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NUMERICAL STUDY OF THE FLOW STRUCTURE AND HEAT TRANSFER ON A ROTATING DISK SURVACE UNDER ANNULAR JET IMPINGAMENT

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The purpose of the paper is to investigate numerically, by DNS/LES methods, the characteristic features of strongly three dimensional transitional and turbulent flows with heat transfer. The analysis will focus on distributions of the components of the turbulent heat flux, Reynolds stress tensor components, Nusselt number, turbulent Prandtl number and other structural parameters. Two flow cases will be investigated. The first one is the annular jet impinging on a heated rotating disk where the heat transfer and fluid flow are closely linked (Fig.1). In the turbulent impinging jet, despite its geometrical simplicity, we observe very interesting phenomena which make it attractive for studying various features of turbulence dynamics. Most articles consider a simple round jet impinging on the stationary wall, however, one of the ways of enhancing the heat transfer is the superimposition of rotation on the impinged disk. The second flow case considered in the paper is the flow with heat transfer in rotor/stator configuration of aspect ratio up to 35 (results will be compare with Schouveiler et al. (2001) experimental data).

In both configurations the flow with heat transfer is described by continuity, Navier-Stokes and energy equations written in a cylindrical coordinate system with respect to a rotating frame of reference. Accuracy of the computations needs an extremely refined, gently graded mesh covering the wall vicinity (up to z^+ ~6). To meet this requirement it is necessary to perform computations on the 100 million colocation points, and this in turn is not possible without parallelization of the DNS code. Therefore we will parallelize the existing DNS code based on Chebyshev-Fourier collocation method, which was used for investigations of the non-isothermal flow in the rotor/stator cavity (Tuliszka-Sznitko et al, 2009). In DNS code we use a second-order semi-implicit scheme in the time approximation, which combines an implicit treatment of the diffusive terms and an explicit Adams-Bashforth extrapolation for the non-linear convective terms. The Gauss-Lobatto collocation points in radial and axial directions are used to ensure high accuracy in near-wall areas.

The no-slip boundary conditions will be used with respect to all rigid walls, so $u = w = 0$ (where u and w are components of dimensionless velocity vector in radial an axial direction, respectively). For the azimuthal velocity component, the boundary conditions are $v = 0$ on the rotating disk and $v = -(Rm + r)/(Rm + 1)$ on the stator, where r is dimensional radius and $Rm=(R_1+R_0)/(R_1-R_0)$ is the curvature parameter. The temperature of the bottom and upper disks is constant, with heated bottom and cooled upper disk.

In the considerations of the impinging jet flow case it is very important to establish inlet and outlet boundary conditions. For establishing the inlet condition we will use either the empirical profile or so called top-hat profile (Chung et al., 2002) and for the outer boundary condition - the convective condition (Hadziabdic, Hanjalic, 2008).

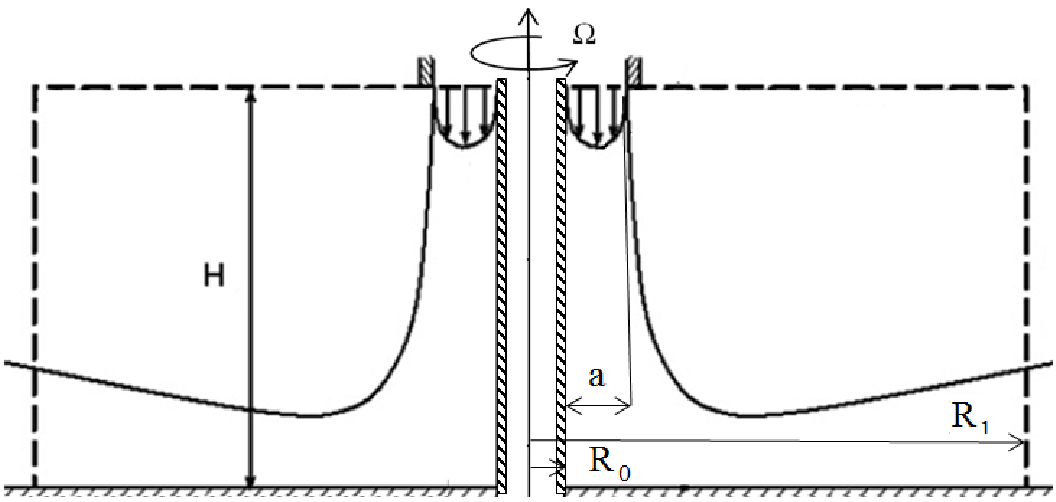

Fig.1 Schematic picture of the proposed annular impinging jet

To perform computations for high Reynolds numbers we will use two approaches of the large eddy simulations (LES): First one is the version of the dynamic Smagorinsky model proposed by Meneveau et al. (1996) and the second one is SVV spectral vanishing viscosity method. It was shown (Pasquetti, 2005) that the second order operator involved in SVV leads to a stable discretization scheme without sacrificing the accuracy of spectral colocation method based on Chebyshev and Fourier series. This algorithm will be presented in the paper together with some preliminary results obtained for different values of geometrical parameter a (Fig.1), different Reynolds numbers $\Omega R_1^2/\nu$ and different inlet conditions.

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