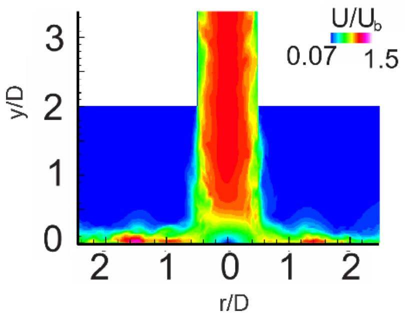
Universität Stuttgart
INSTITUT FÜR THERMODYNAMIK DER LUFT- UND RAUMFAHRT
Direktor: Professor Dr.-Ing. B. Weigand
Pfaffenwaldring 31, 70569 Stuttgart, Germany http://uni-stuttgart.de/itlr

Master thesis

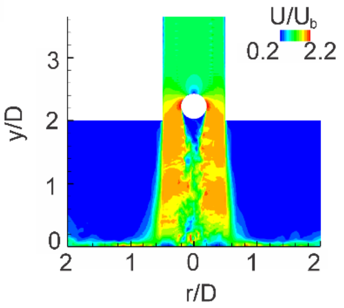
Numerical investigation of impingement cooling with vortex generators within the impingement pipe

Work Description:

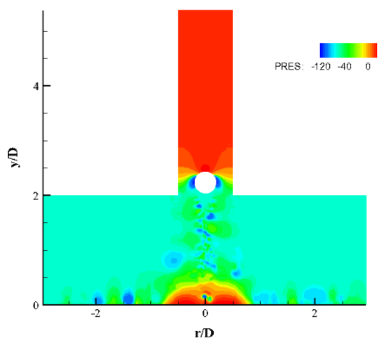
Impingement cooling is one of the most commonly used techniques for cooling the hottest components in gas turbines. The technique involves the creation of a jet of cool fluid that impinges on the hot surface, as can be seen in the Fig. 1(a). It has been shown that the efficiency of this technique can be improved by imposing unsteady fluctuations on the impinging jet. One way to do this is by using a small circular cylinder inserted in the path of the jet to create vortex shedding (Fig. 1(b)). The aim of this master thesis is to discover whether vortex shedding generated by bodies having a different cross-sectional shape (e.g. square or diamond) can produce higher thermal efficiency with a lower pressure drop. The research will be entirely computational, utilizing state of the art Computational Fluid Dynamics (CFD) software tools, and the advanced approach of Large Eddy Simulations (LES) to capture the effects of turbulence mixing on the heat-transfer rates.



(a)



(b)



(c)

Figure 1. Impingement cooling: (a) instantaneous Velocity distribution in the jet and in the impingement region without insert, (b) time-averaged mean velocity with a circular cylindrical insert, (c) pressure distribution within the jet and stagnation zone with the circular cylindrical insert.

Task description:

- Literature review of impingement cooling with superimposed vortex shedding and/or frequency modulation
- Explore the relation between the increase in thermal efficiency due to vortex shedding and the diameter of the circular cylinder
- Related to that, determine the relation between the pressure drop and diameter. The outcome of this part of the study will determine the smallest diameter that gives appreciable increase in thermal efficiency coupled with the smallest pressure drop.
- Explore the performance of other geometric shapes with sharp corners that have the same blockage as the optimal diameter as determined above. For example, would a simple vertical flat plate having a height equal to the diameter give better or worse performance both in terms of pressure drop and thermal efficiency? How about a square cylinder at both 0 and 45 degrees (a diamond), or a triangle?
- Evaluate the performance in terms of Stanton number and frictional pressure drop with different sizes of the insert.
- Documentation of the results

Place of work and duration:

This master thesis will be performed at the Institute of Aerospace Thermodynamics within 6 months. It will be conducted in cooperation with Prof. Bassam A. Younis, University of California - Davis and Prof. Naseem Uddin, Universiti Teknologi Brunei. Supervision will be by combination of in-person meetings and via virtual (Webex) conferencing. Covid permitting, it may be possible to perform some of the research at the University of California.

Supervision of the thesis:

Prof. Bassam A. Younis, Ph.D., UCD
Asst. Prof. Dr.-Ing. Naseem Uddin, Universiti Teknologi, Brunei
Prof. Dr.-Ing. Bernhard Weigand, ITLR

Weitere Fragen zu der Masterarbeit beantwortet:

Bernhard Weigand, bernhard.weigand@itlr.uni-stuttgart.de