SECONDARY FLOW ANALYSIS OF AN ORC RADIAL INFLOW TURBINE USED IN WASTE HEAT RECOVERY APPLICATIONS

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ABSTRACT

Organic Rankine Cycle (ORC) systems are considered as the most promising technology for engine waste heat recovery applications. ORC systems recover useful power from waste heat and thus results in lower fuel consumption and pollutant emissions. ORC systems used in engine waste heat recovery applications are generally medium-sized ORC power systems, of the range of tens to hundreds of kilowatts that employ radial inflow turbines for expansion. The turbine is regarded as the most critical component in Organic Rankine Cycle (ORC) systems. Any improvement in the system efficiency calls for improvement in the performance of the turbine. This requires detailed analysis of the turbine flow field and identification of the various sources of losses.

The design of turbines for ORC systems is quite critical due to the molecularly complex and high dense characteristics of ORC fluids. Moreover, as the single-stage high-pressure radial turbines are generally operated close to the critical point of the working fluids, they will exhibit complex flow characteristics like shock waves. In order to evolve a design that yields better isentropic efficiency, it is imperative to understand the sources of inefficiency by investigating the turbine flow field.

In the present work, three dimensional compressible flow analysis of an ORC radial inflow turbine is performed using Computational Fluid Dynamics (CFD). The turboexpander has been designed based on the design methodologies proposed by Balje, Kun and Sentz and Hasselgruber. The analyses include the identification of the various secondary flows within the turbine, their origins, the corresponding loss in turbine performance, the increase in entropy due to these losses and the effects of various geometrical parameters on these losses. The outcome of this study can also be used to improve the existing preliminary design methodologies for the development of efficient radial inflow turbines for ORC systems.