Flying PIV measurements in a driven IC engine flow

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This work focuses on the investigation of the unsteady flow in a transparent IC engine during the intake cycle. Special focus is laid on evolution of the flow close to the piston crown while the piston is moving. Therefore we developed a Flying PIV method which allows us to follow the flow evolution in a moving system of reference fixed with the piston and where the light-sheet remains at a constant distance to the piston surface. The measurements are realized in a water-analogue of a 4-valve engine at 1600 rpm engine speed in real situation.

Methods

A compact high-speed camera is mounted in the piston shaft and the light-sheet with 1.5mm thickness is moved with the piston crown using a polygonal mirror scanner that is synchronized with the piston motion. Thus, the distance between camera chip plane and the light sheet plane remains constant and particle images are always in focus during the complete intake cycle. A linear traverse is used to dictate the piston motion with the integrated camera system. The whole set up (high speed camera, piston, rotating polygon and four valve system) is synchronized such that the light-sheet position is always in the same distance to the piston crown.

Fig. 1 Experimental set-up: integrated high-speed camera in the piston and moving light-sheet synchronized with the piston motion.

Results

The results of the investigation during the intake cycle show high velocity areas in the region of the piston ground (d=1 mm). The iso-surfaces in Fig. 2 based on the Vorticity magnitude depict the legs of the vortices. These vortices belong to the horseshoe-type vortices generated at the inlet valves during intake, see the sketch illustrated in Fig. 3. While the piston is moving down, the legs of the horseshoe-type vortices are stretched in axial direction which increases rotational speed and generates strong streamwise vortices with their legs attached to the piston wall (Fig. 2).

Fig. 2 Evolution of the flow at the piston crown (CAD=21°,30°).

Fig. 3 Scheme of the vortices during the intake phase.

At CAD=170° the vortices disappeared as seen in Fig. 4. The comparison validates the results of tumble visualization in the middle plane. The flow shown in Fig. 4 left represents a footprint of the tumble on the piston wall.

Fig. 4 Comparison of cycle CAD=170° with the tumble visualization of S. Tag [3].

Recirculation areas (red lines) in the region near the cylinder wall and the high velocity section in the middle of the piston ground (black line) are highlighted.

Conclusion

With the Flying PIV method it is possible to investigate the near-wall flow topology and to determine regions of high wall-shear or flow separation due to the interaction of the swirl and tumble flow with the piston wall and other moving systems. The full paper shows the time-resolved PIV measurements for a complete intake process.

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References