

EXPERIMENTAL MODELLING OF UNSTABLE OPERATION OF A CENTRIFUGAL COMPRESSOR ON A SMALL JET ENGINE IN THE LABORATORY

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Unstable operation (surge) of a compressor is a dangerous phenomenon which occurs during certain operating regimes of compressors in engine turbo-compressors and also in combustion turbines used in transport and stationary energetics equipment. It is manifested by a sudden change of pressure and speed of air flow at the output of the compressor and characteristic sounds, which result in intense vibration of the rotor blades and changes to the character of air flow in other parts of the device. Surge can result in interruption of engine operation, or its destruction due to mechanical damage to the compressor blades or heat damage to the blades of the gas turbine. This is why the formation of unstable compressor modes is inadmissible and a great deal of attention is devoted to preventing it.

The physical nature of the process of the origin of unstable operation is explained by the tearing off of the airflow when wrapping around the compressor blades due to deviations of the operating mode from the calculated mode, which is accompanied by a reverse flow of air and pulsing within the flow of the compressor. The whole process is very complex and is also currently the subject of scientific research.

Research into unstable operation of compressors in real operating conditions is associated with potential safety hazards and significant economic costs due to damage or destruction of real engines [1]. Relevant results can be achieved, however, without these risks in laboratory conditions using an experimental small jet engine that was created by the transformation of a TS-20 turbine starter to a small uniflow engine. Unstable regimes of a centrifugal compressor were simulated under laboratory conditions and motor behaviour was monitored [2]. The measured results and relevant implications for specific parts of the engine are published here.

Results of experimental measurements were also confronted and compared with numerical simulation [3], see Fig. 1. Numerical study of unsteady flow in the cascade of the compressor stage was carried out by the application of the FLUENT CFD software. Mathematical model is based on the system of Navier-Stokes equations for the turbulent flow of compressible fluid [4]. For the turbulence model, the 7-equations Reynolds stress model is adopted [5]. Non-equilibrium wall functions defined in the FLUENT code are used to model the flow near the blade profiles. The numerical model is solved using the Runge-Kutta method in the form of finite volumes. Coupled implicit scheme with second order accuracy and default under relaxation factors was applied.

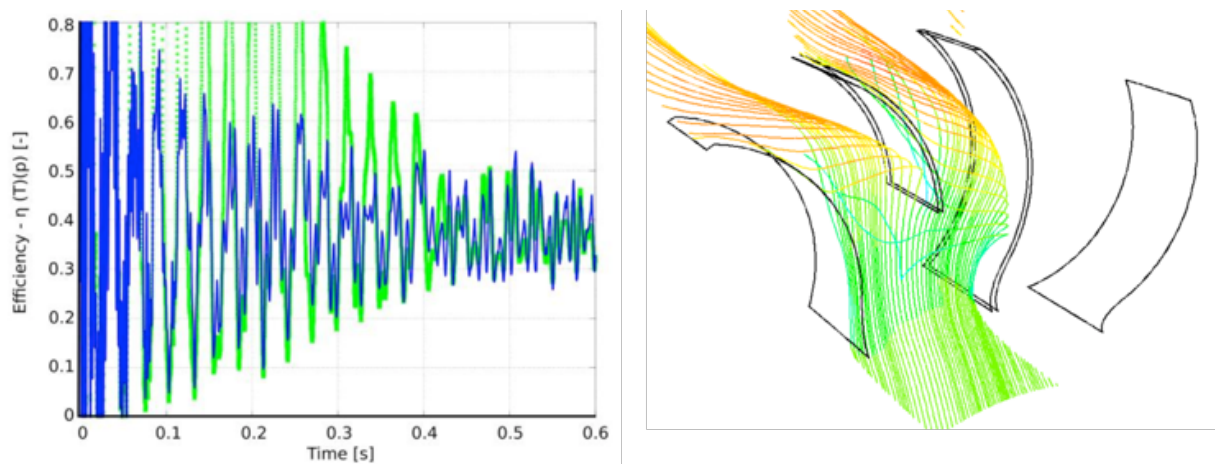


Fig. 1: Efficiency evaluation and path lines, radial compressor operated out of designed point

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REFERENCES

- [1] M. Hocko, 2003, Assessment of the ATCE State Based on Changes in Thermodynamic Parameters, thesis, pp. 338
- [2] M. Hocko, R. Gaspar, 2013, Impact of rapid thermal fluctuations of the airflow into engine inlet to the gas-dynamics stability of the turbojet engine, *12th conference Power System Engineering, Thermodynamics& Fluid Flow*, Pilsen. pp. 8
- [3] J. Polansky, L. Kalmar, R. Gaspar : Aerodynamic performance prediction of centrifugal fan with forward curved blades, *Journal of Thermal Science*, Vol 22, NO 6, 2013 pp 517-521, ISSN: 1003-2169 , 2013
- [4] V. Cyrus, J. Polansky: Numerical simulation of the origins of flow pulsations in cascades of the rear blade rows in a gas turbine axial compressor using low calorific fuel. *ASME journal* 2010, no. 132/3, p. 31012/1-11. ISSN: 0889-504X
- [5] R. Gaspar, J. Polansky: Prediction of aerodynamic characteristics of a highly loaded single-stage axial flow compressor, *AERONAUTIKA 11*. Technical university of Kosice, Slovakia, 2011.