

## INVESTIGATION OF TURBINE CONTROL STAGE AEROTHERMODYNAMICS

Piotr Lampart, Mariusz Szymaniak and Łukasz Jędrzejewski

The Szewalski Institute of Fluid Flow Machinery,  
ul. Fiszerka 14, 80-952 Gdansk, Poland,  
e-mail: lampart@imp.gda.pl

**Key words:** Steam Turbine, Control Stage Flow, CFD, RANS

Partial admission is used to control the power output in large power turbines [1]. Steam flow is admitted through a number of nozzle boxes located at the annulus in the form of discrete arcs. Each nozzle box is equipped with a control valve. Partial admission increases turbine efficiency, especially at low load operation [2]. On the other hand, partial admission introduces strong circumferential non-symmetry of flow parameters in the control stage and therefore is a cause of additional unsteady loads of the rotor blades connected with the cycle of admission. Due to a rapid change of load while entering and leaving the arc of admission, the rotor blades and also blade-fit regions experience high unsteady mechanical stresses and are more vulnerable to failure [3].

The paper describes results of numerical investigations (based on RANS calculations in code Fluent) of partial admission flow in the control stage of a 200MW turbine and a 32 MW turbine. A 3D full-geometry model and 2D full-annulus mid-span model are used for investigations. The 3D computational domain extends on all inlet pipes, all blade-to-blade passages of the nozzle boxes, all rotor blade-to-blade passages and labyrinth seals over the shrouded rotor blades, control stage chamber downstream of the rotor, and leakage chamber with leakage flow passages, Fig. 1.

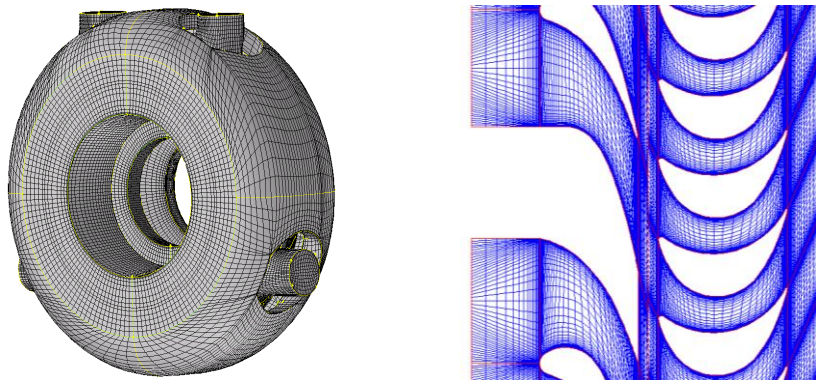


Fig. 1. 3D and 2D grids of the control stage domain.

The results exhibit interesting details of the process of expansion in the control stage. The distribution of static pressure at major control stage elements and at the mid-span section of the blading system for two operating regimes exhibits the circumferential non-uniformity of flow patterns in the control stage region, Fig. 2. These effects will be described in detail in the paper.

