



Background

Motivation

Compound channels are characterized by the presence of a narrow region connecting one or more main channels. These geometries are present in many areas of engineering. Common examples are rod bundle flows in nuclear reactors, annular flows in heat exchangers, flow in rivers with inundated floodplains and air cooling of electronic devices. The renewed interest in the study of these compound channel flows comes not only from their practical importance, but also from the discovery of the formation of large-scale coherent structures in the vicinity of the narrow flow regions of such configurations. These flow structures can be defined as quasi-periodic vortices that are convected along the flow. These are important flow phenomena as they transport fluid, momentum and heat much more efficiently and over much larger distances than turbulent diffusion.

Objective

The aim of this study is to:

- Confirm the existence of coherent structures in compound channel;
- Determine ability of URANS to capture the coherent structures caused by instabilities.

Governing equations

Continuity and Navier Stokes equations:

$$\frac{\partial \bar{u}_i}{\partial x_i} = 0$$

$$\frac{\partial \bar{u}_i}{\partial t} + \frac{\partial (\bar{u}_i \bar{u}_j)}{\partial x_j} = -\frac{1}{\rho} \frac{\partial \bar{p}}{\partial x_i} + \nu \frac{\partial^2 \bar{u}_i}{\partial x_j^2} + \frac{\partial \tau_{ij}}{\partial x_j} = 0$$

Reynolds stress tensor

$$\tau_{ij} = -\rho \overline{u_i u_j} = 2\mu_t \bar{S}_{ij} - \frac{2}{3} \delta_{ij} \rho k$$

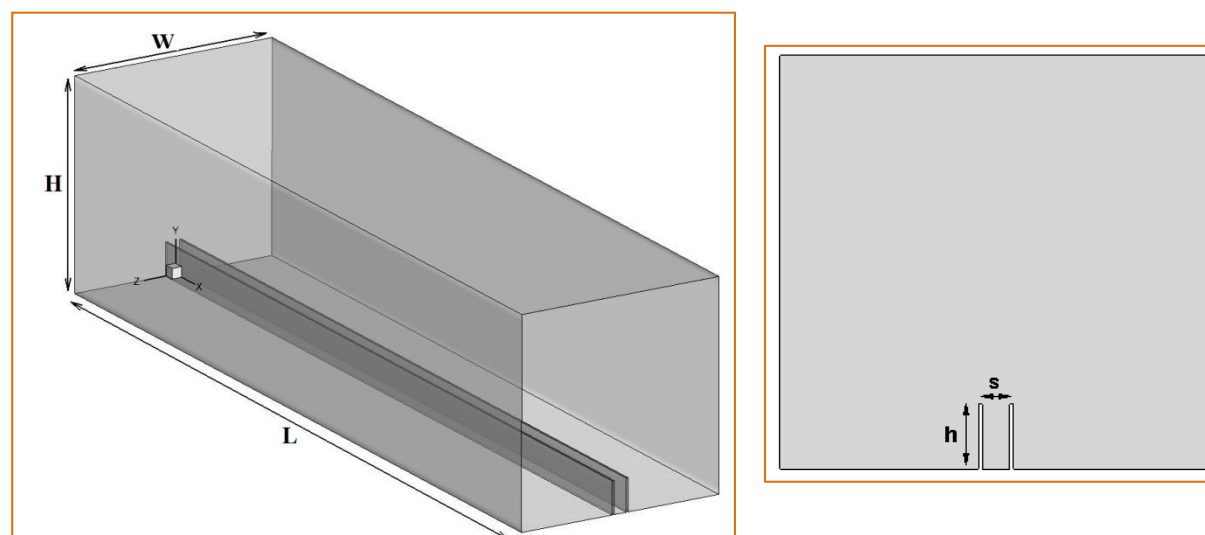
$$\bar{S}_{ij} = \frac{1}{2} \left(\frac{\partial \bar{u}_i}{\partial x_j} + \frac{\partial \bar{u}_j}{\partial x_i} \right)$$

