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EXPERIMENTAL AND NUMERICAL ANALYSIS OF THE TURBULENT FLOW IN T-SHAPED CHANNEL

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Computational fluid dynamics methods have applications useful in many technical areas, particularly in mining, where they are used in flow simulations in resolving ventilation issues. A basic constraint in employing CFD is the need to demonstrate their reliability through experiment. The paper presents the results of experimental and numerical modeling of the flow of air across the T-shaped channel (intersection of the mining face with the ventilation gallery). Maintained for technological reasons, the cave is exposed particularly to dangerous accumulations of methane. Properly arranged ventilation should assure the maintenance of methane concentrations at a safe level.

For this type of flows theoretical investigations is typically performed base on viscosity turbulence models with the standard k-ε model applied in the majority of cases. Numerous papers have been published on periodic, straight or L-shaped turbulent channel using a large variety of modeling techniques: RANS, URANS, LES, DLES and DNS. However only few, have taken up the relatively simple but technologically crucial geometry. In practice, for such high Reynolds numbers, viscous RANS models are used exclusively.

The paper presents the results of numerical and experimental analysis as well as validation of the k-ε model for the flow of air across T-shaped channel (figure 1). In performed cases the inlet mean velocities varies in the range of 3-12m/s - Reynolds number from 60 000 to 200 000. For the experimental work the geometrical scale of physical model was 1:10.

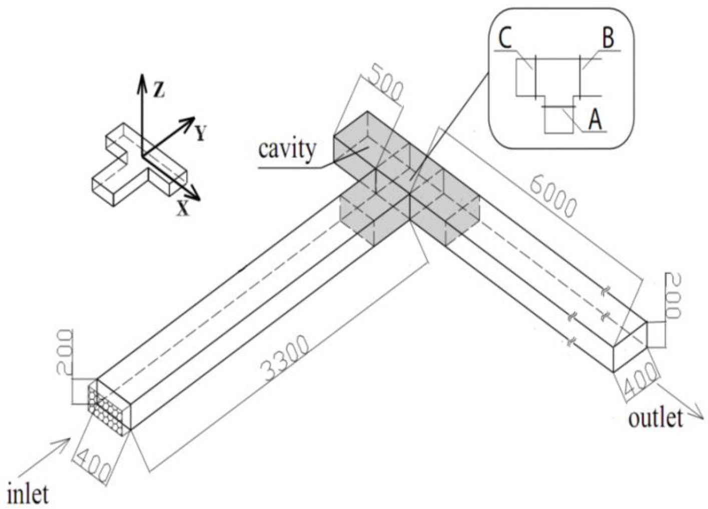

Figure 1. Experimental set-up of T-shape channel flow.

Particle Image Velocimetry (PIV) method was used to evaluate the velocity vector components. The digital images were acquired by 4 Mpx monochromatic CCD camera. In each experiment, 1000 double frame images were recorded with the camera recording at a frequency of 3 Hz, which resulted in an overall time of one measure of around 5 minutes.

In this study for numerical analysis, two models of turbulence were tested: the standard *k-ε* model and a variation of that model, the RNG *k-ε* model. A numerical simulation was performed for conditions identical to experimental using FLUENT software.

Figure 2 shows profiles of stream-wise and wall-normal components of velocities along the horizontal line at the half height of the channel (z*=0) located before and after the cross of the ducts . The geometrical dimensions are normalized by channel height. Fig.2 (top) shows a comparison of the measured and calculated velocity just before the cross of the duct for y*=-0.3. Small differences between the measurements and calculation results for the stream-wise and wall normal components for two considered flow velocities can be seen. Fig.2 (bottom) shows the velocity behind the cross of the ducts for x*=0.3. The predicted velocities are in good agreement with the experimental results in the main stream but differ in the separating zone. The calculations over-predict the negative streamwise components of velocity in the zone where recirculation occurs.

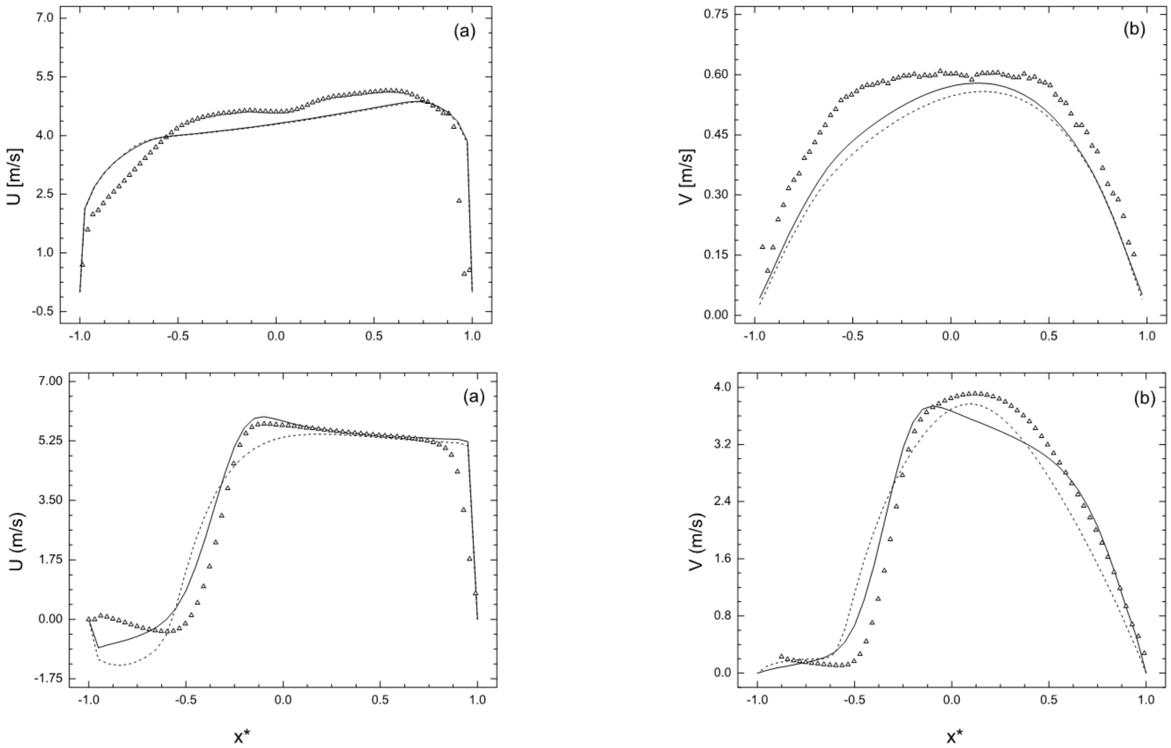

Figure 2. Flow streamwise (a) and and wall-normal (b) velocity component for section A (top) and B (bottom) at z*=0 and Re=57300 .(——) *k-ε*, (- - -)RNG *k-ε* , (Δ)Exp.

For the cross section located before and behind the cross of the ducts, the calculations and measurements are in quite good agreement with the experimental results, bearing in mind the accuracy needed in ventilation problems. However, considerable differences are observed in separation zone and in the cave.

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