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Optimisation of a multi-stage turbocompressor architecture operating with a neon- helium gas mixture

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Within the framework of the Future Circular Collider (FCC) currently being investigated at CERN, the entire cryogenic cycle required to maintain a temperature level of the superconducting magnets near absolute zero had to be revised with respect to the existing Large Hadron Collider (LHC). In particular, a novel as well as sustainable architecture of the pre-cooling cycle had to be developed. This led to a closed-loop cryogenic cycle operating with a mixture of helium and neon, also called nelium.

Whereas screw compressors remain a viable option in a standard helium cryogenic cycle, by ballasting the operating fluid with a heavy gas such as neon, the usage of a multi-stage turbocompressor becomes realistic. Moreover, this new approach justified the collaborative research to work on the turbocompressor side between CERN, MAN Energy Solutions and ITSM at University of Stuttgart. The main goal of this research group is to provide an efficient and economically viable solution for the multi-stage turbocompressor. This poster aims at exploring the different architecture alternatives and highlight the limitations.

The poster will include a description of a 1D performance prediction tool used to predict turbocompressor performance at design point as well as at off-design operation. The influence of using a same impeller for various concentrations of helium and neon on its performance is also presented.

A model predicting the performance of multi-stage turbocompressor from its architecture is then described. Based on the constraints coming from the design of an existing high speed multi-stage turbocompressor as well as the heat load requirements imposed by the particle accelerator during operation, boundary conditions can be set for the machine. The overall machine performance can then be obtained by a stacking method knowing the performance of each individual stage.

Then, the theory behind a Breeder Genetic Algorithm (BGA) is introduced. The latter has been used first to generate an impeller data base optimised for certain boundary conditions as well as to determine the best theoretical multi-stage machine architecture.

The final multi-stage architectures for each gas mixture are then compared and conclusion can be drawn on the most desirable gas mixture with respect to the machine architecture, performance and size.

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