MULTIPOINT OPTIMIZATION OF A 3D RADIAL COMPRESSOR IMPELLER

Steve Kowalski, USA
Supervisors: R.A. Van den Braembussche, Z. Alsalihi, J. Prinsier

The motivation for the present work was the efficient operation of a large air conditioning system throughout the year. The amount of cooling capacity that is required depends on the season and can best be accommodated by adjusting the mass flow of the cooling fluid submitted to the same thermodynamic cycle. This requires a compressor with a large operating range that is capable of providing different amounts of mass flow at constant pressure ratio. A Variable Inlet Guide Vane (IGV) was chosen as the appropriate technique to extend the flow range of the compressor with minimum cost. However different settings of the IGV result in very different impeller inlet conditions. Consequently the impeller should be designed in such a way to perform well at all conditions.

The optimization is made by means of an expert system based on a Database, an Artificial Neural Network (ANN) and Genetic Algorithm (GA). The database containing full three-dimensional Navier-Stokes (NS) computations is used to train the ANN. A well trained ANN has the capability to predict the performance of new geometries with much less computational effort than a full NS. The GA proposes new geometries that, based on biological and genetic evolution, demonstrate superior performance.

The performance of an impeller at given inlet conditions accounts for the efficiency, difference in mass flow in the two flow channels on both sides of the splitter vane, and a blade loading distribution. Geometries not satisfying geometric restrictions, concerning maximum blade lean at inlet and outlet, are eliminated. The multipoint performance during the whole year is expressed as a sum of weighted penalty functions (P_{total}) for the different operating conditions.

$$P_{total} = W_{summer} P_{summer} + W_{spring} P_{spring} + W_{autumn} P_{autumn}$$

Where, the most weight was put on the summer because the most energy is consumed during this season. The weights used for the summer, spring, and autumn seasons were 55%, 30%, and 15%, respectively. This resulted in a different geometry to be used for single and multiple point operation. Finally, Figure 2 shows the performance map of the optimized geometry at different settings of the IGV.

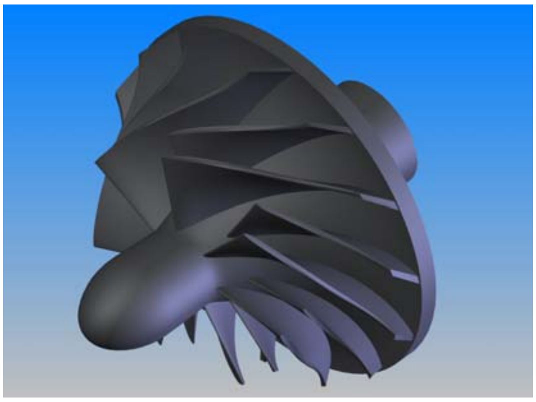

Figure 1. Optimum Impeller

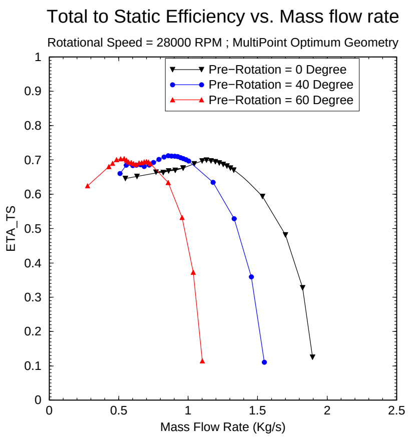

Figure 2. Peformance Map of Optimum