Steady state air flow measurements on engine cylinder heads have been performed for many decades as a simple and early design tool in an effort to predict the performance of an engine. These integral techniques have proved very successful for swirl based engines but have failed to show the same success for tumble flow, where the absence of the piston in steady state work is believed to have a big impact. Modern spark ignition engine design, particularly with direct injection, is finding the tumble flow in the cylinder to be critical, for both guiding of the fuel for stratified operation and as an aid to the combustion speed and stability under all operating conditions. This led to laser diagnostics being applied in place of the simpler integral methods, but with the assumption of a close correspondence between the steady state flow and that in a running engine.

This paper looks at a comparison between in-cylinder flows under steady state and motored engine conditions to test the above assumption. LDA measurements were made in a horizontal plane for the steady state measurements and vertical planes for the motored engine flows. Calculated tumble ratios and correlation factors are used to give a quantitative comparison between the flows generated for the two cases.

The results from these comparisons showed the tumble ratio to be higher in the engine flows, as expected due to the presence of the piston acting as one of the generators for tumble. An unexpected cross tumble flow was measured for the steady state measurement that was not present in the engine, indicating an asymmetry of the flow structure for these measurements. This feature of the flow will be further studied, but no precise explanation is available at present. The correlation coefficients were approximately 0.5, which although not high, does indicate some similarity between the flows. This similarity can be visually observed in velocity profile plots, although in some instances there is an apparent lateral shift apparent on the profiles between the two sets of measurements.

A final qualitative comparison is given between PIV vector fields, now in a vertical plane, for the steady state measurements and the LDA vector fields for the motored engine. The visual comparison indicates a high degree of similarity in the flow fields away from the piston crown, suggesting that local pressure differences in the cylinder are partially responsible for the generation of the tumble flow.

The conclusion from this study is the suggestion that with careful selection of the measurement tools and the strategy employed, there is the possibility to use data collected on the steady flow rig to give a good indication of the flow generated in the engine cylinder.

References


Boccadoro Y., Kermanc’h L., Siauve L. and Vincent J., The new Renault TCE 130 1.4l turbocharged gasoline engine, 30th Internationales Wiener Motorensymposium, 2009


Glanz R., Differentielle Erfassung von Tumble-Strömungsfeldern, MTZ, 2000


Middendorf H., Krebs R., Sengel R., Pott E., Fleiss M. And Hagelethin D., Volkswagen introduces the worlds first double charge direct injection petrol engine, 14th Aachener Kolloquium Fahrzeug- und Motorentechnik, 2005


Tsujii N., Sugiyama M. and Abe s., The new 3.5l V6 gasoline engine adopting the innovative stoichiometric direct injection system D4S, 27th Internationales Wiener Motorensymposium, 2006