The University Of Sheffield.

E-Futures

Mini-project report

Permanent magnet machine topologies for wind power generation

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Summary of the mini project – Permanent magnet machines topology used in wind power generation

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1. Introduction

Wind energy is one of the world's fastest growing renewable energy sources. It is important to investigate various topologies and design concepts of generator both used in real wind power market and laboratory experiments. In real wind power market, three types of wind power system for large wind turbines exit. The first type is fixed-speed wind power with a multi-stage gearbox and a traditional squirrel-cage induction generator (SCIG), directly connected to the grid. The second one is a variable speed wind system using a multi-stage gearbox and a doubly fed induction generator (DFIG), with a power less rating of 30% of the generator capacity passing the power electronic converter from the rotor winding. The same as SCIG, the stator winding of the DFIG is directly connected to the grid. The third type is also a variable speed wind turbine, which is famous as a gearless or direct-drive system. Usually it contains a low-speed high-torque synchronous permanent magnet (PM) synchronous generator and a full-scale power electronic converter, which is called direct-drive PMSG system.

Normally, a machine with a permanent magnet for exiting source can be called the PM machines. But as for a wind turbine generator, the output voltage of the machine usually must be sinusoidal. The types of PM machines studied in this paper focus on traditional PM generators that can be divided into radial-flux and axial-flux machines, according the flux direction in the air gap.

2. Radial-flux PM wind generators

Basically, there are two types of radial-flux PM wind generators in real application as shown in Fig. 1.

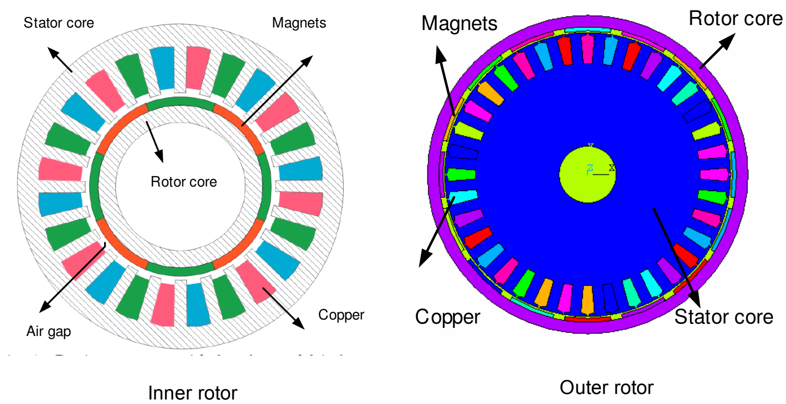

Figure 1 Inner and outer rotor radial-flux PM generators

In a fact, only the two topologies are applied in MW wind system. There are a lot of experiences and studies in the inner rotor PMSGs. They also show a good electrical operation performance and better cooling effect for stator. As for the outer rotor radial flux PMSG, they are easily directly coupled between wind turbine and generators mechanically .This topology has a better cooling effect for rotor and magnets, but difficult cooling for stator, while most of wind generator loss is on this side.

For dual stator and IPMSG, illustrated in Fig. 2, they are just used in small power wind system, from 1kw-50kw. The dual stator structure has higher torque capability and the IPM topology is good for resisting demagnetization. The IPM topology is widely used in industrial application. But for a large power system, its large volume and the performance is easily influenced by load change.

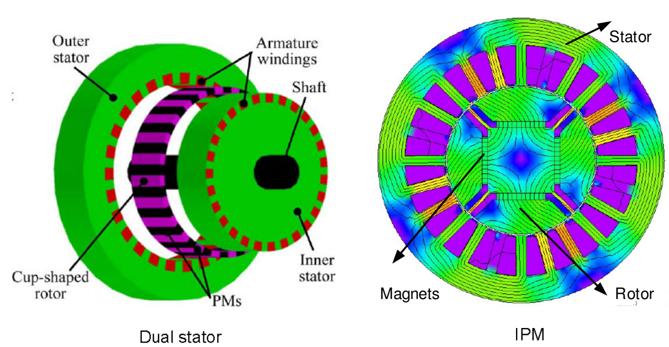

Figure 2 Dual stator and IPM radial-flux PM generators

Double stator and single side axial flux PMSG are widely used in small wind power system, and the structure can be seen in Fig. 3. Double stator axial flux PMSG has a higher torque capability and the performance is superior to the single side one. Besides, the topology is too complicated to useful for a large wind generator system. The sing side axial-flux PM generator has simple construction and is easy for mass production. But when it comes to large power and large blade radius, mechanical dynamic balance is a serious problem.

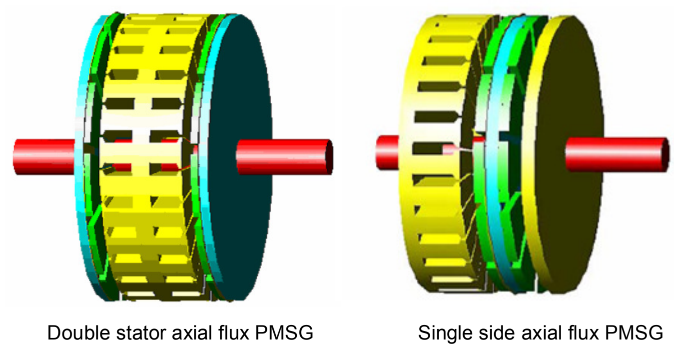

Figure 3 Double stator and single side axial flux wind PMSG

Lastly, two problems of PMSG used in wind power are introduced. First is the inherent cogging torque due to magnet materials naturally attractive force. This kind of torque is bad for operation, especially stopping wind turbine starting and making noise and vibration in regular operation. But It can be reduced as small as possible by reasonable design, for instance fractional slot design. The other one is the risk of demagnetization because of fault happening and overheating of magnets. This risk is very dangerous and the cost for replacing bad magnets is much higher than the generator itself. Currently, this kind of risk can be avoided by online re-magnetization or fault-torrent design. They are all my future research tasks.

3. Conclusions

This paper simple introduces permanent magnet machine topologies used in wind turbine in recent 15 years, including laboratory and application level. Radial and axial flux PM machines are investigated as two main types. Advantages, disadvantages and comparisons are given for understanding and reference for designers or researchers in wind power generators.

4. Selected References

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