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3D CFD analysis of a twin screw expander for small scale ORC systems

Iva Papes [1], Joris Degroote [2] and Jan Vierendeels [3]

Ghent University, Department of Flow, Heat and Combustion Mechanics
[1] iva.papes@ugent.be, [2] joris.degroote@ugent.be, [3] jan.vierendeels@ugent.be

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INTRODUCTION

With the growing energy demand and the pollution produced by the combustion of fossil fuels, the interest to generate electricity from renewable sources like waste heat has dramatically grown. Among a number of solutions to generate electricity from low temperature heat sources, the Organic Rankine Cycle (ORC) is the most widely used. Although these ORC systems are now well developed, research efforts are increasingly directed towards higher efficiencies and powers.

Expanders of the organic fluids are the key element for power generation in ORC systems. Studies have shown a big potential of positive displacement machines, like a twin screw expander, for small scale ORC systems [1]. One of the advantages of using screw expanders is the possibility to use existing compressors with opposite sense of rotation. However, the performance of the screw expander is affected by several factors like leakage flows through the gaps, internal volume ratio, design of the high pressure port, thermal properties of the working fluid etc. In this paper 3D CFD (Computational Fluid Dynamics) calculations are performed, in order to get a better understanding of the expansion behaviour in a particular screw expander.

In ORC systems with a low temperature heat source, R245fa is one of the most commonly used organic fluids. Since the ideal gas equation of state shows big deviations in the ORC working conditions [2], an appropriate real gas model should be used. In this work, the cubic Augnier Redlich-Kwong equation of state [3] has been used in the CFD modelling because of its relative simplicity and low computational costs.

CFD MODELLING

The geometry of the twin screw expander is shown in Figure 1. The rotors inside the casing are rotating and forming narrow gaps between the screws and between the housing and the screws. Because of that, the grid in the casing is built by stacking two-dimensional structured rectangular grids in slices of the casing. To generate these two-dimensional grids, a grid generation algorithm developed in [4] was used. The grid of the inlet, outlet, and injection channels is stationary and is joined together with the grid in the casing by using sliding interfaces.

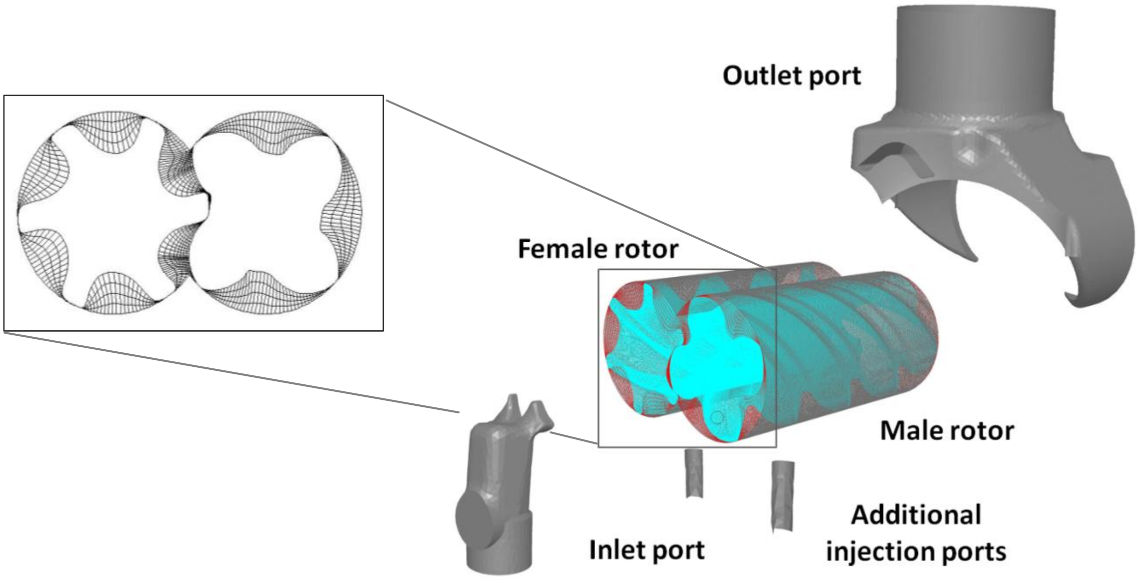

Figure 1.The geometry of the twin screw expander, with the different parts shown separately for clarity

The mass flow rates through the clearance gaps have a significant influence on the expander performance. In order to evaluate the effects of individual clearance gaps on the performance of the expander, time dependent mass flow diagrams for each of them are provided and studied. Two effects that will additionally lower the power output are pressure drop in the expander inlet and pre-expansion which occurs during the suction process. However the negative influence of these effects can be reduced by modifications in the design.

CONCLUSION

Transient 3D CFD analysis of a twin screw expander with R245fa has been performed. The outcome of the detailed analysis will be used for further improvements which will lead to maximization of the power output.

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