amounts of capital and with risks like fluctuating metal prices, exchange rates, rising costs, labour unrest and geological uncertainties, it is important to have optimum planning and management systems in place. This project focused on how to optimise the output levels of current operations thus minimizing all of the mining-related risks in a direct or indirect manner. It is a simple means to leap closer to mining professionalism in first-world countries.

The GAP varied between the different operations and ranged between over-production and 60% below the optimum potential. On average it was 50% below optimum performance levels[2]. It has to be noted that these observations are based on half levels outputs and not on shaft capacities. In other words, where shafts are operating at design capacities, the same production can be obtained by manning half the amount of levels implicating cost savings instead of increased production. The current planning practices are thus not adequate to truly optimise the operations.

SAMEVATTING

Die doel van hierdie studie was om die huidige konvensionele ondergrondse mynbousisteme soos in gebruik in die platinum mynbou-industrie te ondersoek. Die ondersoek het hoofsaaklik gehandel rondom die ontwerp van 'n mynbeplanningsisteem om sodoende die konvensionele mynbou-operasies in Anglo Platinum te kan optimeer.

Die maksimum konstante produksietempo's van ondergrondse myne is bereken vanuit 'n mynbou- asook ingenieursoogpunt om sodoende die produksiegapings te kon bepaal.

Die basiese behoeftes rakende die dienste, infrastruktuur en toerusting om die sogenaamde optimum produksievlakke te bereik, is bereken en 'n beplanningsagtewarestelsel is ontwerp vir die gebruik deur die verskillende myne in Anglo Platinum. Verder is 'n analise aangaande die vervanging van die hoof kapitaalinfrastruktuur gemaak om sodoende skagkapasiteite te kon evalueer.

Alle konvensionele ondergrondse myne in Anglo Platinum is ondersoek in terme van huidige produksiepotensiaal en sodoende die produksiegaping asook die hoof vereistes om die gaping te benut. Elke mynondersoek is gedoen deur van spesifiek ontwerpte vraelyste gebruik te maak waarop die huidige situasie noukeurig genoteer is. Die hoeveelheid en toestand van toerusting en infrastruktuur is ook ondersoek en elke item is met 'n puntestelsel vanaf nul tot tien geklas – nul indien geen toerusting beskikbaar was nie en tien vir 'n nuwe item.

Hierdie werk is tesame met die personeel op elke myn gedoen om die bevindinge te verifieer. Om almal in die proses te kon betrek, is verkeie samekomste gebruik met, onder andere, sessies waar die gehoor die voorbeelde vir modellering kon voorstel. Wysigings is aangebring en die resultate is gedebateer. Die wyse en eenvoud en resultate van die sisteem word deur verskeie dissiplines ondersteun, onder andere mynontwerpspesialiste asook ertsreserwebestuurders.

Die mynindustrie is die grootste bron van buitelandse valuta vir Suid-Afrika en dit is ook die hoofbron van werkverskaffing met Anglo Platinum wat ongeveer veertigduisend mense direk en indirek in diens het. Ertsreserwes is onvervangbaar en dit is in almal se belang om dit optimaal te benut. Myne benodig enorme hoeveelhede kapitaal en met risiko's, soos wisselende metaalpryse, stygende kostes, arbeidsonrus en geologiese onsekerhede, is optimale beplanning- en bestuursisteme uiters noodsaaklik. Hierdie dokument fokus op die optimering van mynproduksie om sodoende die risiko op 'n direkte of indirekte wyse te help verminder

Die gaping soos bevind varieer van area tot area maar 'n gemiddeld van vyftig persentasiepunte onder die optimale produksievlak is bevind. Kennis moet geneem work dat bevindinge op half-vlak uitsette gebaseer is en dat die hoofinfrastrukture nie noodwendig meer produksie kan hanteer nie. In so 'n geval kan konsentrasie van produksie uit sekere areas kostebesparings in pleks van verhoogde uitsette teweeg bring. Huidige sisteme is nie altyd gebruikersvriendelik om werklike optimering van myne mee te doen nie, maar, behoort steeds tesame met die sisteem, soos dit in hierdie studie behandel is, gebruik te word.

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Due to the extreme competition in the mining industry, confidentiality agreements between the company and the author as well as for ethical reasons, most of the results may not be disclosed without written approval from the author and an Executive from Anglo Platinum.

NOMENCLATURE

Brown fields mines: Existing operations.

Chairlift decline: An excavation parallel to the reef plane, equipped with a chairlift for conveying people (endless rope with chairs attached).

Common block: The smallest unit that can be used to define the layout and thus the basic development requirements.

Conveyor belt incline: Inclined excavation normally parallel to the reef plane, equipped with conveyor belts for rock handling. Some mines have man-riding conveyor belts that convey men and rock.

Development: Creating tunnels to access, service and extract the ore body.

Dilution: The dilution refers to the lowering of the reef grade due to the addition of rock with a lower grade or the loss of content through various possible mechanisms.

Dyke: A plane-like intrusion also breaking the reef plane – it may result in displacement.

Equipping: The preparation of a ledged-out area to allow the extraction of the remaining reef area through a process called stoping.

Fault: A "break" in the reef plane with displacement.

Geological losses: Are normally expressed as a percentage of the total ore reserve lost due to faults, dykes, potholes, slumps and certain reef replacements (i.e. iron replacement).

Green fields mines: New or virgin areas.

Half level: The half level is the smallest self-sustainable production unit containing all mining activities.

Ledging: The widening of tunnels (normally in the reef plane) to install equipment necessary for reef extraction (stoping).

Material incline: Inclined excavation normally parallel below the reef plane, equipped with a winding or hoisting device and tracks. Material, rock, men and equipment may be conveyed through this excavation.

Ongoing capital development: The ongoing capital development is the excavations required to replace levels.

Pothole: Common to igneous reef planes – it can be explained as a load upon the reef plane (whilst in liquid state) thus displacing reef resulting in a narrower reef width in the area where the load occurred. Potholes vary in

size and some may be kilometres in diameter. In some cases it is possible to mine the reef below the pothole.

Reclamation: In this activity all the useful material is reclaimed for use in other areas, which includes pipes, winches, electric cables, etc.

Reef width: The width of the reef is measured at 90 degrees relative to the reef plane – the minimum thickness measurable.

Return airway: Used ventilation air gets exhausted through this excavation.

Slump: Is formed through similar processes but reef widths may not be affected.

Stoping: The main reef production activity from an equipped stope.

Strike: This refers to a line that can be drawn inside the reef plane that lies parallel to the horizontal plane and 90 degrees relative to true dip direction.

Sweeping and vamping: Removal of all remaining broken ore left behind after the stoping activity. This may commence during the stoping phase and continues after stoping has been completed.

True dip: The steepest average angle at which the reef plane is inclined relative to the horizontal plane (normally at its origin closest to the earth's surface). It ranges from 0 to 90 degrees and is represented by an arrow pointing from the origin, parallel to the steepest inclined line in the plane. The direction of this arrow is also defined relative to a standard survey system.

Winch: A winch in the underground sense is an electrical winding device with normally two steel rope drums rotating in opposite directions enabling the linear movement of a scraping device.

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