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Internal Power Recovery in Cryogenic Cooling Plants, Part II: Compressor Development

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Abstract : The electrical power consumption related to refrigeration systems is evaluated to be in the order of 15% of the total electricity consumption worldwide. For this reason, in the last years several energy saving techniques have been suggested to reduce the power demand of refrigeration and air conditioning plants. The research work deals with the development of an innovative internal power recovery system for industrial cryogenic cooling plants. Such system is based on a Compressor-Expander Group (CEG). Both the expander and the compressor have been designed starting from automotive turbocharging components, strongly modified to take refrigerant fluid properties and specific system requirements into consideration. A preliminary choice of the machines (radial compressors and expanders) among existing components available on the market was realised according to the rules of the similarity theory. Once the expander was selected, it was strongly modified and performance verified by means of steady-state 3D CFD simulations. This paper focuses the attention on the development of the second CEG main component: the compressor. Once the preliminary selection has been done, the compressor geometry has been modified to take the new boundary conditions into account. In particular, the impeller has been machined to address the required total enthalpy increase. Such evaluation has been carried out by means of a simplified 1D model. Moreover, a vaneless diffuser has been added, modifying the shape of casing rear and front disks. To verify the performance of the modified compressor geometry and suggest improvements, a numerical fluid dynamic model has been set up and the commercial Ansys-CFX software has been used to perform steady-state 3D simulations. In this work, all the numerical results will be shown, highlighting critical aspects and suggesting further developments to increase compressor performance and flexibility.

Keywords : vapour compression systems, energy saving, refrigeration plant, organic fluids, centrifugal compressor
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