World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:10, No:09, 2016

Combustion Variability and Uniqueness in Cylinders of a Radial Aircraft Piston Engine

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Abstract : The work is a part of the project which aims at developing innovative power and control systems for the high power aircraft piston engine ASz62IR. Developed electronically controlled ignition system will reduce emissions of toxic compounds as a result of lowered fuel consumption, optimized combustion and engine capability of efficient combustion of ecological fuels. The tested unit is an air-cooled four-stroke gasoline engine of 9 cylinders in a radial setup, mechanically charged by a radial compressor powered by the engine crankshaft. The total engine cubic capac-ity is 29.87 dm3, and the compression ratio is 6.4:1. The maximum take-off power is 1000 HP at 2200 rpm. The maximum fuel consumption is 280 kg/h. Engine powers aircrafts: An-2, M-18 „Dromader", DHC-3 „OTTER", DC-3 „Dakota", GAF-125 „HAWK" i Y5. The main problems of the engine includes the imbalanced work of cylinders. The non-uniformity value in each cylinder results in non-uniformity of their work. In radial engine cylinders arrangement causes that the mixture movement that takes place in accordance (lower cylinder) or the opposite (upper cylinders) to the direction of gravity. Preliminary tests confirmed the presence of uneven workflow of individual cylinders. The phenomenon is most intense at low speed. The non-uniformity is visible on the waveform of cylinder pressure. Therefore two studies were conducted to determine the impact of this phenomenon on the engine performance: simulation and real tests. Simplified simulation was conducted on the element of the intake system coated with fuel film. The study shows that there is an effect of gravity on the movement of the fuel film inside the radial engine intake channels. Both in the lower and the upper inlet channels the film flows downwards. It follows from the fact that gravity assists the movement of the film in the lower cylinder channels and prevents the movement in the upper cylinder channels. Real tests on aircraft engine ASz62IR was conducted in transients condition (rapid change of the excess air in each cylinder were performed. Calculations were conducted for mass of fuel reaching the cylinders theoretically and really and on this basis, the factors of fuel evaporation "x" were determined. Therefore a simplified model of the fuel supply to cylinder was adopted. Model includes time constant of the fuel film τ, the number of engine transport cycles of non-evaporating fuel along the intake pipe γ and time between next cycles Δt. The calculation results of identification of the model parameters are presented in the form of radar graphs. The figures shows the averages declines and increases of the injection time and the average values for both types of stroke. These studies shown, that the change of the position of the cylinder will cause changes in the formation of fuel-air mixture and thus changes in the combustion process. Based on the results of the work of simulation and experiments was possible to develop individual algorithms for ignition control. This work has been financed by the Polish National Centre for Research and Development, INNOLOT, under Grant Agreement No. INNOLOT/I/1/NCBR/2013.

Keywords : radial engine, ignition system, non-uniformity, combustion process
Conference Title : ICAMAME 2016 : International Conference on Aerospace, Mechanical, Automotive and Materials Engineering
Conference Location : San Francisco, United States
Conference Dates : September 26-27, 2016