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Simulation of a hybridised solar gas turbine system

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Abstract

This study involves the creation and analysis of a thermal-fluid network simulation model using a specified commercial software package (Flownex), as part of a larger solar power research programme at the Council for Scientific and Industrial Research (CSIR). The model was needed for performance simulation of a Concentrating Solar Power (CSP) system incorporating a Rover 1S/60 gas turbine engine with modified recuperator, to be used in a hybridised operation mode with a solar receiver and thermal storage unit. Full performance characteristics of the Rover 1S/60 gas turbine engine were required prior to the final model being created. Fuel leaks in the combustor resulted in unsustainable combustion, leaving the engine inoperable and testing results from Prinsloo (2008) were used as a means to validate the simulation results.

After the main components in the system had been characterised three simulation models were created using Flownex software, a standard Rover model – excluding recuperator, a modified Rover model – including recuperator and intake system, and a solar Rover model – including the solar receiver tower and thermal storage unit. Results of the models showed an increase in thermal efficiency, at the design operating point of 46000 revolutions per minute, from 10.5 % for the standard model to 12.8 % for the modified model and 14.1 % for the solar model. Furthermore the fuel usage was seen to decrease rapidly with an increase in solar power into the system. The thermal storage results were validated against testing results from Klein (2011). These were found to correlate well and yielded similar charging and discharging times. Further analysis showed that an increase in solar power input into the system as well as a larger-scale thermal storage unit would greatly increase the overall system performance and economic feasibility.

The model can be used to simulate other solar thermal systems of this type, with instructions provided in an appendix on how to do this. The program offers the ability to model combustion comprehensively with both reactants and products being

defined. It was recommended that Flownex is more than capable of modelling gas turbine systems of this type.

Additionally the program does allow the user to construct an interface environment which greatly simplifies the detailed network model into a manageable graphic interface to easily monitor performance parameters of the system. From a solar perspective while more advanced commercial software exists which allows for the sensitive modelling of the solar tracking aspect of a solar power plant combined with the power cycle, Flownex does allow the user to build custom defined power block components for incorporating solar heat inputs into any model and is a powerful tool for modelling thermal systems of this type.

The scientists of today think deeply instead of clearly. One must be sane to think clearly, but one can think deeply and be quite insane.

Nikola Tesla