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Validated analytical modelling of supercharging centrifugal compressors with vaneless diffusers for H_2-biodiesel dual-fuel engines with cooled EGR

(Article)

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Abstract

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The supercharging centrifugal compressor with a vaneless diffuser is a key element in diesel powertrains that has not been comprehensively modelled using explainable mathematical trends. This study thus develops an analytical model for this type of compressors for hybrid H_2-Biodiesel dual-fuel engines with cooled EGR. Specifically, for this proposed type of compression ignition system, the study develops an analytical model of the velocities at the exit of impeller of the supercharging compressor. In addition, a sensitivity analysis is conducted on the developed models of the total power required to drive the compressor and its mechanical efficiency. The developed models have been validated using case studies that are based on field data gathered experimentally. Furthermore, a modified model of the Stanitz's slip factor is presented for radial blades accounting for the Coriolis circulation, boundary layer effect, and blade thickness. The modified Stanitz's slip factor provides better accuracy of matching the experimental results with relative error of 1%. The relative error with respect to the parameters of the velocities at the impeller and the analytical model of the power required to drive the rotor of the compressor is 7%. In addition, the relative error with respect to the model of the mechanical efficiency of the compressor is 10%. These relative errors are of an order of magnitude of deviation that is comparable with that of widely recognized models in the field of vehicle powertrain modelling such as the CMEM and GT-Power. These developed models follow from the principles of physics so that they are widely valid models. Having addressed and corrected flaws in corresponding models presented in key references in this research area, these developed models can help more effectively evaluate the power input to this type of compressors and thus the fuel consumption reducing the environmental foot-print thereof.

Author keywords

Analytical modelling Bio-diesel engines Centrifugal compressors EGR Hydrogen fuel

Indexed keywords

Engineering controlled terms: Analytical models Biodiesel Boundary layers Centrifugal compressors Centrifugation Diesel engines Digital storage Efficiency Engines Errors Fuels Hydrogen fuels Impellers Powertrains Sensitivity analysis

Compendex keywords: Blade thickness Boundary layer effects Compression ignition Consumption reducing Developed model Mechanical efficiency Vaneless diffuser Vehicle powertrains

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	Virginia Polytechnic Institute and State University	VT	See opportunities by VT

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