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Performance Improvement of Piston Engine in Aeronautics by Means of Additive Manufacturing Technologies

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Abstract : The reduction of greenhouse gases and pollution emissions is a worldwide environmental issue. The amount of CO_2 released by an aircraft is associated with the amount of fuel burned, so the improvement of engine thermo-mechanical efficiency and specific fuel consumption is a significant technological driver for aviation. Moreover, with the prospect that avgas will be phased out, an engine able to use more available and cheaper fuels is an evident advantage. An advanced aeronautical Diesel engine, because of its high efficiency and ability to use widely available and low-cost jet and diesel fuels, is a promising solution to achieve a more fuel-efficient aircraft. On the other hand, a Diesel engine has generally a higher overall weight, if compared with a gasoline one of same power performances. Fixing the MTOW, Max Take-Off Weight, and the operational payload, this extra-weight reduces the aircraft fuel fraction, partially vinifying the associated benefits. Therefore, an effort in weight saving manufacturing technologies is likely desirable. In this work, in order to achieve the mentioned goals, innovative Electron Beam Melting – EBM, Additive Manufacturing – AM technologies were applied to a two-stroke, common rail, GF56 Diesel engine, developed by the CMD Company for aeronautic applications. For this purpose, a consortium of academic, research and industrial partners, including CMD Company, Italian Aerospace Research Centre – CIRA, University of Naples Federico II and the University of Salerno carried out a technological project, funded by the Italian Minister of Education and Research – MIUR. The project aimed to optimize the baseline engine in order to improve its performance and increase its airworthiness features. This project was focused on the definition, design, development, and application of enabling technologies for performance improvement of GF56. Weight saving of this engine was pursued through the application of EBM-AM technologies and in particular using Arcam AB A2X machine, available at CIRA. The 3D printer processes titanium alloy micro-powders and it was employed to realize new connecting rods of the GF56 engine with an additive-oriented design approach. After a preliminary investigation of EBM process parameters and a thermo-mechanical characterization of titanium alloy samples, additive manufactured, innovative connecting rods were fabricated. These engine elements were structurally verified, topologically optimized, 3D printed and suitably post-processed. Finally, the overall performance improvement, on a typical General Aviation aircraft, was estimated, substituting the conventional engine with the optimized GF56 propulsion system.

Keywords : aeronautic propulsion, additive manufacturing, performance improvement, weight saving, piston engine
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