IMPROVEMENT OF 1D RADIAL TURBINE OFF-DESIGN PREDICTION MODEL BY MEANS OF NUMERICAL EXPERIMENTS

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The accurate prediction of radial turbine off-design performance (turbine maps) is of interest for conducting multi-point design optimization, trade-off studies, off-design and transient overall system performance. In the case of automotive turbocharger turbines this is of even greater importance due to the significant amount of off-design operation. Because the performance is calculated at many different operating conditions it is attractive to consider the use of 1D methods instead of more time & resource intensive 3D methods such as CFD for the prediction of off-design performance. The key consideration is that the 1D analysis method used must be sufficiently accurate to give confidence in its use.

This report details the work performed and results of research to improve the accuracy of an existing 1D off-design performance prediction code for radial turbines. Loss models for incidence and clearance loss were investigated and implemented as well as a correlation for deviation. In addition, the determination of the 1D exit geometry input parameters was improved to better approximate Radial Equilibrium in a single value suitable for use in a 1D method. The research was conducted using numerical experiments in which the test hardware, setup and instrumentation are all "virtual" and the testing consists of 3D Navier-Stokes (CFD) calculations. The primary motivation for the use of numerical experiments is that it gives you a complete data set with all of the desired flow properties at all locations unlike physical experiments in which you are limited to selecting several flow properties at a limited number of locations as well as being fast and economical when testing different geometries.

The results of the numerical experiments were used to create or validate loss models and correlations for the 1D computer code. When these were implemented into the original 1D code the accuracy of the off-design performance prediction was significantly improved, both in terms of the mass flow characteristics as well as the efficiency trends.

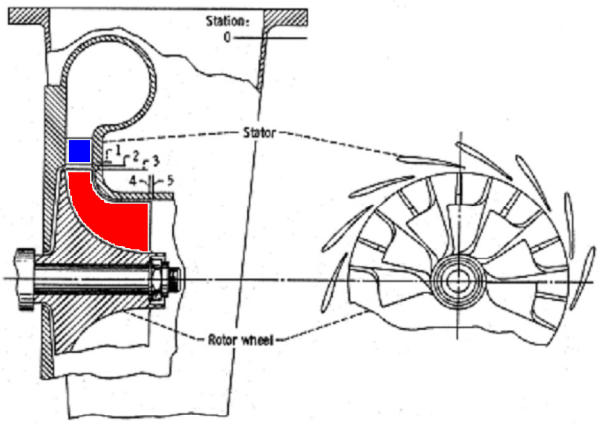

Figure 1: X-sec of a Radial Turbine

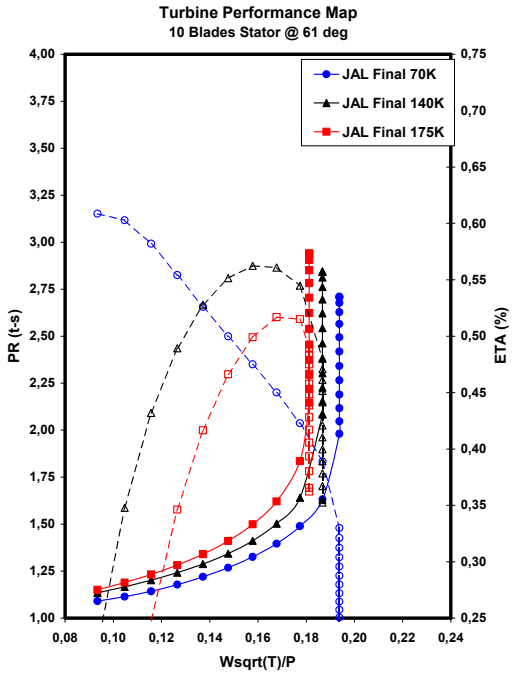

Figure 2: Example Turbine Map