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Author: Mr. Tobiasz Mayer
Institute of Aviation, Poland

Mr. Bartosz Bartkowiak
Institute of Aviation, Poland

ANALYSIS AND EXPERIMENTS CONSIDERING 98%+ HYDROGEN PEROXIDE HYBRID ROCKET MOTORS WITH ADDITIVE MANUFACTURED FUEL GRAINS

Abstract

Institute of Aviation (IoA) from Warsaw, Poland is advancing in the matter of space propulsion related to HTP 98%+ (High Test Peroxide) since 2009. A great deal of research has been done in the matter of liquid engines and hybrid motors. As the leading Polish research & development facility in terms of Rocket propulsion, IoA is determined to investigate any new accessible technology that allow to achieve better performance in the field of hydrogen peroxide applications. One of this technology is additive manufacturing.

The scope of presented paper covers present activities done at IoA in terms of investigating materials and processes of additive manufacturing as the main technology for fabricating grains for hybrid motors utilizing HTP.

Fused Deposition Modeling (FDM) can be used to fabricate fuels for hybrid motors what has been confirmed during many previous studies. More advanced geometries with similar physical properties regards to conventional processes are achievable with use of strict control of the additive manufacturing process. FDM fabrication allows engineers to design more complex multiport grains (i.e. helix shape ports) or even multi-material grains which leads to increase of regression rate and performance of the motor. Beside new opportunities, new technology brings also new challenges, new rules for geometry design and quality control. Quality of additive manufacturing process strictly depends on material, fabrication parameters, geometry and even conditions at which raw material is stored before manufacturing. All of those are within the scope of the performed study, with the main drive to develop knowledge that helps engineers improve motor performance. Data analysis from multiple hot fire tests of small scale hybrid motors (with in-house 3D printed multiport grains from different materials) will be presented. Tested materials include: polyethylene, ABS, PLA, nylon and abs with aluminum particles. Fuel regression rates and performance are examined.

Additive manufacturing also brings potential cost reduction to the process of grain manufacturing. Also higher quality with elimination of special tooling for conventional fabrication and middle steps of manufacturing can be achieved. IoA has developed a 4 kN class hybrid rocket motor for the ILR-33 AMBER Rocket, which utilizes 98%+ HTP and in-house manufactured polyethylene grain (without use of additive manufacturing). However use of additive manufacturing for such scale is possible. Therefore, cost comparisons and trade-offs between existing technologies of manufacturing and FDM fabrication are presented.