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ADAPTION AND USE OF A COMPRESSIBLE FLOW CODE FOR TURBOMACHINERY DESIGN

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Abstract. *The present paper presents and discusses the use of different codes regarding the numerical simulation of a radial-inflow turbine. A radial-inflow turbine test case was selected from published literature [1] and commercial codes (Fluent and CFX) were used to perform the steady-state numerical simulations. An in-house compressible-flow simulation code, Eilmer3 [2] was also adapted in order to make it suitable to perform turbomachinery simulations and preliminary results are presented and discussed. The code itself as well as its adaptation, comprising the addition of terms for the rotating frame of reference, programmable boundary conditions for periodic boundaries and a mixing plane interface between the rotating and non-rotating blocks are also discussed. Several cases with different orders of complexity in terms of geometry were considered and the results were compared across the different codes. The agreement between these results and published data is also discussed.*

1 INTRODUCTION

The pursuit of sustainable solutions for the current energy landscape is one of the world's biggest challenges. In this context, engineered geothermal resources look to be a promising energy source for baseload electrical power generation in Australia. Overall, current geothermal plants, enjoy less than 40% of the ideal (Carnot) efficiency, contrasting with other existing power technologies able to achieve around 70% of their ideal efficiency [3]. This can be taken as an indication that there is scope for improvement in geothermal cycles and, in particular, for engineered geothermal systems by focusing on key challenges such as optimum energy extraction, efficient power conversion, development of efficient cooling systems and improved power transmission techniques. These issues have been the primary focus of the Queensland Geothermal Energy Centre of Excellence (QGECE) in Australia. A closed Brayton cycle as part of a binary cycle and using supercritical CO_2 as the working fluid was identified as a suitable candidate for producing power from geothermal resources. When considering the same resource conditions in a temperature range between $200 - 250\,°C$ (overall measured subsurface granite temperatures in South Australia), with comparable subsurface investment, this cycle has the potential to produce 50% more electricity at a higher efficiency than using steam as the working fluid [3] also as a consequence of compressor work reduction. However, in this situation, high pressures (around 22 MPa) for the turbine inlet and an outlet pressure of around 8 MPa are to be used, which in addition to a higher fluid density may comprise a significant challenge in terms of turbine design. It is the aim of the QGECE Thermal Power Group to design and demonstrate a suitable turbo expander to make optimum use of this energy resource, with a 1 MW field demonstration planned within 5 years. Therefore, a radial inflow turbine is being considered for the current application because this type of machine was found to be efficient and relatively easy to build for the initial target power, allowing to have the additional benefit of a high blade stiffness, contributing to the robustness and rotor-dynamic stability of the entire unit [4]. This led to the use of suitable Design, Computational Fluid Dynamics (CFD) as well as Finite Element Analysis (FEA) tools that proved the feasibility of this type of design [5] and will allow further understanding of the suitable options, models and phenomena involved as well as the development of local in-house existing tools. This paper will present the first step of this process in terms of design and CFD calculations, comparing results between codes as well as discussing the selected models and implementations in the local in-house code.

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