Copper & Motor Rotors

The incorporation of copper for the conductor bars and end rings of the induction motor in place of aluminum would result in attractive improvements in motor energy efficiency.

The main advantage of using copper for the rotor of an induction motor is either cost reduction, or efficiency improvement.

Since copper has a higher conductivity than aluminum (relative electrical conductivity at 20°C of copper is 100, while aluminum is 62), it is a natural choice. However, its high melting point and the resulting high cost for die casting was for a long time a major barrier.

Several technological breakthroughs in copper die-casting have been recently achieved, removing this barrier and clearing the way for industrial production.

Already, regular production at medium volume exists. About 250,000 units with die-cast copper rotors are in use. The efficiency of these motors improves on average around 3% compared to motors with aluminum rotor.

This 3% improvement corresponds to a global annual electricity savings potential of 108 TWh. (Annual global electricity consumption = 18,400TWh. Of which 40% or 7,360TWh is industrial consumption. Of which 60% or 4,400TWh is used by motor systems. A savings of 3% on 4,400TWh = 132TWh.)

According to a survey conducted by Leonardo Energy, in January 2006, among manufacturers, users, researchers, engineers and members of associations, reveals that the copper rotor motor has now become an accepted technology. A majority assess the technology ready for mass production. Higher efficiency, lower heat production and reduced cost are seen as major advantages.

The main application domain is for industrial low voltage induction motors of 1 up to 100kW, but the technology also has potential for fractional kW motors.

Copper is the preferred electrical conductor

The electrical efficiency of motors can be improved by replacing the standard aluminum electrical conductor in the motor rotor with copper, which has a much higher electrical conductivity

Copper rotor saves material. When designing a motor with die-cast copper rotor, two different ways exist to benefit from the higher conductivity of copper. If all the other parameters of the motor are kept the same, using copper instead of aluminum. We can reduce the motor weight without compromising higher efficiency, thus leading to improved power density.

Reductions in weight and manufacturing costs have turned out to be supplementary benefits of optimization for the copper rotor.

Material mass comparison of motors optimized for same EPACT electrical efficiency.

Example 1. Power = 5.5 kW efficiency = 89.6%

Rotor Conductor	Al	Cu
Stator + Rotor Steel final kg / starting kg	34.5 / 45.9	27 / 35.9
Stator winding (kg)	7.3	4.4
Rotor cage (kg)	2.0	3.6
Copper content (kg)	7.3	8.0
7.5 / 10 kg less steel 0.7 kg more copper		

Example 2. Power = 11 kW efficiency = 91.1%

Rotor Material	Al	Cu
Stator + Rotor Steel final kg / starting kg	54.5 / 72.7	43 / 57.3
Stator winding (kg)	10.2	8.7
Rotor cage (kg)	3.0	5.9
Copper content (kg)	10.2	14.6
11.5 / 15 kg less steel 4.4 kg more copper		

Industrial production of induction motors with die-cast copper rotors is now ready. As of end 2005, over 250,000 copper rotor motors are in operation.

The main advantages of this new technology are higher efficiency, or for the same efficiency, lower volume, weight and cost. The technology is apt for:

- High premium efficiency industrial motors
- Hybrid and electric vehicle motors
- Air-conditioning compressor motors
- Submersible pump motors
- Appliance motors

Low-loss and high permeability steels in combination with die-cast copper rotors enable efficiency class EFF1 performance, and better, resulting in reduced environmental impact.

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