DEVELOPMENT OF THE GAS TURBINE WITH DETONATIVE COMBUSTION CHAMBER

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ABSTRACT

At the Institute of Aviation in Warsaw, a project of a turbine engine demonstrator with a detonation chamber was implemented. A helicopter's turbine engine GTD-350 was chosen as a test bad since in a such engine configuration replacing of its combustion chamber with an experimental detonation chamber was relatively easy. A specially dedicated research stand with computer-controlled power supply systems, measurement and acquisition systems, ignition system and compressed air supply system was constructed. Initially several different configuration of detonation chambers with new fuel injection system were build and tested.

The newly designed detonation chambers were supplied with Jet-A fuel, Jet-A fuel with the addition of hydrogen and with gaseous hydrogen only. Addition of hydrogen to Jet-A air mixtures was very helpful to initiate and maintain stable detonation, but for narrow range of conditions also continuously rotating detonation was achieved. However, best operating conditions were for hydrogen-air mixture, for which very stable detonation was always recorded. For all test pressure variation and velocity measurements were recorded. The velocity of the continuously rotating detonation wave was determined by measuring the pressure in the chamber with high-frequency piezoelectric pressure sensors. After section of the optimum geometry of detonation chamber, the chamber was connected to the GTD-350 engine and the test of the system were performed for a three different fuel supply modes: for Jet-A fuel, for the mixture of Jet-A with small additions of gaseous hydrogen and for gaseous hydrogen only. For all kind of fuels engine could work stationary and it was also possible to vary engine power during test. The engine was tested only for the power changing from idle up to cruising range. Usually engine test were lasting less than the minute, since such time was sufficient to measure engine performance on quasi state conditions. For engine operation on gaseous hydrogen only the tests duration were limited by capacity of hydrogen tanks and usually lasted less than a minute.

Engine performance with detonation chamber was measured for Jet-A as well as for gaseous hydrogen fuel. It was found the for Jet-A supply efficiency of the engine with detonation chamber was lower than the efficiency of the based engine. This was mostly due to fact that not all droplets of Jet-A fuel were reacted in detonation wave and some of them were afterburning much later and did not contributed to power generation. However, for hydrogen fuel engine exhibit higher performance and calculated efficiency was 5-7% higher than the efficiency of base engine working on Jet-A fuel. It could be also mentioned that this efficiency might be higher, since there were compared to base new engine, however, engine used for experiments was partially worn out and its elements efficiency were lower than that of the new engine. Also it should be mentioned that the noise generated by engine working with detonative chamber was at similar level as with classical combustion chamber.

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