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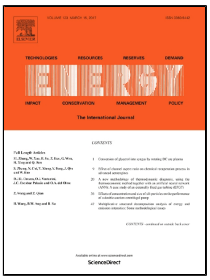

Exergo-economic Competitiveness Criteria for Hybrid Power Cycles using Multiple Heat Sources of Different Temperatures

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Exergo-economic Competitiveness Criteria for Hybrid Power Cycles using Multiple Heat Sources of Different Temperatures

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Abstract

Hybrid power generation systems using multiple heat sources of different temperatures are gaining strong interest, especially because of their ability to incorporate efficiently the use of low temperature heat sources such as renewable and waste heat, and thus also reduce specific emissions and depletion of fossil fuels and improve energy security. Past studies focused only on the exergo-economic analysis of specific thermal hybrid systems but no general theory about the performance of this class of hybrid systems was developed. This paper developed the general theory and equations for exergo-economic evaluation of such hybrid power generation systems (based on thermodynamics and the SPECO method), discusses the results, and draws conclusions about their possible improvements. Major types of power generation cycles were studied, including hybrid Rankine cycles (with and without reheat and regeneration), hybrid Brayton cycles (with and without intercooling, reheat and regeneration) and hybrid combined cycles. Positive and negative prices of externalities were included. The study found that for all the types of hybrid power cycles studied, the difference between the levelized electricity costs (LEC-s) of the hybrid system and the corresponding single heat source reference system could be generalized by two equations: one for the fuel-saving mode when the additional heat sources (AHS, beyond one) are used to save fuel, and the other for power-boost mode when the AHS is added to generate more power. These equations can be, and were, used to find he fuel price and the values of the price-beneficial externalities at which the LEC of the hybrid system becomes lower than that of the reference system. Considering that the price of the non-renewable fuel will increase in the long run, that the cost of AHS equipment will decrease as technologies improve, and that the cost of undesirable externalities will be increased, the LEC of the hybrid systems will become lower. The results also show that higher carbon and other environmental taxes/penalties will boost the economic competitiveness of the hybrid systems and provide guidance for government in determining their magnitudes.

Highlights

► The advantages of multi-temperature heat input hybrid power systems were identified.
► The economic evaluation methodology for such systems was developed.
► The methodology is general to major types of power systems.
► General equations were developed to find the LEC competitiveness of such systems.
► The effects of carbon tax, value of byproducts, and hybridization cost were included.

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