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Application of the NS equations for 3D viscous turbulent flow on bladeless fluid machines

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ABSTRACT

Application of the Navier-Stokes equations for 3D viscous turbulent flow on steady grids with standard k-omega turbulent model.
For a symmetrical three dimensional flow we use the transformation of the equations to the cylindric system. The principal used tools are as follows:

- non-reflecting boundary conditions at the inlet and outlet
- combination of static pressure and total state values for inlet and outlet boundary conditions
- modification of the Riemann’s solver by preferred vector of velocity for boundary conditions on a moving wall
- state values normed by using critical terms at the inlet.

The finite volume method with explicit time marching was used. For higher accuracy in space we used Van Leer or Van Albada scheme. The classical Riemann problem is modified for physically relevant boundary conditions with the aim to keep conservation laws. The left hand and right initial condition in the Riemann problem is replaced by the suitable one-sided boundary condition. This results in the acceleration of the numerical method itself. Described method can be used for flow simulation in symmetrical channels of arbitrary apparatuses.
The application was tested for the bladeless fluid machines. The principle of the application is based on the transmission of the fluid kinetic energy to an axis-symmetrical rotor by a boundary layer on its surface. Both active and passive cases were solved: active swirl flow in a gap between rotor and stator turns the rotor on (turbine mode) or, on the contrary, the rotating surface of a rotor forces gas into movement (energy losses occurance).
Developed method was succesfully verified by measuring in wind tunnel. In addition, the presented method can succesfully solve some problems of high-speed aerodynamics which solved by commercial code gave not real results on the boundary defined as standard pressure outlet, symmetry etc.

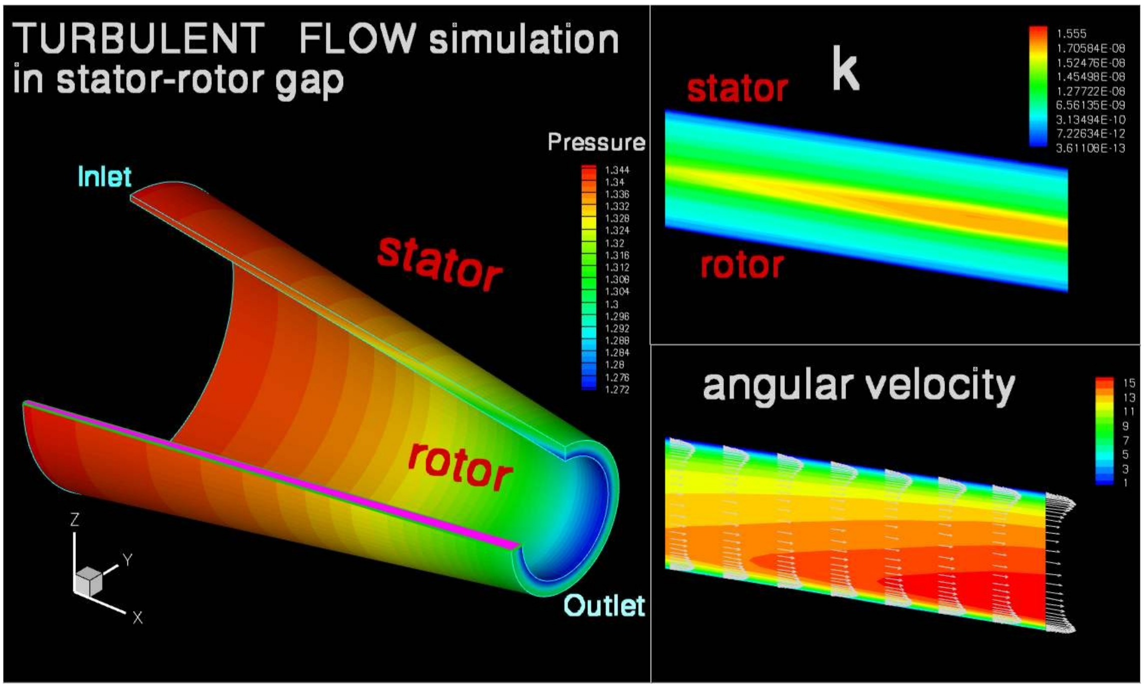

Figure 1. Bladeless fluid machine, numerical simulation. Fluid flows from the left side, outlet is at right side of the picture. Rotor rotates with given angular velocity, same given velocity was prescribed at the inlet part. Figure shows distribution of the pressure throughout the rotor-stator gap, and isolines of the turbulent kinetic energy and angular velocity at the outlet part of the machine. This illustrates the transmission of the fluid kinetic energy to an axis-symmetrical rotor by a boundary layer on its surface.

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