CASE STUDY
FOSSIL FUEL POWER GENERATION

FLOWNEX® SIMULATION ENVIRONMENT

USING FLOWNEX® AS A TOOL TO DEVELOP NEW ENGINEERING METHODS AND CORRELATIONS FOR STEAM TURBINE PERFORMANCE PREDICTION

Keywords: Steam turbines, Nozzle theory, R&D, Power generation

ABSTRACT

This case study demonstrates the ability of Flownex to be used as a tool to develop, test and implement new correlations and methods used in the prediction of steam turbine performance. Flownex empowers the user to quickly carry out multiple tests and parameter studies, saving time and money.

CHALLENGE

The challenge in developing new correlations is finding a tool to test it on. Often, one is left with the daunting task of developing additional code (such as solvers for conservation equations and fluid properties databases) in order to test the correlation in its entirety. Furthermore, multiple tests and parametric studies form part of the correlation development and this is can be extremely time-consuming.

BENEFITS

Software that contains the fundamental governing equations, various material and fluid property databases, the most recent correlations for numerous engineering applications and third-party tool add-ins (e.g. Excel, Scripts, Engineering Equation Solver, etc.) provides the user with a full rounded tool to test and analyze newly developed correlations. Furthermore, having the ability to easily do parameter studies with various test cases empowers the user to quickly compare their models to realistic data sets.

SOLUTION

Flownex aided the development of new correlations and methods to model steam turbines more accurately with using minimal geometric input data. Flownex could be further used to build a comprehensive set of guidelines and case studies for these methods, due to its ability to model an entire system of components, which further solidified the validity of these newly developed methods.

> *Flownex is an ideal tool to develop reduced-order models of complex thermo-fluid networks. I have used it extensively to model steam turbines, and because it simply does not take any shortcuts w.r.t. the fundamentals of thermodynamics, I can trust the overall system results.*

UNIVERSITY OF CAPE TOWN
W.F. Fuls – *Associate Professor*

USING FLOWNEX® AS A TOOL TO DEVELOP NEW ENGINEERING METHODS AND CORRELATIONS FOR STEAM TURBINE

FLOWNEX® SIMULATION ENVIRONMENT

INTRODUCTION

Predicating the accurate performance of steam turbines can become a tedious task due to the intricate geometry of these types of machinery. Complex CFD software also requires one to obtain 3D geometrical models of these turbines – which is rarely provided by the original equipment manufacturers. One is often left with only a 2D-drawing of the cross-section of a turbine. A typically supplied steam turbine drawing is shown in Figure 1.

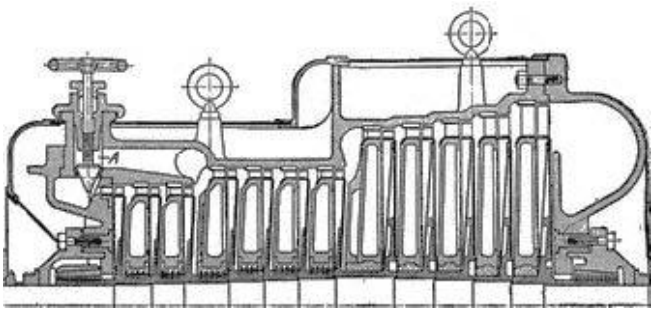

Figure 1: Typical cross-sectional drawing of a steam turbine.

METHODOLOGY

With the aid of Flownex, Wim Fuls (an associate Professor at UCT and deputy director at ATProM Unit) was able to accurately predict the performance of steam turbines using very little geometrical inputs. Inputs which can be obtained from a 2D drawing, as shown in figure 1.

The first method was developed using a simple Nozzle analogy and two, by Enhancing the traditional Ellipse Law for more accurate prediction of the behaviour of steam turbines.

For the Nozzle Analogy, Flownex proved to be a perfect tool in that it already had a nozzle component built-in. By applying a Nozzle for the stator and a nozzle for the rotor, with the appropriate inlet conditions and loss factors, a single-stage steam turbine could be modelled, specifically under abnormal conditions.

The second method, which is an enhancement of the traditional Ellipse law, was developed by determining methods to calculate the choking behaviour and critical pressure ratio.

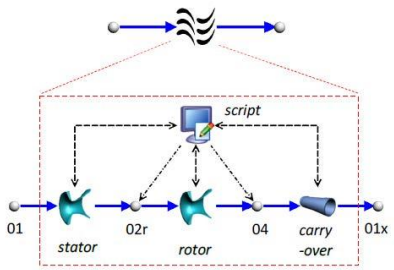

Figure 2: Flownex model of a turbine stage.

Ref: Application of the Nozzle Analogy to easily Predict Steam Turbine Performance with Minimal Geomteric Input, Proceedings of ASME Turbo Expo 2019

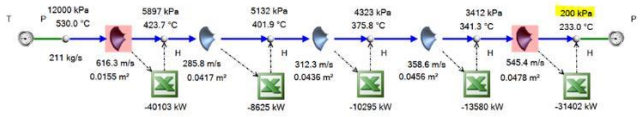

Figure 3: Flownex model of a turbine stage.

Ref: Enhancement of the Traditional Ellispe Law for More Accurate Modeling of a Turbine with a Finite Number of Stages, Journal of Engineering for Gas Turbines and Power.

CONCLUSION

Through the careful application of Flownex, correlations and methods could be developed to predict the performance of steam turbines using minimal design inputs.

Results indicated that these newly developed methods proved superior to traditional methods, such as Stodola's Ellipse law, even under off-design conditions. Results for these newly developed methods are shown in figure 3.

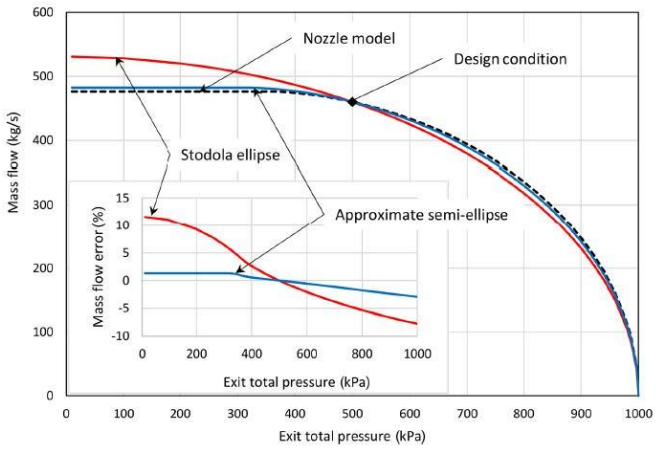

Figure 4: Results from using the newly developed correlations

Furthermore, a comprehensive set of guidelines and examples could be developed in Flownex to further solidify the validity of the correlations.

Flownex aided the development of new methods and correlations that can now be used by engineers to accurately model steam turbines with a finite number of stages under realistic conditions. Various papers have been published in journals such as Elsevier: Applied Thermal Engineering. These methods could also be presented at the ASME Turbo Expo in 2019.