Engineering versus marketing

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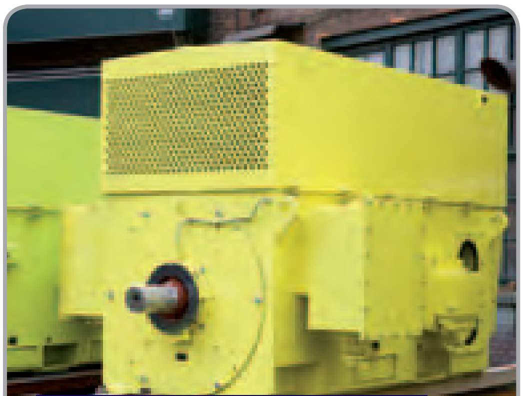
The engineering history of slip ring motors in recent times could arguably be used to showcase the subtle, or perhaps not so subtle, play of market forces. In the case of slip ring motors, marketability has absurdly pushed the production of a structural compromise while driving a clearly superior design type into near-obsolescence. Then again, what may sound like a swan song of an entire series is actually the success story of niche players who continue to build it.

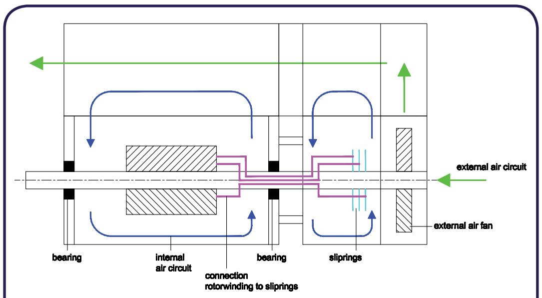
The principal deployment scenarios for slip ring motors today are applications characterised by specific acceleration requirements. Cases in point are, above all, high-inertia machines, such as mills, shredders and crushers, as well as drives with great mass inertia. A classic example is the fan, because here the deployment suitability of a given motor depends almost exclusively on the starting time, and not on the nominal output.

It is here, then, with these scenarios, that the slip ring motor plays its winning card, which is the forte of a high starting torque in combination with a low starting current. At the same time, this type of drive is often subject to particularly high requirements in terms of the motor's mechanical robustness, as well as of its torsional vibration resistance, even when it serves purposes other than driving fans. Specific demands on the resilience of a motor are made by torsional stress, but even more often by the vibrations the machine load generates, and by peak loads. All of these stress factors are mechanical in nature, and require a sturdy, tough construction to ensure that electrical life expectancy is matched by the service life.

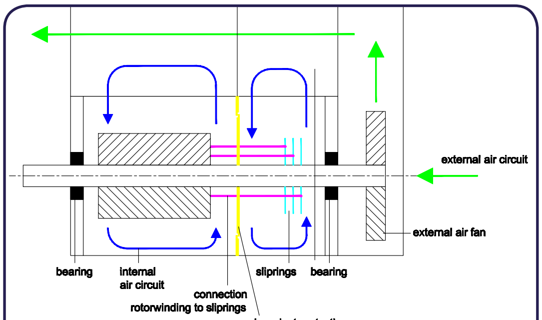
The structural requirements of the slip ring motor also extend to the slip ring body, which is used to switch a starter into the rotor circuit using sliding contacts (carbon brushes). The carbon brushes, when running on the slip rings during operation, create carbon dust that must under no circumstances get into the windings on account of its conductivity. That is why the slip ring compartment needs to be mechanically separated from the windings. One way to achieve this is by attaching a separate slip ring compartment to the motor block. It represents a structurally simple design that is more or less borrowed from the squirrel cage motor, and that looks back on a long engineering and service history. And yet, this construction has the principal drawback that the terminal leads need to be fed from the rotor end winding to the slip rings through the very motor shaft – which is constructed us a tubular shaft for this purpose – and thus, with the shaft, through the bearing between the two motor compartments. For obvious reasons, this point constitutes a potential weak spot susceptible to short circuits. In other words, the potential hazard posed by this design necessitates a thicker shaft and a larger bearing diameter accordingly.



Menzel's integrated design slip ring motor



Separate slip ring room and fan



Integrated design

As an alternative, the slip ring compartment may also be located inside the motor housing, in which case, however, it needs to be adequately enclosed to keep it away from the windings. In addition, the motor must include filters that trap and regularly remove the carbon dust. This so-called integrated design places the slip ring body between the two bearings of the machine, so that the motor shaft can be solid-built to provide either more rigidity or a smaller diameter. To replace a bearing it is not necessary to remove the slip ring body, and this advantage alone will save on major dismantling and mounting effort. While saving on time and money, the layout also minimises the risk of damaging the sensitive slip ring body.

