Experimental results of an asynchronous machine with thermoelectric cooling modules

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2 authors, including:

Rupert Gouws
North West University South Africa

EXPERIMENTAL RESULTS OF AN ASYNCHRONOUS MACHINE WITH THERMOELECTRIC COOLING MODULES

Rupert Gouws and Heino van Jaarsveldt

Electrical, Electronic and Computer Engineering, North-West University, Potchefstroom, South Africa.

Introduction

It is estimated that globally around 40% of the electricity supplied to the industrial sector is consumed by electric motorised systems and for South Africa around 60% of the electricity supplied is consumed by asynchronous machines in the industrial sector [1]. It is therefore important to invest in projects to lower the energy consumption (or improve the efficiency) of electric motorised systems and specifically asynchronous machines.

In this paper the authors present the experimental results obtained from a single phase asynchronous machine with thermoelectric cooling modules (TECMs). The TECMs are used to lower the stator winding temperature and core temperature of the single phase asynchronous machine.

A single phase asynchronous machine was used during the experimental setup and was cooled by means of TECMs. The same method of cooling can also be applied to three phase motors and other electric motorised systems. The efficiency of the asynchronous machine was determined by using the equivalent circuit method. From the experimental results on the efficiency analysis, temperature analysis and equivalent circuit analysis, it was calculated that the efficiency of the asynchronous machine can be increased by 4.44% when cooled by TECMs.

Materials and Method

This section provides an overview on the single phase asynchronous machine and the method used to perform cooling. Fig. 1 shows an overview diagram of the experimental setup of the single phase asynchronous machine with a dc generator connected to the shaft. The dc generator was used as a load on the single phase asynchronous machine. The output of the dc generator can also be used to power the TECMs.

The single phase asynchronous machine is capacitor started by means of an auxiliary winding. The main winding is used for continuous (running) operating conditions. The temperature of the main winding (stator winding) of the single phase asynchronous machine is lowered by means of TECMs. The TECMs is supplied with a 12 V DC source and is controlled according to the temperature of the main winding. An autotransformer controls the speed of the single phase asynchronous machine and is supplied with a 230 V AC, 50 Hz source.

A digital wattmeter, ammeter and voltmeter connected to the terminals of the single phase asynchronous machine are used to measure the power consumption and determine the parameter of the equivalent circuit. The no-load test and blocked rotor test are performed on the asynchronous machine to determine the parameters of the equivalent circuit. More detail on single phase asynchronous machines and equivalent circuits is provided by [2].

The power consumption of the TECMs is measured separately with another digital wattmeter. The total of the two digital watt-meters represents the total energy consumption of the single phase asynchronous machine with the TECMs. More detail on the efficiency calculation (analysis) of an asynchronous motor at an industrial plant in South Africa and the simulation model development of an asynchronous motor is provided by [3].

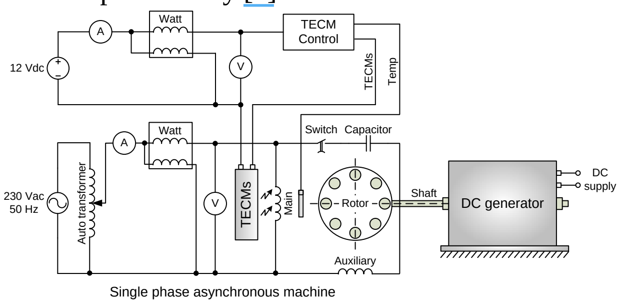

Fig. 1. Experimental setup of the asynchronous machine with the TECMs.

Fig. 2 shows a photo of the single phase asynchronous machine with the installed TECM housing structure. The single phase asynchronous machine is cooled by the TECMs on the front end and back end side. The designs done by means of the SolidWorks® Flow-Simulation were used to fabricate and construct the various parts for the final design.

More detail on the simulation model development of the single phase asynchronous machine done in SolidWorks® and the thermal analysis performed on the single phase asynchronous machine by means of the SolidWorks® Flow-Simulation software is presented by [4].

