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Voyage Analysis of a Marine Gas Turbine Engine Installed to Power and Propel an Ocean-Going Cruise Ship

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Abstract : A gas turbine-powered cruise Liner is scheduled to transport pilgrim passengers from Lagos-Nigeria to the Islamic port city of Jeddah in Saudi Arabia. Since the gas turbine is an air breathing machine, changes in the density and/or mass flow at the compressor inlet due to an encounter with variations in weather conditions induce negative effects on the performance of the power plant during the voyage. In practice, all deviations from the reference atmospheric conditions of 15 ^oC and 1.103 bar tend to affect the power output and other thermodynamic parameters of the gas turbine cycle. Therefore, this paper seeks to evaluate how a simple cycle marine gas turbine power plant would react under a variety of scenarios that may be encountered during a voyage as the ship sails across the Atlantic Ocean and the Mediterranean Sea before arriving at its designated port of discharge. It is also an assessment that focuses on the effect of varying aerodynamic and hydrodynamic conditions which deteriorate the efficient operation of the propulsion system due to an increase in resistance that results from some projected levels of the ship hull fouling. The investigated passenger ship is designed to run at a service speed of 22 knots and cover a distance of 5787 nautical miles. The performance evaluation consists of three separate voyages that cover a variety of weather conditions in winter, spring and summer seasons. Real-time daily temperatures and the sea states for the selected transit route were obtained and used to simulate the voyage under the aforementioned operating conditions. Changes in engine firing temperature, power output as well as the total fuel consumed per voyage including other performance variables were separately predicted under both calm and adverse weather conditions. The collated data were obtained online from the UK Meteorological Office as well as the UK Hydrographic Office websites, while adopting the Beaufort scale for determining the magnitude of sea waves resulting from rough weather situations. The simulation of the gas turbine performance and voyage analysis was effected through the use of an integrated Cranfield-University-developed computer code known as ‘Turbomatch’ and ‘Poseidon’. It is a project that is aimed at developing a method for predicting the off design behavior of the marine gas turbine when installed and operated as the main prime mover for both propulsion and powering of all other auxiliary services onboard a passenger cruise liner. Furthermore, it is a techno-economic and environmental assessment that seeks to enable the forecast of the marine gas turbine part and full load performance as it relates to the fuel requirement for a complete voyage.

Keywords : cruise ship, gas turbine, hull fouling, performance, propulsion, weather
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