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APPLICATION OF EARSM TURBULENCE MODEL TO SIMULATION OF REACTING FLOW FIELD IN JETS ENGINES COMBUSTION CHAMBER

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The study of reacting flow field properties is done in many cases via CFD simulations because physical conditions do not allow experimental measurement. The flow properties inside combustion chambers of jets engines are complex therefore LES turbulent models are suitable [1,2]. The main disadvantages of this method are hardware requirements due mesh resolution and time consumption. In the case of industrial applications there are often used RANS model of turbulence that allowed decrease number of cells and time consumption to study more variants of developed chamber.

Most RANS turbulence models is based on Boussinesq assumption (1) which implies isotropy in Reynolds Stresses.

$$-\rho \overline{u_i' u_j'} = \mu_t \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right) - \frac{2}{3} k \rho \delta_{ij} \quad , \qquad (1)$$

This assumption is not correct in the case of complex flow field. Full Reynolds Stress model could be used but there are not strong benefits (increasing of computational time, lower stability of discretization schemes). Therefore several authors e.g. [3,4,5] use an additional anisotropy term (2)

$$\rho \overline{u_i' u_j'} = \mu_t \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} - \frac{2}{3} \frac{\partial u_k}{\partial x_k} \delta_{ij} \right) - \rho \left(\frac{2}{3} k \delta_{ij} + a_{ij}^{(ex)} \right) \quad , \qquad (2)$$

in the model of Reynolds stresses approximation.

The phenomena of the combustion is in principle unsteady and it is closely connected with turbulence via time-scale (3).This timescale must contains an additional term that respect anisotropy part of Reynolds stress tensor.

$$t_k \approx c_{mix} \sqrt{\frac{1}{\rho} \left(\frac{k + tr\left(a_{ij}^{(ex)}\right)}{\epsilon} \right)^2} \qquad (3)$$

Presented model was applied to two test cases. The first one is a case of counter flow flame where temperature profiles for different turbulence model are compared (Fig. 1.). The second one is a case of developed combustion chamber where the temperature field (Fig. 2.) in nozzle slice is shown.

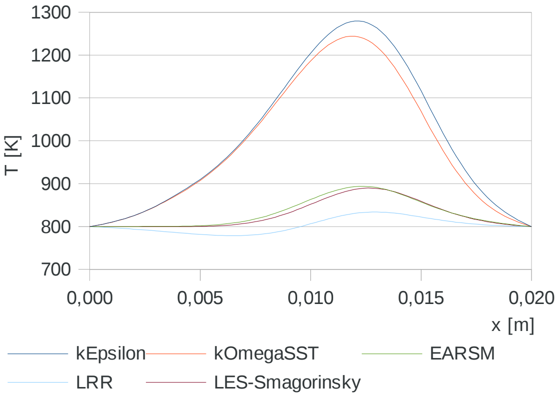

Fig. 1.: Temperature profiles for counter flow flame

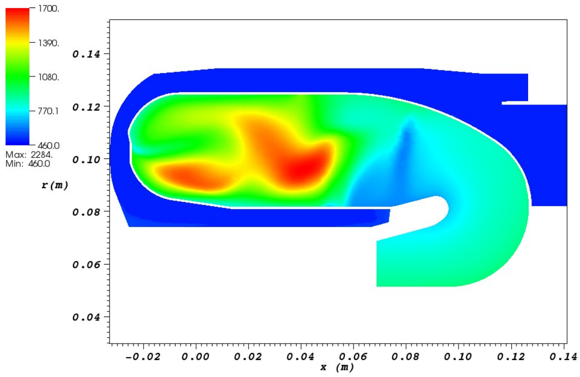

Fig. 2.: Temperature field in nozzle slice of com. chamber

The temperature profile obtained by EARSM model is closed to LES data and Full Reynolds Stress model. In comparison of temperature field in nozzle slice with data achieved in previous simulations [6,7] it is possible to see more realistic temperature profile. By usage EARSM turbulence model similar results with LES simulation were obtained. Applications ot this model leads to lower time and hardware requirements than standard high-resolution simulations. For the future results some improvements will be implemented especialy the anisotropy model for turbulent diffusion of heat.

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