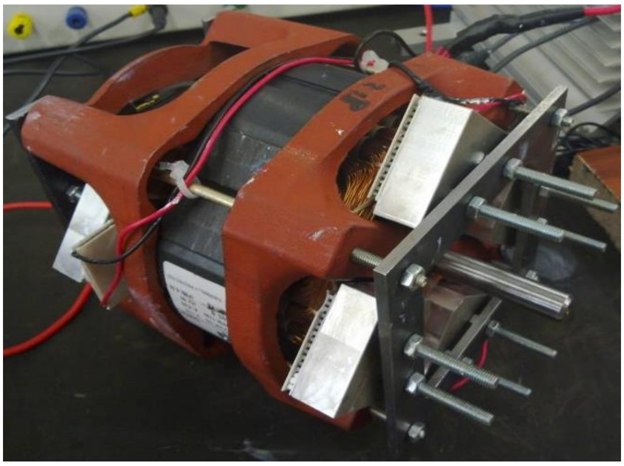

Fig. 2. Photo of the single phase asynchronous machine with the TECM housing structure.

Results and Discussion

This section provides the experimental results obtained from the single phase asynchronous machine with the installation of the TECMs. Fig. 3 provides a graph on the stator resistance against the stator temperature.

From this graph it can be seen that the data follows a second order polynomial of $y = 0.0011x^2 - 0.0565x + 3.8637$, with a R^2 value of 0.9889. More detail on second order polynomial line fittings (or trend-lines) and the coefficient of determination (R^2) are provided by [5].

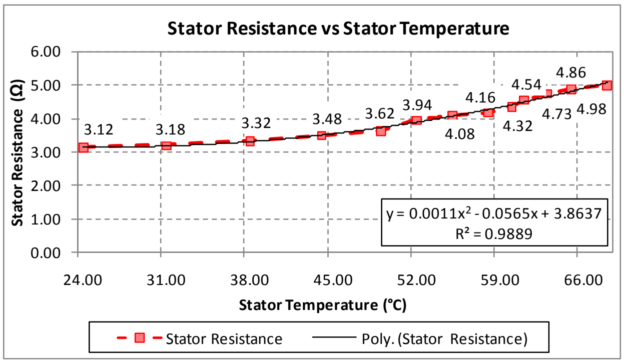

Fig. 3. Plot of the stator resistance against the stator temperature.

Fig. 4 provides a graph on the machine efficiency against the stator temperature. From this graph it can be seen that the data follows a second order polynomial of $y = -0.0009x^2 - 0.0306x + 48.773$, with a R^2 value of 0.9987.

The efficiency of the asynchronous machine was increased from 42.61% under the normal operating condition (stator winding temperature at 68.8 °C) to 47.05% under cooled operating condition (stator winding temperature at 30 °C).

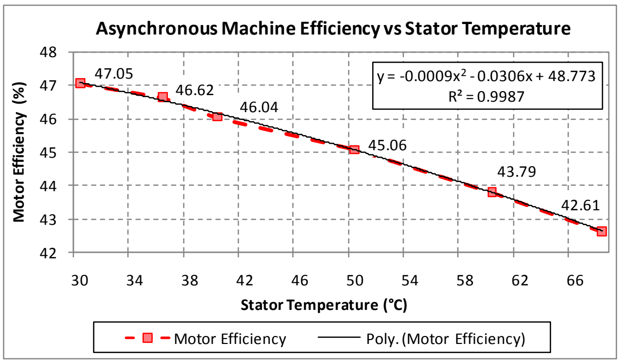

Fig. 4. Plot of the asynchronous machine efficiency against the stator temperature.

Conclusion

In this paper the stator and core temperature of a single phase asynchronous machine is lowered by means of TECMs. The impact of the cooling (by means of the TECMs) on the efficiency of the single phase asynchronous machine was presented.

The experimental results included an efficiency analysis, temperature analysis and equivalent circuit analysis. It is shown that when the stator temperature increased, the stator resistance increased, but the machine efficiency decreased.

When the stator temperature was decreased by the TECMs the stator resistance decreased which in turn increased the efficiency of the single phase asynchronous machine. The TECMs also has an influence on the core temperature of the single phase asynchronous machine. The efficiency of the single phase asynchronous machine was increased from 42.61% under normal operating condition to 47.05% under cooled operating condition (by means of the TECMs).

The efficiency of this specific single phase asynchronous machine can therefore be increased by 4.44%. More detail on the efficiency analysis of the asynchronous machine is provided by [4].

References

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