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CEMEP Topic: Industrial revolution until 2025: the culture of "new" for the 1st day

Motors for EVs and their Impact on Industrial Motors

Abstract

Some 20 or 30 years ago, electric motors seemed to be the most boring subject in electrical engineering. Everyone was happy with what had been achieved. Hardly any progress was made. Then in the late 90s, everything changed.

Electric energy became more valuable and manufacturers were forced to design new motors with higher efficiency. Line-start permanent-magnet or synchronous-reluctance motors are just two examples of newer motor designs that have emerged recently. Power electronics became cheaper and computer control systems became much more powerful. Suddenly it was feasible to build motors that could not be operated on line but needed sophisticated power electronics and control algorithms. Variable speed control became the standard in demanding applications.

Magnetic material was much improved. In particular, rare earth magnets (first Samarium-Cobalt and later Neodymium- Iron-Bor) enabled motor designers to reach power densities never seen before. Also, better soft magnetic materials like SMC (soft magnetic composite) or amorphous alloy became widely available. Consequently, higher rotor frequencies and motor speeds and also new topologies like switched reluctance machines became possible.

In recent years, the automobile industry has initiated yet another disruptive development of electric machines. By throwing a lot of money and resources into the optimization of electromagnetic and thermal design, such motors are now approaching the absolute limits of physics. By using mass calculations with numerical computer software, designs are optimized like never before. Cooling systems are becoming more and more sophisticated.

All these factors have led to an astonishing increase in performance. Specifically, power density (the power per weight ratio) of electric motors has increased by two magnitudes from the 1970/80s to

today. Conventional induction machines for industrial applications weigh about 10 kg per kW of continuous output power. Current electric drives for electric vehicles are below 1 kg per kW. Laboratory samples and even pre-production motors now approach 0,1 kg total weight per kW continuous output power.

A new field of application is electric airplanes. And these will not be limited to small 1 or 2 seaters. Boeing and Airbus are preparing the next step in aviation with all electric airplanes for some 100 passengers and ranges up to 1000 km. Even better power densities much below 0,1 kg are needed to achieve these goals.

So, what exactly are the influences of electric cars (EVs) on motors for industrial applications?

- New winding designs like hairpin-windings and also highly automated winding machines have been developed that will influence the design and cost structure of industrial motors.
- In general, the level of automation in increased and more sophisticated production machines are being developed for several sub-components of electric-motors.
- Better grades of steel, like M230-35A, are going to be produced in large quantities and will become the standard.
- More sophisticated control strategies, that can operate even very non-linear machines, are being developed and open new possibilities of motor design.

On the other hand, it is expected that the increasing demand of power electronics for electric vehicles will lead to a shortage of semi-conductor components, namely IGBTs, in the near to middle-term future. Also, due to the demand of motor-design experts by the car manufacturers, it is currently quite difficult to find well-trained engineers in this area.

There are more trends in motors for EVs that may not have a great influence on industrial motors. These are the increase of power density by higher speeds of rotation (up to 30.000 /min) and by improved water cooling. Higher speeds are hardly feasible for most industrial processes. Quite the contrary, even todays motors often run too fast and must be slowed down by a gearbox. Water cooling is a no-go for most industrial applications due to cost and also reliability concerns.