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[Extended Abstract]

Turbocharger Heat Transfer Determination with a Power Based Phenomenological Approach and a CHT Validation

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Introduction

The conventional measurement of turbochargers on hot gas test benches is thermodynamically adapted on realizable options in terms of measuring devices, possibilities and costs. For todays high requirements of the application e.g. in automotive systems, this procedure leads to differences between reality and measurement because of the met assumptions and the considered operating range. Several studies including our own investigations have shown that the expansion and compression process is not adiabatic. Heat flows occur between the compressor and the turbine which lead to falsified isentropic efficiencies. Additionally heat flows occur between the turbocharger and the ambiance. Some of the heat flows are consumed by the lubrication oil and if available by the cooling water.

Methods

Therefore a powerbased approach has been developed in previous works to determine heat flows on compressors and turbines. It led to some advantages in relation to transfer issues on new turbochargers because the model does not have to be calibrated. It only needs measurement data. The basis for the approach was precisely described in [1] and [2] and summarized in [3]. The test bench setup has been described in [2] as well. The essential measurement of the turbine exit temperatures of the highly inhomogeneous flows with a mixer has been described in [1] and [2]. A new adiabatic criterion and the characteristic turbine power curves has been investigated on four different sized turbochargers[4][5]. It has been shown that the approach works without geometrical data and is applicable on various devices. In [3] the new phenomenological approach was expanded on the compressor. Furthermore the recalculation of the isentropic efficiencies of a wastegate turbocharger has been shown and validated for both the compressor and the turbine.
A Conjugate-Heat-Transfer simulation has been carried out in the present work on the turbine for validation of the approach. Results have shown that isentropic efficiencies fit well for values of turbine inlet temperatures of 600°C. For other temperatures the differences between the determined values and CHT are greater. The differences rise with higher temperatures. Hence, an additional dependency of turbine inlet temperatures has been implemented in the model. The modification has shown better results and smaller differences to CHT results. Especially at low speeds where the former approach has had big differences the modification improves the distribution. A wastegate turbocharger has been investigated from small gasoline engine applications. In future investigations the approach will be tested on the compressor with a modification, too, as well as on different turbochargers. The

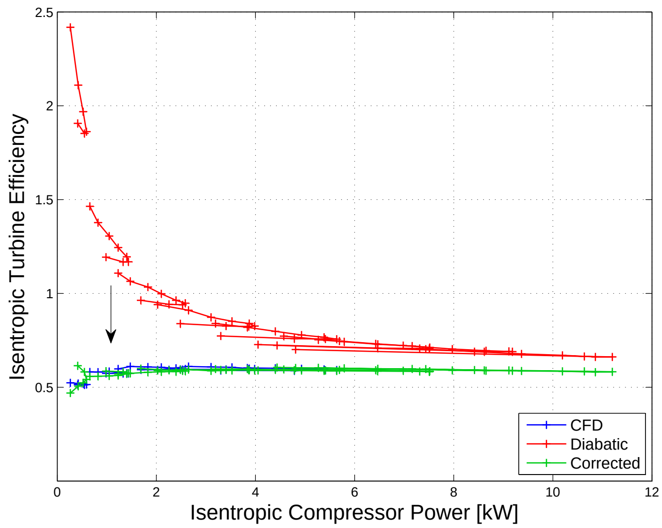

Figure 1. Turbine isentropic efficiency

objective is to create a methodology for parameterization of a thermal network model based on the modified approach as a start point. Recently the experimental basis has been developed to determine heat flows on radial turbines and compressors. It has been recently validated for the compressor with experimental data under near adiabatic conditions. For the turbine a CFD simulation has been carried out and the comparison is illustrated in Figure 1. Both comparisons have shown good results for turbine inlet temperatures of 600°C.

References

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