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Session:

Experimental and numerical investigation of a heated impinging jet for a small nozzle-to-plate distance and high Reynolds number

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This paper presents a comprehensive study of an impinging jet configuration, which has been selected for its high Reynolds number Re_D = 60,000, small nozzle-to-plate distance H/D = 3 and temperature difference between the heated jet and the ambient (see Fig. 1). First, the experiments are described and analysed, then numerical simulations (DNS, LES, ZDES and RANS) are assessed to evaluate the resolution level required to capture the salient features of this configuration.

Experimental results

A thorough presentation of the experimental data is given in Ref. [1]. Velocity and temperature fields have been measured along with heat transfer on the impinged plate, which allows a detailed analysis of the physics of the jet/plate interaction. The final paper will provide an overview of the data available for the numerical simulations evaluation, which will also rely on the identification of the main mechanisms responsible for the Nusselt number distribution on the plate (Fig. .2)

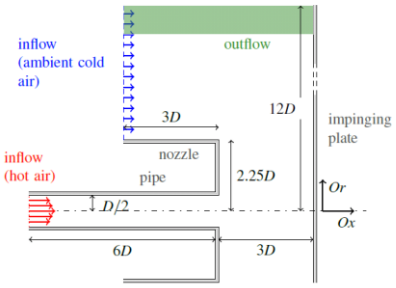

Fig. 1. Sketch of the configuration

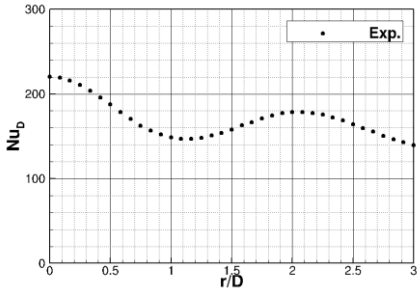

Fig. 2. Nusselt number distribution on the plate

Session:

Numerical results

In order to give an overview of the reliability of numerical simulations in the framework of jet/plate heat transfer prediction, DNS (Fig. 3), LES (Fig. 4), ZDES and RANS approaches have been carried out.

In the final paper, the results of the simulations will be assessed based on the physics educed from the experiments. This will allow to link the turbulence resolution level to the accuracy of the heat transfer computed. The unsteady mechanisms involved in the jet/plate interaction are captured by the DNS and LES simulations. Significant discrepancies are observed between RANS models; and only non-linear RANS models can reproduce the dual-peaked-shaped Nusselt number distribution (see Fig. 2). This explains the lack of accuracy of ZDES mode 2 simulations to predict this quantity since this RANS/LES approach relies on the Spalart-Allmaras model for the attached boundary layer on the plate.

Eventually, the results suggest that the impinged plate boundary layer should be resolved (rather than modelled in RANS) for quantitative heat transfer predictions.

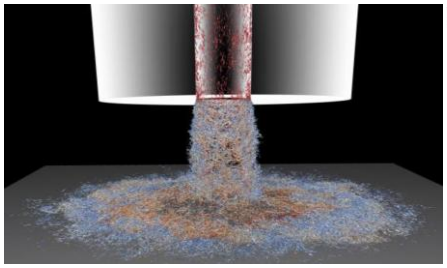

Fig. 3. DNS simulation

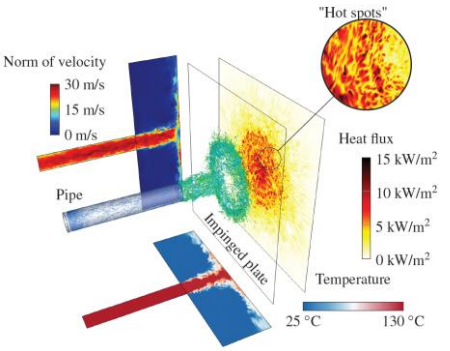

Fig. 4. LES simulation

References

[1] Grenson, P, Reulet, P. and Aupoix, B., "Flow dynamics and heat transfer of an impinging heated jet for a small nozzle-to-plate distance and high Reynolds number", *51st 3AF International Conference on Applied Aerodynamics, 4 – 6 April 2016. Strasbourg, France. Paper FP19-2016*, 2016

[2] Grenson, P., Deniau, H. and Aupoix, B., "LES of an impinging heated jet for a small nozzle-to-plate distance and high Reynolds number", in *11th International ERCOFTAC Symposium on Engineering Turbulence Modelling and Measurements*, 21-23 sept. 2016