Project: Robust Modular Machines for Offshore Wind Applications

Key focus: modular design, reduced Levelised Cost of Energy, thermal management

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Background

Since October 2008, the United Kingdom (UK) has been the world leader in offshore wind power with a current operational wind capacity of 3.6 Gigawatts (GW). This figure is growing rapidly, and by 2020, it is projected that the deployment of offshore wind power will be 8 – 15 GW within a total wind power capacity of 19 - 28 GW. It is recognised that there is a very high potential for deploying up to 40 GW by 2030. This dramatic uptake of offshore wind power is mainly driven by the higher potential yields of wind resource and hence more power than onshore, remoteness from inhabited areas and hence greater public acceptance to the noise point of view, and so on… However, a number of challenges still exist, most notably in addressing concerns of modest reliability due to the harsh operational environment and the subsequent high repair and maintenance costs. These are dominant factors that challenge the growing mass-market penetration for offshore wind turbines. Therefore, it has long been recognised that reliability improvement and hence the reduction in maintenance costs remain pivotal in enable future growth and investment.

Project description

In order to overcome the above challenges, the project proposes robust modular machine topologies as shown in Figure 1. Such machines will have a segmented stator with flux gaps (FGs) between adjacent stator segments. There are a series of advantages for such a modular design, e.g. (a) improved electromagnetic performance such as increased torque/power density, reduced torque ripple, and increased efficiency, (b) a simplified winding process and also an increased slot fill factor, (c) reduced iron material waste and up to a 70% reduction in iron lamination materials, (d) an improved fault tolerant capability due to physical, electromagnetic and thermal insulation between adjacent segments, leading to reduced operation and maintenance costs.

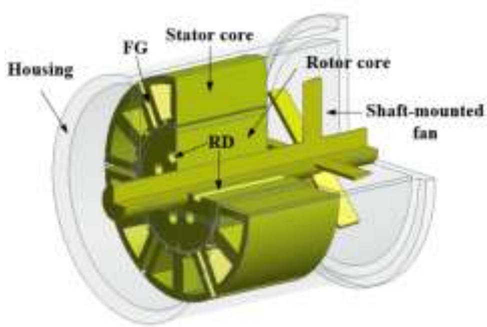

Figure 1: Modular machines with flux gaps (FG) in the stator iron core for improved cooling. RD stands for rotor ducts.

This project will look at another key aspect of the proposed modular machines, i.e. effective cooling. Due to the existence of FGs in the stator iron core, improved cooling within the modular machine becomes possible. This is mainly because the exchange surface area (additional surface area due to the FGs) has been increased for the stator iron core. Together with a rotor mounted fan and rotor ducts (RD), as shown in Figure 1, the axial air flow inside the modular machine can be significantly increased. As a result, the machine's thermal performance can be improved as shown in Figure 2.

Thermal performance is a well-known barrier to machine torque/power density improvements in electrical machine design.

Research outcomes/impact

The modular machine design will have improved electromagnetic, thermal and mechanical performance (and also reduce the material cost), leading to a reduced Levelised Cost of Energy (LCoE) for offshore wind power. Furthermore, breakthroughs in these type of technologies can transform the UK from a world-leader in offshore wind research and innovation to the world leader in this key market sector. Finally, this project will help to safeguard and extend the UK position in offshore wind to 2030 and beyond; it can provide a competitive lead to UK engineering companies and also strengthen the UK supply chain, thus benefiting the UK economy.

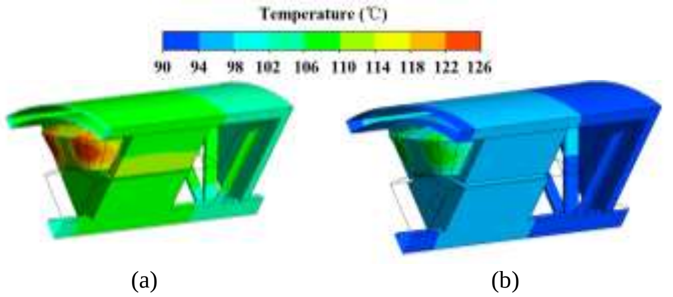

Figure 2: Temperature distribution without (a) and with (b) flux gaps and rotor ducts. Peak temperature in (b) is 15oC lower than that in (a).

Project Sponsorship:

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