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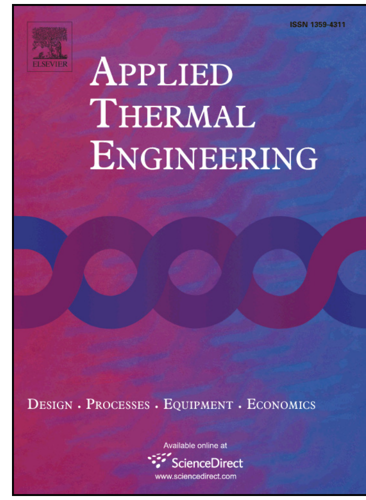

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Effect of the inlet geometry on performance, surge margin and noise emission of an automotive turbocharger compressor

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Abstract

Centrifugal compressor performance at low mass flow rates has become an issue in the latest years due to engine downsizing and the increase of low-end torque request. The principal drawback of this operating region is the appearance of the surge phenomenon, which is strongly affected by the compressor inlet geometry. This work is addressed to study the impact of different inlet geometries on the compressor performance, including compressor efficiency, noise emission and surge margin. An engine test bench is set up with a centrifugal compressor and both steady and transient (tip-out) tests are performed in order to obtain a complete view of the influence of each configuration. The results show a clear sensitivity of the compressor parameters to the variations of the geometry upstream the compressor inlet.

Keywords: Engine test bench, Tapered duct, Nozzle, Tip-out test

1. Introduction and literature review

Turbochargers (TC) are well known machines with a development of near a hundred years. However, the application of turbomachinery to reciprocating internal combustion engines (ICEs) is relatively new, experimenting a notable increase in the last fifteen years for diesel engines and even less for gasoline engines. Thus, there is still room for further studies of the couple TC-ICE. The study of this combination is particularly relevant due to the trend that most engines are following, the downsizing, which is the tendency of reducing the total cylinder displacement. Turbocharging is really interesting when using this approach, because it helps achieving higher specific power and efficiency.

Nevertheless, a turbocharged engine presents some drawbacks due to the coupling between two different machines. On one hand, the four stroke ICE is a reciprocating machine that performs its thermodynamic cycle in four piston strokes, generating acoustic pulses that propagate through the pipes arriving and interacting with the compressor and the turbine. Its rotational velocity varies from about 800 to 5000 rpm in common situations. On the other hand, the turbocharger is a continuous flow machine which axis rotates at very high revolutions per minute (50k to 200k depending on the size). In addition, the TC responds to mass flow rate variations with a reduced rate of change of shaft speed due to the TC rotational inertia, among other factors. The mismatch between the dynamics of the engine and the turbocharger introduces what is called turbo-lag, which consists of a delay of the turbocharger response to engine demands.

Compressor working range is limited by choke conditions at very high mass flow rates. Wheel structural integrity also constrains maximum rotating speed. At low mass flow rates the compressor flow is not capable of overcoming the adverse pressure gradient due to its reduced velocity, and reversed flow ap-

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