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Development of Copper Rotor of AC Induction Motor

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Abstract: The paper presents the development of copper rotor for AC induction motor i.e. it indicates only the rotary part of induction motor. The research project whose aim is to investigate efficiency of the induction motor, making use die cast copper rotor cage with H10 non-grain oriented electrical steel sheet as lamination. The study concerns to develop a prototype copper rotor of induction motor in the lab. In this study, developed copper rotor consists of 8 rotor slots, 0.5 hp, 4 pole induction motor. It has shown that copper rotor reduces the losses about 5.11 watts per unit and improved around 1.0% efficiency compared to existing aluminum rotor. The copper rotor has an annual energy savings of 40.32 kWh per year per unit and it can save RM 13.54.

Key words: Copper rotor, copper bar, induction motor, non-grain materials etc

INTRODUCTION

The Induction motor is the most widely used machine. The induction motor has often been termed the "workhorse of modern industry." Credit for such acclaim must go to the simplicity and ruggedness of the squirrel-cage rotor assembly. An electric motor converts electrical power to mechanical power in its rotor. The rotor receives power due to induction from stator rather than direct conduction of electrical power. An induction motor is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction. Induction motors are now the preferred choice for industrial motors.

The use of copper for the conductor bars in the rotor circuit and end rings of induction motors in place of aluminum results an attractive improvement in motor energy efficiency. This project has identified and demonstrated development process, and durable mold materials that have enabled economical production of die-cast copper rotor of induction motors. The main goal in this project is to developed a prototype copper rotor of induction motor which consists of 8 rotor slots under 0.5hp induction motor. The copper rotor verified in the machine design laboratory. In this project, one should be noted that during development stage of copper rotor of induction motor there are some major point's needs to be concern. The AutoCAD design file for rotor slots which is depending on software and it is used by EDM wire cut machine, during melting the metal copper power into the rotor slots which is under around 900^0C, and during plunging process of metal copper power just before the melting stage, which is done by hand press machine, are some development challenges of copper rotor of induction motor.

Methodology:

The scope of this project is wide. A lot of steps needed to complete the whole system. Major parts have been based on experimental setup. AutoCAD design file also necessary during machining stage. The following steps could be summarized,

- Literature review about copper rotor of induction motor
- Design the rotor slot frame using AUTOCAD software
- Order for non-grain oriented electrical steel materials as lamination
- Cutting, welding and machining under EDM (Electro Discharge Machine) wire cut machine in the laboratory
- Melting copper power in the rotor slot under 900^0c in the furnace lab
- Test copper rotor of induction motor in the lab

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A hard laborious substitution method of copper for aluminum in the rotor conductor bars will generally provide a significant reduction in losses, and thereby an increase in motor efficiency. However, if the designs of the rotor are re-evaluated to account for the better electrical conductivity of the copper, the even greater improvements in efficiency can be obtained. But it has been noted that if some one change the slot number in the rotor circuit, then further verification could be done whether increasing or decreasing the motor efficiency. The excellent electrical conductivity of copper materials produces a significant reduction in I^2R losses in the rotor's conductor bars as compared to standard electrical grade aluminum.

Designing a high efficiency motor requires that the designer focus on other aspects of motor performance other than efficiency. The customer also demands reasonably shaped, torque-speed curves. Starting conditions are especially important to project drive solutions. One major point in the design of high efficiency motors is to reduce rotor resistance R^2. In copper rotor motors this is obviously done by a much better conductivity of the cage material. However there are rotor design alternatives that allow for somewhat more cage cross sectional area which additionally helps to reduce R^2. On the other hand rotor design also strongly influences the torque performance. Therefore these choices have to be carefully considered.

Results Obtained:

Fig. 1: Shear machine to cut lamination

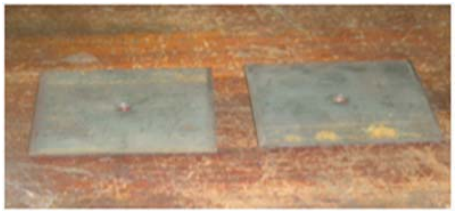

Fig. 2: Steel sheet used as lamination

Fig. 3: Wielded stack of lamination

Fig. 4: Plunger machine (Plunging process)

Fig. 5: Furnace chamber (Where copper is melted in rotor slots)

