Numerical investigation of heat transfer in flat vortex channels

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Providing required wall temperature is important task in cooled structures. There are many methods of heat transfer intensification for decrease the wall temperature and increase the heat flux: finned walls, special hydrodynamic structure of flow, complex mediums, etc. The vortex channels[1] is one of the insufficiently known methods of heat transfer intensification, which combines increase of surface area (finned wall) and enhanced convective cooling. The vortex channels is a duct, formed by combination of hot wall and load-bearing wall with milled fins intersected at different angles (Fig.1).

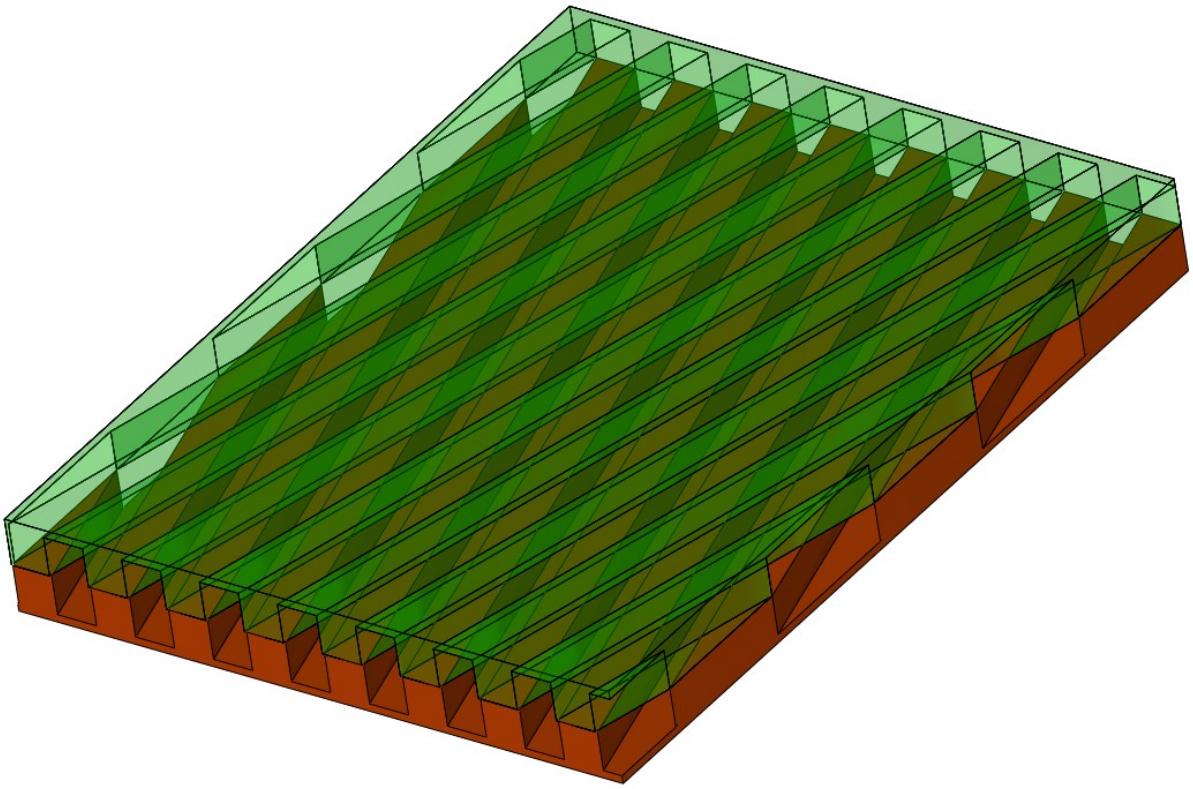

Fig.1. Flat vortex channels.

The investigation of heat transfer in vortex channels was carried out by means of CFD. The vortex channel, where the height of hot wall fins and load-bearing wall fins was equal, was considered. Flow was simulated in wide range of Reynolds numbers, heat and hydraulic characteristics were obtained for this duct. The total effect of heat transfer intensification is the sum of two components: the convective component and increase of surface area by means of fins. The high convective component is caused by mutual crossed flow leading to intensive turbulence development in flow mixing layers and turbulence transition to the hot wall.

