ENERGETICS

CRT/DENERG - Pushing the limits of large-scale energy storage by designing an ultra-efficient centrifugal compressor for caes applications

Funded By	DENERG - Progetti - Progetti ricerca Unione Europea ed Internazionali FONDAZIONE CRT CASSA DI RISPARMIO DI TORINO [P.iva/CF:06655250014]
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Context of the research activity	This scholarsip is framed into a broader research project aiming at solving the existing challenges for a high-efficient, cost-effective CAES technology. Among other tasks, the proposed objective will be achieved by modelling and designing a single stage compressor with outlet conditions over 65 bar. That outcome will be reached through feasibility research and compressor performance modeling. Also, the use of high temperature lubricants and of magnetic levitation techniques will be studied, to reduce friction will be taken into consideration when calculating the residual thrust of the compressor and its long-term reliability.
	The researcb activity related to this proposal is framed within the PUSH-CCC research project (Horizon Europe framework), and is carried out in close cooperation with Riegosur SA, Universidad de Sevilla and National Technical University of Athens. The focus of the activity is the design of a single stage compression phase with outlet conditions over 65bar. That outcome will be reached through feasibility research and the computational modeling of the compressor performance. Also, the use of high temperature lubricants will be studied and the possibility to use magnetic levitation techniques to reduce friction will be taken into consideration when calculating the residual thrust of the compressor and its long-term reliability. The project will rely on an extensive literature review about centrifugal compressors performance for CAES applications; on the study of efficient methods for the 0D/1D/3D numerical simulation of centrifugal compressors; on the development of in-house methods for compressor analysis and design optimization the wheel, including the preliminary calculation of residual axial thrust and performance maps. Optimization methods will be implemented for the design of the compressor

Objectives	while taking into consideration boundary conditions provided by the PUSH-CCC partners. The main goal of the activity is to develop a methodology to design the compressor components to cope with extreme pressure ratio starting from a 0D/1D approach with correlations and verifying the final configuration using 3D CFD. One of the most relevant outcomes of the doctoral study is the feasibility study of the compressor with the prescribed pressure ratio. Another relevant outcome will be the verification of the mechanical stresses and of the optimal selection of bearings (including lubrication). Each step of the research will be validated using available experimental data from academic test cases. More in detail, a preliminary version of the 0D/1D algorithm will be used to design a baseline geometry under steady boundary conditions for the prescribed working parameters. The impact of the selected correlations will be quantified for the investigated cases, thus releasing a design practice able to guide the designer towards the optimal solution. During the doctoral activity an in-house tool will be released for generic purpose and the use in other projects. Component interaction (impeller/diffuser/volute) will be accounted for by using loosely coupled approaches in the final 3D analysis for different mass-flows. Leakage flows will be accounted for both in the 0D/1D models and the 3D calculation, thus allowing for calculating the actual mass-flow through the impeller and the residual axial thrust. The impact of different materials may be considered by means of a limited number of analyses of the mechanical stresses based on the pressure field obtained from 3D CFD.

Skills and competencies for the development of the activity	The candidate must have knowledge of basic technical characteristics of compressors working principles and of energy storage by CAES method. Also, a basic knowledge of 0D/1D modelling (with commercial tools) is welcome. Experience in the optimization field, in Computational Fluid Dynamics, and in Fortran programming may represent an added value.