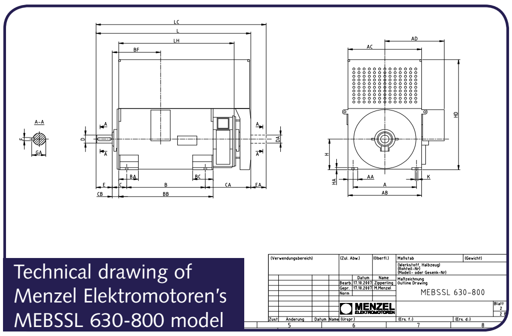
And there is another aspect: the wider the shaft diameter is in a given frame size, the less space one has for the laminated rotor core, which in turn reduces the electric output of the respective frame size. A premature upgrade in frame size will translate into increased material

Attached slip ring compartment	Integrated design
The cables connecting rotor windings and slip ring bodies are led through a hollow shaft and thus through the bearing > Requires a thicker shaft to avoid an insufficient degree of rigidity	Solid shaft > A thinner shaft will provide the same degree of rigidity while offering a superior economy of space
When replacing the bearings, the external fan and the slip ring body need to be removed • Involving a major effort • Posing the risk of damaging sensitive parts	Only the external fan needs to be removed, whereas the slip ring body remains in place • Substantially reduced effort • No risk of damaging parts
Substantially longer machine structure • Higher manufacturing costs • Higher shipping and packaging costs • Larger footprint, and hence requiring a longer base plate	Substantially shorter machine structure • Lower manufacturing costs • Lower shipping and packaging costs • Smaller footprint, hence a smaller base plate will suffice
Longer overhangs outside the bearings • Increasing the susceptibility to vibrations • Reducing the torsional vibration resistance	Short overhangs outside the bearings • Less susceptible to vibrations • More torsional vibration resistance

requirements and thus into higher costs, while output and life expectancy remain the same! In short, from a material resource perspective, the integrated design has a lot to recommend itself.

In the case of enclosed motors (applicable degrees of protection being IP 44, IP 54 and IP 55), the internal air circuit of the motor is enclosed and shut off from the ambient air. Smaller motors are frequently constructed as ribbon-cooled machines (cooling method IC 411) or as machines with concentric tube cooling (cooling method IC 511). However, this type of construction only plays a role in the lower output range. The standard cooling method for air-cooled drives with a higher power output of 1.5MW or more is IC 611, which includes modular machines with externally mounted air-air heat exchangers. With this design, the external air flow is generated by a fan mounted on, and driven by, the motor shaft. If one opts for the integrated design, this external fan can be fitted directly outside the bearing on the non-drive end, as the slip ring compartment is located directly on the inside of that bearing. As added benefits, the short overhangs of this design result in a reduced susceptibility for vibrations, a higher torsional rigidity, and a shorter overall length of the motor.

Having covered the mechanical differences of the two types, it must be said on a historical note that the construction of slip ring motors as an integrated design is anything but a new development. Motors of this design have been produced for decades, and, though production has sharply fallen, they continue to be available from a variety of manufacturers. Which brings us to the Achilles heel of the integrated design, which is the necessity to run a separate production line for a given slip ring motor series. Having an extra series production translates into an additional effort many manufacturers are no longer willing to make for obvious cost and capacity reasons. Many of the slip ring motors available on the market today are, therefore, based on squirrel cage type motors, and are no longer built as integrated design because, from a manufacturing point of view, a slip ring motor with attached slip ring compartment is closely related to the cage motor type. The theoretical similarity of design, however, does not automatically imply any cost benefits. On the contrary, fabricating motors of this type actually tends to be more costly. The thing is, that the reasons underlying the decision to suspend the production of slip ring motors of integrated design in favour of those with attached slip ring compartments are not structurally motivated, but entire market driven. What has prompted manufacturers to take this step is simply the fact that slip ring motors account for a sales share of less than five per cent compared to squirrel cage motors. Then again, for the few players that remain in the game, the relatively small sales figures of the overall market and the consequent phasing out of production, are a blessing in disguise. Residual demand for slip ring motors of integrated design, when seen in absolute figures, is served by a lower number of vendors with a disproportionately high production share of integrated design type motors. As a result, laying claim to a sub-market share that contrasts sharply with their overall market share, specialised manufacturers such as Menzel Elektromotoren have thus turned the engineering and manufacturing of this type of slip ring motors into a paying proposition, beating the market at its own game.



Technical drawing of Menzel Elektromotoren's MEBSSL 630-800 model

Manufacturing decisions have forced fewer integrated design slip ring motors to be built making them a more specialist product