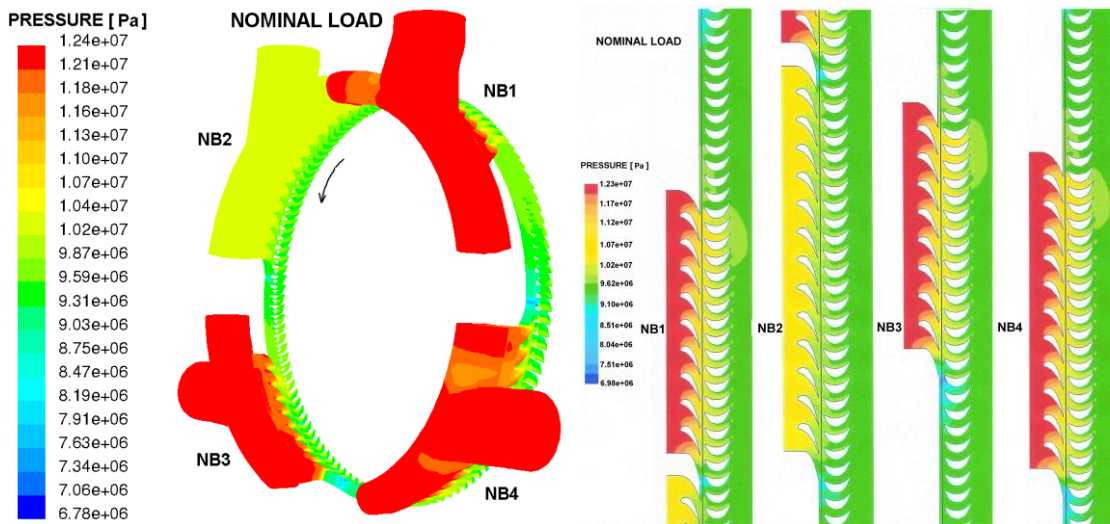


Fig. 2. Instantaneous static pressure contours at control stage elements and at the blade mid-span

Unsteady forces connected with the cycle of admission acting on the rotor blades of the control stage are also calculated. The paper shows how the unsteady forces can be reduced thanks to geometrical modifications within the control stage stator, Fig. 3.

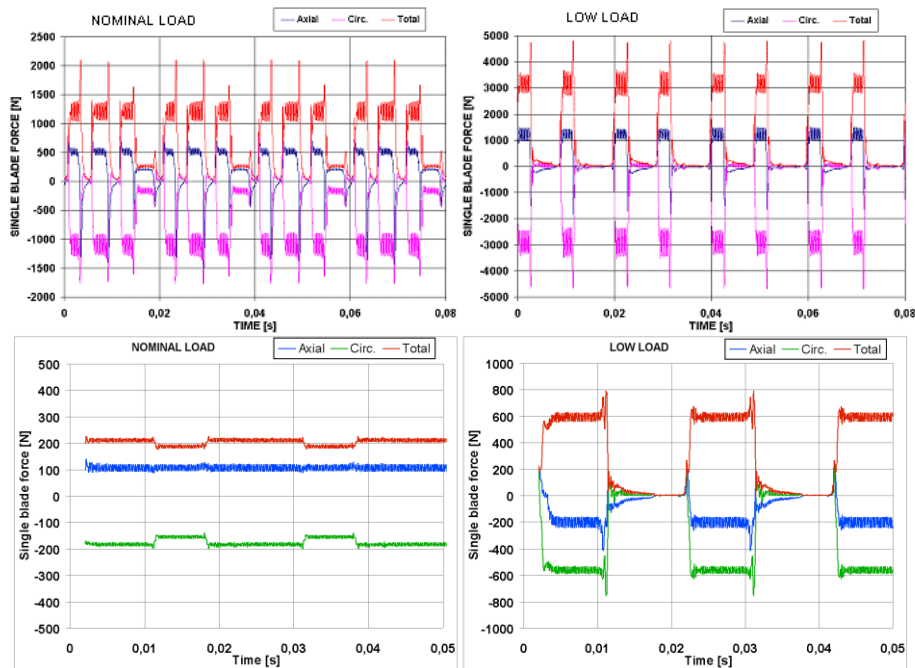


Fig. 3. Rotor blade forces in the classical control stage (top) and improved control stage (bottom): nominal load (left), low load (right).

## REFERENCES

- [1] S. Perycz, "Steam and gas turbines" (in Polish), Turbomachinery Series, **10**, Ossolineum, Wrocław-Warszawa-Kraków, Poland, (1992).
- [2] G. Wakeley, I. Potts, "Unsteady flow phenomena in partially-admitted steam turbine control stages", Proc. Inst. Mech. Engrs., Conf. on Turbomachinery; Rugby, UK, December 9-10, 77-86, (1996).
- [3] P. Lampart, M. Szymaniak, R. Kwidziński, "Numerical investigation of unsteady flow in a partial admission control stage of a 200 MW steam turbine", Proc. 6<sup>th</sup> Europ. Conf. on Turbomachinery Fluid Dynamics and Thermodynamics, March 7-11, Lille, France, 376-389, (2005).