Chapter 5
Model-Based Performance Analysis

During the operation of the gas turbine a controller measures spool speeds, fuel flow and a few pressures and temperatures. In addition to these indispensable quantities, some controllers record additional data which are helpful for diagnosing the overall performance and the health status of the engine. Hundreds of temperatures and pressures are recorded during engine development tests.

Spool speeds, pressures and temperatures are the raw data for test analysis which tries to answer questions like how do the components of the gas turbine perform? Do they operate as intended? What will the performance of the engine be on a Standard Day?

There are two fundamentally different ways to analyze the raw data. The traditional approach is to compute specific fuel consumption, component mass flows, pressure ratios, efficiencies and duct pressure losses from the measured data. The calculation requires some a priori knowledge about the secondary air system and parasitic losses. The result of such test analysis computations are ISA corrected component and overall performance data.

The comparison of the test result with the nominal performance or an engine development target is left to the engineer. The problem is that the analyzed compressor efficiency number alone does not tell you much. Imagine you have analyzed a compressor efficiency to be 0.845. Whether this is a good or a bad test result depends on the engine operating point, see Fig. 5.1-1.

The engineer checks the numbers against those from his performance prediction program to assess the compressor performance as being above or below expectation. However, the number comparison is strictly valid only if the secondary air system and other calculation details are the same in both the test analysis and the performance prediction programs. If this is not the case, then the predicted compressor operating line is not consistent with the test. It obviously needs some effort to make the two programs compatible.

Model-based performance analysis combines test analysis and performance prediction within a single program. The prerequisite of the method is a performance model of the tested engine. Run the model for a performance analysis with the same

J. Kurzke and I. Halliwell, *Propulsion and Power*,
https://doi.org/10.1007/978-3-319-75979-1_5

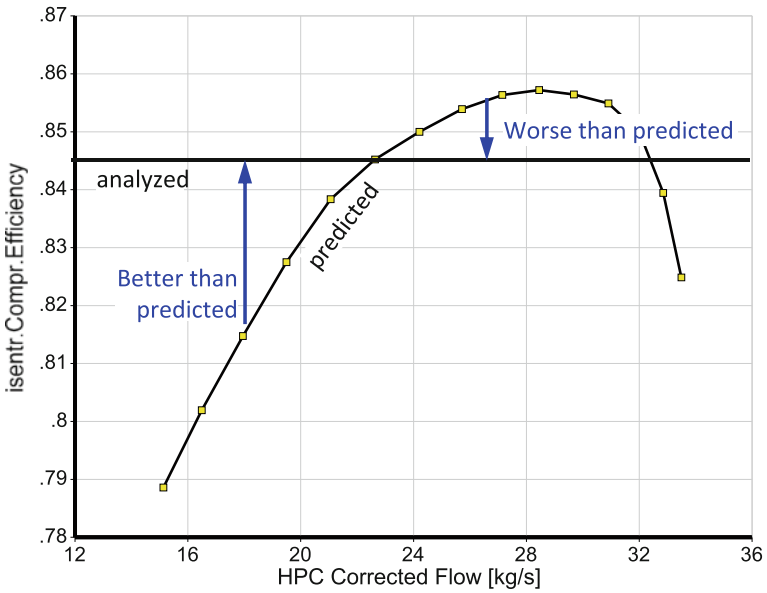

Fig. 5.1-1 Interpretation of a test result

entry conditions and the same command input as the engine on the testbed. The program calculates modifiers for the component maps in a special test analysis mode which make the model agree exactly with the measured data. The magnitude of the model adjustment factors is the actual component performance test result: the tested engine is better or worse than expected.

5.1 The Analysis by Synthesis Methodology

Model-based performance analysis is also known as Analysis by Synthesis, abbreviated to *AnSyn*. The noun Synthesis refers to a combination of two or more entities that together form something new; alternately, it refers to the creation of something by artificial means (Wikipedia).

A performance prediction program synthesizes the overall engine performance from the performance of its compressors, turbines, burners, nozzles, ducts, the secondary air system and other elements. It is an engine performance synthesis program. In test analysis mode, this program reconciles the performance synthesis with the measured data.