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Evaluation of Warm and Cold Shaft Designs for Large Multi-megawatt Direct Drive Offshore Superconducting Wind Generators

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For offshore wind power generation applications, multi-megawatts rated direct drive generators are believed to provide an opportunity to convert the abundant wind energy into electricity. Because of its ability to generate high flux fields, superconducting (SC) technology can offer significant size and mass reduction over traditional technologies. However, many challenges still exist, and cryogenic cooling design is one of the major obstacles. Many current SC designs use cold shaft designs, which enclose the rotor inside a single cryostat and cool it to the cryogenic temperatures. Such approach may not be practical for large generators because of the large rotor mass that requires long cool down time during startup. Instead of cooling the entire rotor, a warm shaft design offers an alternative to the SC cold shaft rotor design. Each pole has its own separate cryostat and keeps the rest of the rotor at room temperature. This provides faster cool down time. Another major advantage is lower maintenance time and cost, which can be very expensive when considering the costs associated with troubleshooting in offshore wind turbines. For warm shaft design, it is possible to replace a cryostat pole onsite resulting in minimum downtime. Warm rotor design, however, does present a significant challenge as the cryostat design is so compact, it is more difficult to minimize heat leak and it requires special design concepts for structural integrity. This paper presents the investigations on the advantages and disadvantages of both rotor designs for large SC generators from manufacturability and service perspectives.

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