Volumetric Velocimetry Study in a Transitional Wall Jet Flow with Passive Flow Control via Flaps

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Keywords: bird feathers, wall jet, biomimetic, Time Resolved 3D Scanning PIV

Introduction

Birds developed their flight technique over a period of approximately 150 million years and have very sophisticated wings with several adaptations for stall delay at high angles of attack. It was discovered that during landing some of the cover feathers pop up when the angle of attack is very high. This effect might prove very useful in aerodynamics and still needs to be investigated further as there is only little information about the actual influence of these structures. In this study a wall jet above a flat plate is used as a well-defined flow to compare the influence of flaps along the plate on the shear-layer roll-up process.

![Experimental setup](image1)

Fig. 1 Experimental setup

![Multiple-exposure images](image2)

Fig. 2 Multiple-exposure images

Material and Methods

The experimental set-up is shown in Fig. 1 with the flap array embedded in a smooth platform at a distance of 8 d behind the nozzle outlet. A laser sheet is focused by a lens and split into 20 sheets by a rotation polygon with 40 facets and a synchronized high speed camera records the individual laser sheets for further analysis. Three configurations are analyzed; the wall jet over a flat plate and a flap array with 100 and 200 µm elastomer foil.

Results and Discussion

To illustrate the overall flow pattern in selected phases of the flow we used, the method of image-overlapping to mimic multi-exposure pictures of the flow from the recordings (Fig. 2). The particles path lines display the roll up process at the shear layer which gets more pronounced in spreading of the jet in wall-normal direction and with increased entrainment from the ambient fluid when inserting a flap array. Here the vortex pairing seems to be delayed to the position of the first flap rows.

Isosurfaces make the forming role visible as well as larger flow structures which develop when interacting with hairpin vortices from the boundary layer.

![Isosurfaces](image3)

Fig. 3 3-Dimensional time step with isosurfaces

In both cases the flap array is influencing the vortex forming and interaction. It generates high wall-normal velocities and a delay in vortex interaction further downstream.

Conclusions

The first results with arrays of soft flaps show that the interaction process delays the vortex pairing process further downstream, however, then the vortical structures increase in size. By making the flaps stiffer this effect is strengthened. Ongoing measurements with variations in parameters such as flap geometry, material, equilibrium angle and position as well as the position of the flaps relative to the nozzle exit will be carried out.

Acknowledgements

We thank Mr. Benjamin Ponitz and Mr. Mark Sastuba for their support in reconstructing the 3-D voxel-volume and in data post processing. Part of the study is funded within the framework of PEL-SKIN project EU-FP7, GA no. 334954. All funding provided is gratefully acknowledged.