ON THE TECHNICAL AND ECONOMICAL PERFORMANCE OF GAS TURBINES AND COMBINED CYCLES USING SUPER HYDRATED ETHANOL AS FUEL

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Overview

Due to the large ethanol production in Brazil, it became a much-used automotive fuel, with this history beginning in the 1970s. It was a natural path that this fuel was considered for other types of engines, including those applied to power generation. Thus, the studies about the use of ethanol in gas turbine engines started in the early years of the 1970s. The results showed in 1976 with a 625 kVA turbo generator, Paraná II. The engine was made of a Garrett IE-831-800 coupled to a Toshiba electricity generator. The set was expected to be installed as a combined cycle in a cassava ethanol production plant in Caucaia, Ceará State. The high costs of ethanol from cassava led to the abortion of the project. Two other initiatives were started in 1977 and 1979, using different gas turbine engines and variations of ethanol. The last experiment happened at the Juiz de Fora Thermal Power Plant, in the mid-2000s, in a work reported by Machado, 2010. Since the decade of the 1970s, ethanol production technology has changed and evolved. Costs are now lower than they were. The same happened to the gas turbine technology, performance and costs.

Methods

The methods applied to this work consist of using the regular Thermodynamic First Principles to simulate the gas turbine engine components - compressor, combustor, and turbine - and the steam cycle components - HRSG, pump, condenser, and steam turbine. For simplicity's sake, the air, the natural gas, and the combustion fuels are considered ideal gases. For the economic analysis, the methodology applied is based on that described by Bejan et al., 1995. The exergy analysis presented by the authors is not included in this paper. This work will review the history of ethanol use in gas turbines and show a thermodynamic performance and economics comparison of gas turbine engines. Both configurations, open-cycle and combined-cycle are considered. The benchmarks are the same cycles running on natural gas.

Results

The use of ethanol, in its different forms, was explored in the past, as well as recently, and its technical feasibility is well known. Although the performance of the use of ethanol, super hydrated ethanol in this work, is well understood, mainly with regards to the fact that adaptations must be carried out due to the lower calorific value of the ethanol. Thus, the challenge lies in the economics of this type of power generation mode, which are not finished at the time we submitted this abstract, but will be in due time. Whether favourable or not, the outcomes of this study will contribute to the understanding of the economics of the gas turbine engines and respective combined cycles under the sugar cane and ethanol industry scenario in Brazil.

Conclusions

In this paper, we conducted a technical and economic analysis of gas turbine engines operating in simple and combined cycles using superhydrated ethanol, SHE, as fuel. The simulations considered ideal thermodynamic cycles running at the design point only, and the gases involved in the processes were deemed to be perfect. The challenges of using SHE are now related to the costs. It's most likely that the best results will be towards the application of SHE on power plants dedicated to heat and power supply to the sugar mills and their surroundings. This leads to small gas turbines with consequent limited-size combined cycles.

References

To be included in the final version.