URANS equation requires an additional model in order to obtain a closed equations system:

➔ Reynolds Stress Model (RSM)

Methodology

Computational Domain



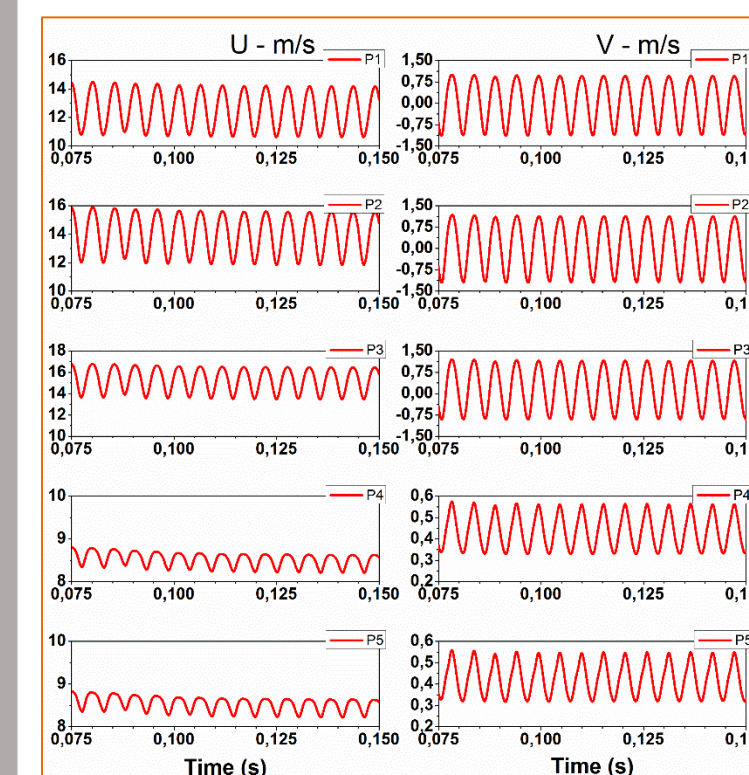
Case	h/s	H/h	Re
C1	2.5	6,4	4.10 ⁴
C2	5	3,2	4.10 ⁴
C3	7.5	2.13	4.10 ⁴
C4	2.56	3.2	4.10 ⁴
C5	3.85	2.13	4.10 ⁴

- Five configurations of channel with two fins are studied using air as working fluid in turbulent flow.
- The geometries and conditions of the present study were selected to match the experiments in the literature.
- Geometries were meshed using a 3D structured mesh consisting of hexahedral volumes.

Turbulence Modeling

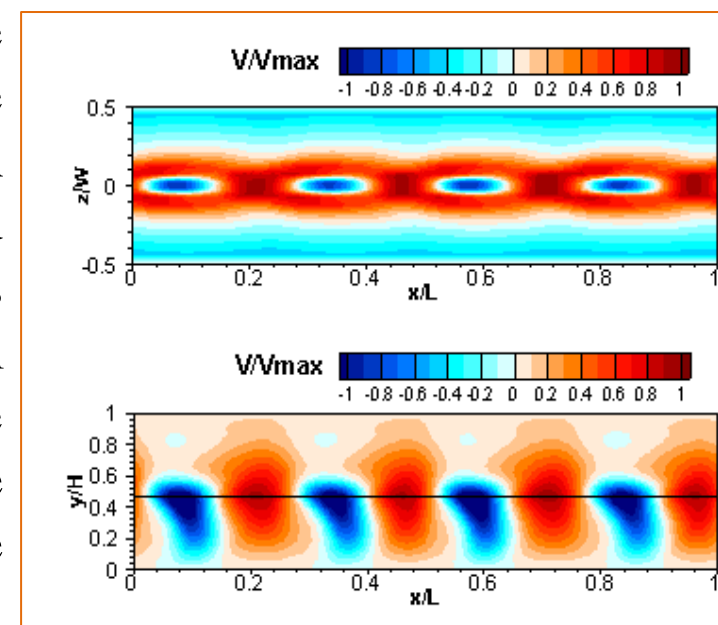
URANS RSM was used with periodic boundary conditions in the inlet and outlet of the channel.