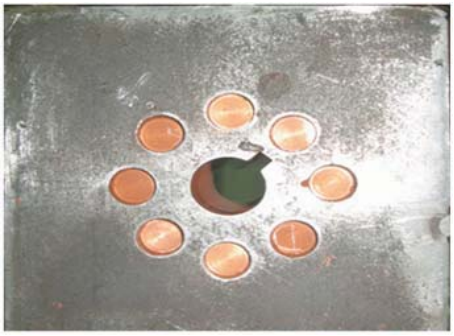

Fig. 6: Copper rotor after melting stage

Fig. 7: Sample after being cut using EDM wire cut machine

Fig. 8: EDM wire cut machine

Fig. 9: Copper rotor with shaft and bearing

Fig. 10: Fabricated copper rotor of IM

Fig. 11: Complete copper rotor of induction motor

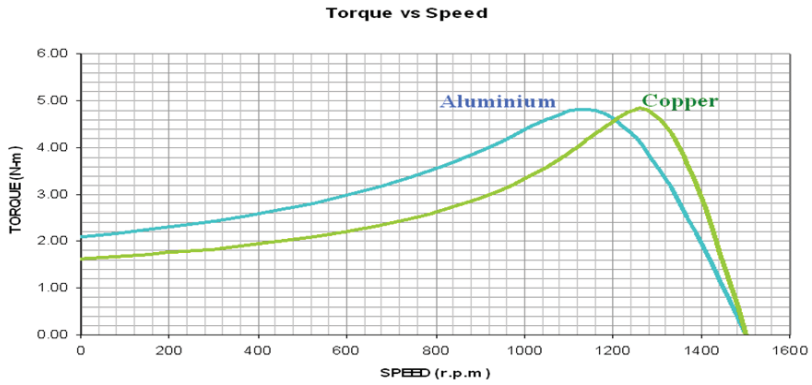

Fig. 12: Torque vs. Speed of Aluminum & Copper Rotor

Table 1: Loss Comparison of Existing Aluminum Rotor and Copper Rotor.

Losses Measur ement	Existing Rotor (W)	Copper Rotor (W)	Energy Saved (Existing rotor-Copper rotor (W)
Stator Copper Loss	11.84	6.77	5.07
Rotor Loss	5.82	4.8	1.02
Core Loss	63.63	64.61	-0.98
Friction & Windage Loss Stray Loss	8	8	0
Total Loss (W)	103.52	98.41	5.11
Effciency (%)	81.8	82.7	Inereased Approximately=1%

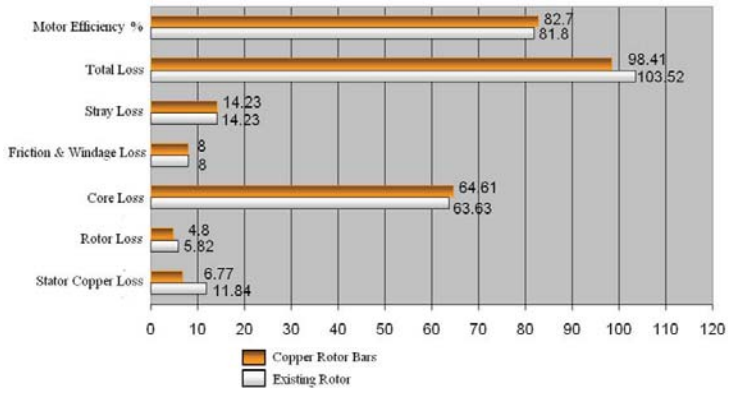

Fig. 13: Copper Rotor bar and Aluminum Rotor Performance

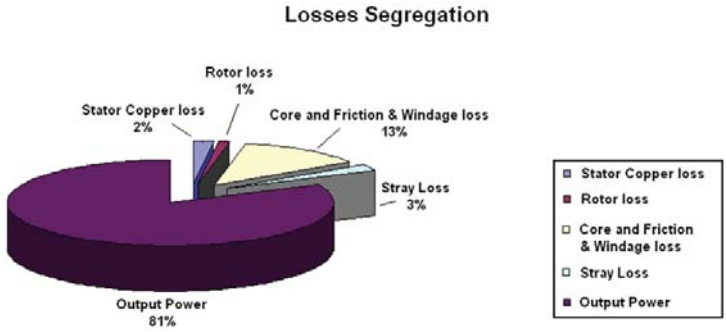

Fig. 14: Loss Segregation of Aluminum Rotor of 0.5hp Induction Motor

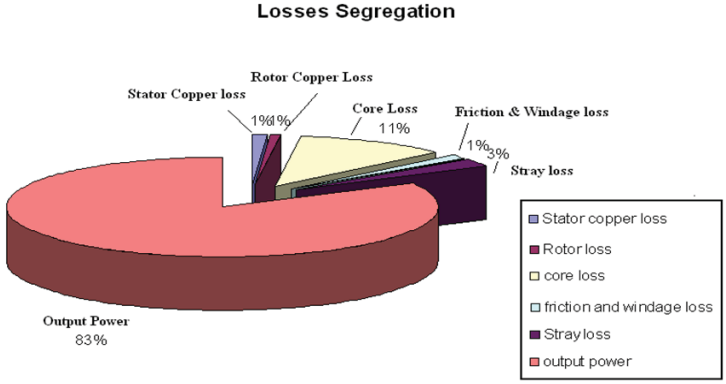

Fig. 15: Loss Segregation of Copper Rotor of 0.5hp Induction Motor

Discussion:

Knowing a lot of features such as design of 8 rotor slots in the rotor circuit using AutoCAD, cutting and machining process of steel laminations by EDM wire cut machine, shear machine and compress it to form lamination stack according to rotor length, how copper power is melted into the rotor slot to produce the copper rotor. Torque vs speed for aluminum and copper rotor shown in Figure 12. In Table 1, it shows the overall losses for copper and aluminum rotor of induction motor. It is found that 1% increased efficiency using copper rotor. In Figure 14 & 15 shows the loss segregation of 0.5 hp induction motor for existing aluminum rotor and copper rotor respectively. Finally copper rotor is tested in the lab and running smoothly.

Conclusion:

As a conclusion I would like to mention here that the rotary part of induction motor which is made by

copper rotor has been proposed and developed. This project has identified and demonstrated design methods using OPERA 2D software, fabrication process using EDM wire cut. It is found that using copper rotor 1% increased efficiency compare to aluminum rotor of induction motor. It also shows that using copper rotor found less loss compare to aluminum rotor of induction motor. It can save huge energy if multiple numbers of motors produced for industrial purposes.

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