15th International Symposium on Flow Visualization
June 25-28, 2012, Minsk, Belarus

SIMULTANEOUS PIV MEASUREMENTS IN THE INTAKE MANIFOLD'S RUNNERS OF A RUNNING AUTOMOTIVE ENGINE

D. BONNET[1,c], M. BARTHÈS[1], L. GIRARDOT[1], Y. BAILLY[1]

[1]Institut FEMTO-ST, département Énergie, Belfort, 90000, France

[c] Corresponding author: Tel.: +33384578207; Fax: +33384570000; Email: dimitri.bonnet@femto-st.fr

KEYWORDS:

Main subjects: flow visualization
Fluid: transient flows
Visualization method(s): particle image velocimetry
Other keywords: image processing, automotive air loop

ABSTRACT: The knowledge of flows inside an engine's air loop is a necessity to improve automotive efficiency. More precisely, the design of the intake manifold directly influences in-cylinder flows, and so engine performance [1]. Thus we aimed to experimentally measure velocities in the eight runners of an intake manifold on a real running engine. Previous and preliminary works in different locations of the air loop (intake and exhaust gas recirculation ducts) already showed that the use of PIV to acquire velocity fields associated to each crank-angle was successful [2, 3]. Thus, we decided to apply PIV method to acquire simultaneously the velocities in the eight runners of the intake manifold at representative speed and load (1500 rpm, 40 Nm). Optical measurements on a running engine environment result in several kinds of constraints (vibrations, lack of space...). A specific PIV system was designed to deal with these constraints. It consisted in an integrated system interdependently linked with the engine, and was composed of a dual beam pulsed laser Nd:Yag, two cameras, two specific optical benches (emission and reception) and a data acquisition center. The emission bench allowed the single laser beam to reach the eight intake manifold cells with respect to a similar optical path length. The reception one (still with regards to the optical path length) was designed to obtain on each camera an image of flows inside four of the eight runners, thus eight runners were captured with two cameras. The data acquisition center recorded signals of a counter (to know the crank-angle) and the laser Qswitch time. Thereby, it was possible to know to which crank-angle any image referred to. Concerning the PIV post-process, since vibrations induced displacement between two successive pairs of image and moreover, since there were four distinct regions of interest (ROI) on each image, we choose to develop a python-coded full PIV software. This last one allows to pre-process images for experiments dealings with vibrations, and to apply different processes on each ROI (taking into account geometrical transformations due to, for instance, prisms or mirrors that change images' orientations). After images pre-processing, an iterative cross-correlation PIV process [4] was applied to determine velocity vectors field in each runner. An average velocity was then calculated for every crank-angle, so velocities in each runner were drawn versus the crank-angle (cf. Fig 1.). This study was very challenging because of the engine environment and its technical constraints. Nevertheless, clean images were captured, enabling the PIV process to successfully calculate velocity vectors fields in each runner.

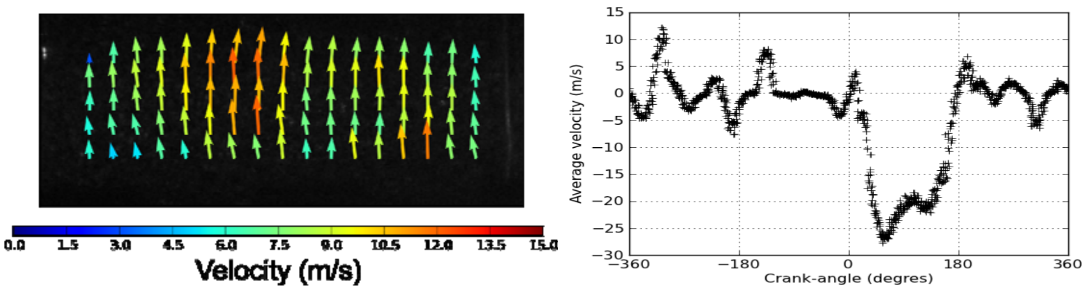

Fig. 1 Left: Instantaneous velocity vectors field in the first helicoidal runner at crank-angle -125°. Right: Average velocities in the first helicoidal runner versus the crank-angle.

References

1. Jemni M. et al. *Influence of intake manifold design on in-cylinder flow and engine performances in a bus diesel engine converted to lpg gas fuelled, using cfd analyses and experimental investigations.* Energy

2. Guermeur F. et al. *Phase locked piv measurements in an inlet manifold.* in: ISFV13, Nice, France, 2008

3. Bonnet D. et al. *Vélocimetrie par PIV d'écoulements pulsés instationnaires sur banc moteur industriel*. in: congrès de Mesures et Techniques Optiques pour l'Industrie, Toulouse-Labège, France, 2010

4. Westerweel J. et al. *The effect of a discrete window offset on the accuracy of cross-correlation analysis of digital piv recordings*. Experiments in Fluid 23 (1), 1997