A number of calculations with modifying the height fraction of hot wall fin in total height of duct were performed to estimate the contribution of each heat transfer intensification component.

The comparison of heat transfer intensification by means of flat vortex channels and finned wall was performed at Reynolds number $Re = 2 \cdot 10^4$, specific heat flux $q = 5$ MWt/m^2. It was shown that flat vortex channels provide to transfer the higher heat flux, than finned wall at the same conditions. Average hot wall temperature at the fire side in the case of flat vortex channels intersected at the angle of 90 degrees is more than 50 K lower than in finned channel (Fig.2).

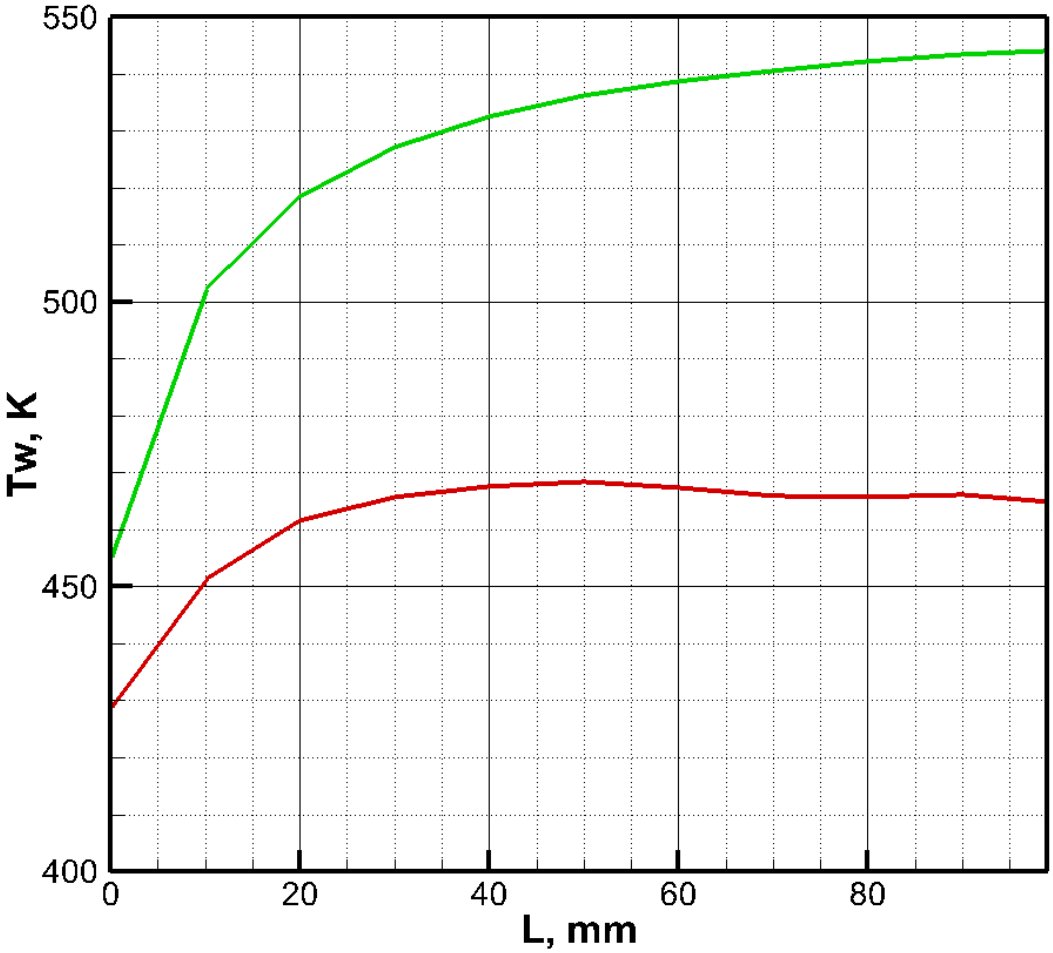

Fig.2. Comparison of wall temperature distribution for finned wall (green line) and flat vortex channels intersected at the angle of 90 (red line).

References

1. S.A. Orlin, S.A. Posnov “Experimental investigation of heat transfer and hydraulic resistance in vortex channels”, Trudy MVTU № 417, 1984.