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CFD MODELLING OF A BETA-TYPE STIRLING MACHINE

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In the last decades the Stirling technology has experienced a renewed interest in industry and academy, due to a wide range of possible applications for energy generation from renewable resources and waste-heat recovery. In this context, the adoption of CFD can give a substantial contribution to the development of this technology, since it allows to enhance the understanding of the physical phenomena occurring inside the machine and to provide useful guide-lines for its optimization.

In the present work CFD is applied to the simulation of a Beta-type Stirling machine. As preliminary step, in order to model the specific features of the machine, ad-hoc submodels were implemented on the basis of the open-source software OpenFOAM. In particular specific mesh motion strategies were developed for the description of the motion of the power piston and of the regenerator, in order to reproduce the variation of the volumes of the working spaces. Moreover, heat-transfer models were implemented for taking into account the presence of the heat source/sink of the cycle and the regenerator.

Simulations were performed on a small 300 cm^3 Beta Stirling configuration, installed at the laboratory TEMPO (University of Valenciennes, France) and instrumented with thermocouples and pressure transducers. Particular care was paid to the choice of the mesh resolution, in order to accurately describe the heat transfer inside the cold sink. The computational model was validated both on global quantities, such as the indicated power and heat transferred to the cold sink in a cycle, and on local measurement of temperature inside the machine.

The CFD model was applied in order to perform a parametric study involving different aspects related to the machine: regenerator properties, working fluid, mean cycle operating pressure and amount of heat introduced in the machine. Moreover, the effect of the law of variation of the volumes was investigated. In particular, an ideal law, not constrained by the need to impose the alternative piston/regenerator motion by means of a crankshaft,

was applied showing improvements in terms of an higher efficiency of the cycle.