Gas turbine loss model validation

Kim Hirsch, Ramin Moghadam *Lund University*

Designing new gas turbines requires a lot of skill and knowledge. To simplify the process, designers rely on many different design tools and loss models. In order to manufacture a competitive product the design tools and models must be able to accurately predict the performance and losses within the gas turbine. To ensure this, a new tool is under development and must be validated.

Loss models at Siemens

Siemens Industrial Turbomachinery AB (SIT) relies on correlation based loss models originating from a series of cascade tests done in Russia in the 1960's. In those days, the blade designs were quite simple compared to the more extreme and intricate 3-D profiles used today.

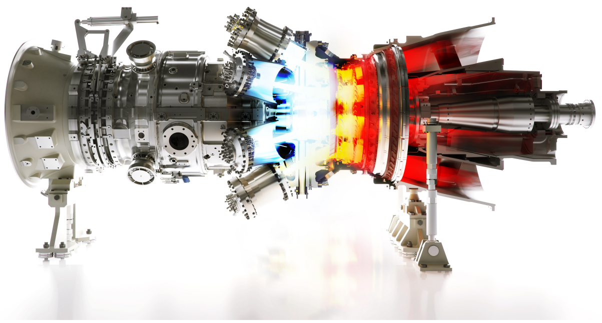

Figure 1: *SGT-750, courtesy of Siemens*

Possibilities and purpose

Loss models are efficient and time saving. However, one problem with correlation based loss models is that they are usually only valid for comparable blade designs. To evaluate how they perform with different design philosophies, they must be validated against tests with real or model gas turbines. The validation process is a time consuming, but necessary step for future development of competitive gas turbines.

What was done?

Tests were made at a test turbine at the Royal Institute of Technology (KTH) by Johan Dahlquist. The measurement data acquired was used as boundary conditions for various SIT in-house codes. The predicted performance and losses were compared to the measured data in an effort to validate the models and to pinpoint sources of prediction errors. This process was done iteratively, where the results from each cycle dictated the next move.

Results

The new SIT in-house code Mean Line Tool (MLT) was initially expected to give quite good predictions. However, this was not the case! For existing full scale turbines, global parameters such as efficiency are predicted with an accuracy of below 1 %-point. The accuracy of efficiency prediction for the test turbine was in the range of 3-5 %-points. The probable source of this large error has been found to be weaknesses in the correlations, especially for secondary losses. Comparison with well-established secondary loss models indicates that MLT is predicting only a third of secondary losses! Secondary losses are due to the secondary flows, vortices, which occur as a result of boundary layers interacting with the curvature of the blade passage. This causes the fluid to move in directions other than the principal direction of flow [1, p. 32]. Another source of error is the measurement data. It was discovered that the traversed measurements within the stage were inaccurate. This was caused by a newly installed pressure probe. The size of the probe in relation to the turbine size was too large causing large interactions with the flow. However, it was concluded that this alone cannot be the sole cause of the under-predictions.

References

[1] H. Moustapha, M. H. Zelesky, N. C. Baines, and D. Japikse, *Axial And Radial Turbines*. Vermont, USA: Concepts NREC, 2003, ISBN:0-933283-12-0.

Original title: Validation of one–dimensional loss models for axial gas turbines

Authors: Kim Hirsch, Ramin Moghadam