Results: Quasi-periodic patterns

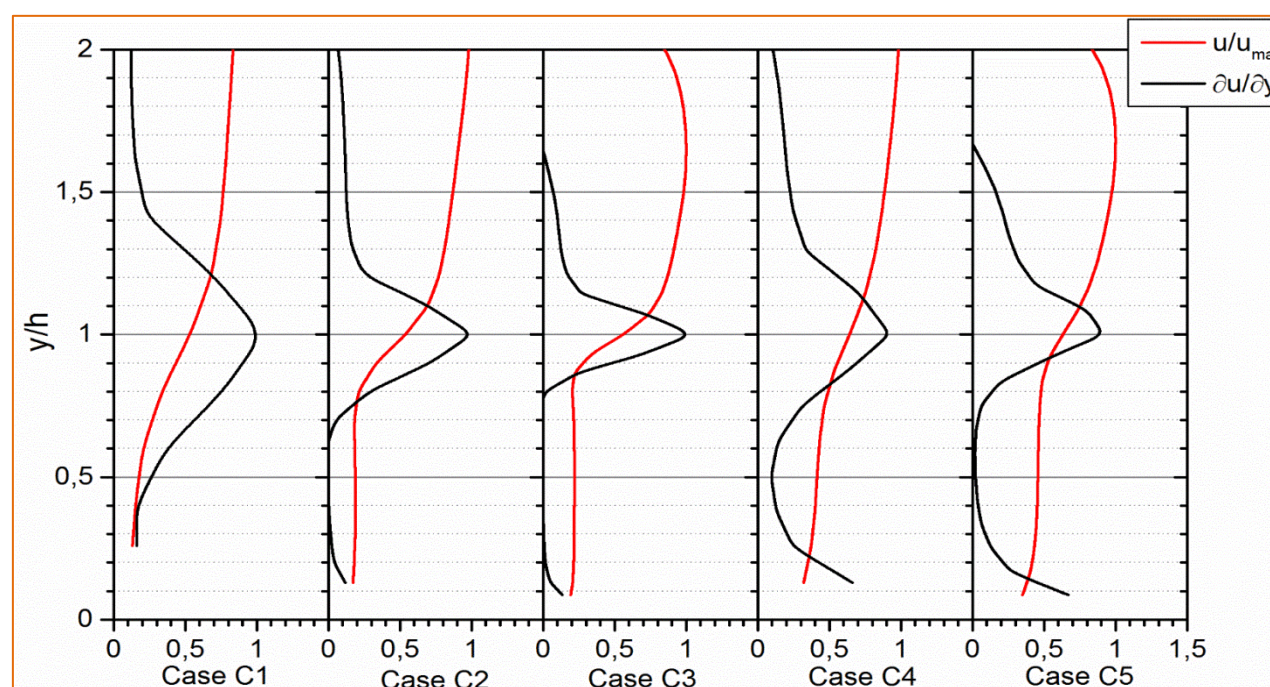


The velocity time-traces indicate the quasi-periodic nature associated with the flow

An array of large scale vortices in the streamwise direction with centers located between the two fins can be implied from the velocity time traces and the sequences of positive and negative velocities



Results: Velocity profiles



Between the fins and near the edge, the velocity profile presents an inflexion point that is a necessary condition but not sufficient for the onset of the Kelvin-Helmholtz instabilities that result in the formation of large scale coherent structures.

Concluding remarks

The main findings of this work can be summarized as follow:

- URANS proved to be able to accurately capture the coherent structures existing in compound channels;
- Time-traces of the velocity between the two fins were found to exhibit clear sinusoidal patterns.

Future Work

Document coherent structures characteristics such as axial spacing and convective speed.

Acknowledgment

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