

Design and Development of 2MW, High Speed Permanent Magnet Alternator

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Based on the reference below, a development of an advanced 2MW high-speed alternator (HSA) directly coupled to a gas turbine (GT) was embarked on last year for the British Navy. This system incorporates a Calnetix Radial Flux HSA with permanent magnet technology directly coupled to a GT at variable speeds. The result is a reduction in size, weight and complexity of the system.

The HSA functions as a motor to provide starting torque to the GT and as a generator to produce electric power at the GT's operating speeds.

Unique design features include:

1- Graphite Composite Sleaving: Used for magnet retention, the graphite sleaving allows for higher tip speeds and smaller magnetic gap between the rotor and stator as compared to a more standard metal sleeve. This results in better magnet (Samarium Cobalt) retention, better magnetic performance and a more compact design.

2- An Integral Fan is mounted on the main rotor shaft to provide cooling air for the rotor as well as buffer air for the shaft seals.

The design process of the HSA involves continuous iterations of Electromagnetic, Thermal, Structural and Rotor Dynamic designs. Optimum designs were obtained by balancing all of these design criteria.

To ensure a successful development program, major technical risks were identified early on in the program and a Development Risk Mitigation plan including analyses and testing of scaled components were implemented. A scaled-down rotor with the same diameter as the actual unit and one third of the length was fabricated to demonstrate manufacturing feasibility and to verify the HSA Composite Rotor integrity. Testing was also conducted to verify demag-

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netization characteristics due to a wide variation of loading under high temperature.

Fabrication was completed early 2004 and the performance mapping of the HSA will be conducted with the unit mounted in a back-to-back configuration.

The 2MW high-speed generator offers significant cost and performance advantages compared to conventional systems shown in the table below:

- (1) Higher efficiency with an operating efficiency of 98%+
- (2) Smaller footprint for installation in a wide range of locations and applications
- (3) Higher reliability and lower maintenance
- (4) Direct drive system provides simplified assembly and integration

Table 1 Conventional vs. Calnetix Generators

Parameters	Conventional	Calnetix
Power	2,000 kW	2,000 kW
Nominal Speed	1,800 rpm	22,500 rpm
Efficiency	96.30 %	Over 98 %
Weight (Packaged)	5,130 Kg	750 Kg
Length	2.29 m	1.35 m
Diameter	1.85 m	0.72 m
Volume	6.26 m ³	0.57 m ³
Power Density	321 kW/m ³	3,500 kW/m ³

References:

Co Huynh, Larry Hawkins, Ali Farahani and Patrick McMullen: "Design and Development of a 2MW, High Speed Permanent Magnetic Alternator for Shipboard Application" Electric Machines Technology Symposium, Philadelphia, Pennsylvania, USA, January, 2004