Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: PROPHY
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Type: Oral
Status or corresponding author: Regular

Development of the Liquid Green Propellants at the Łukasiewicz-Institute of Aviation

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Abstract

Rapid development of liquid rocket's propellants started after the Second World War (WWII), since it was necessary to develop rockets to transport nuclear warheads and other weapons and accelerated when Space Era started. Since that time a lot of rocket liquid propellants combinations were tested. Alcohols, ethers, amines, aromatic hydrocarbons, petroleum fractions including kerosene, saturated and unsaturated hydrocarbons including methane, propane, hydrazine and hydrazine related substances and hydrogen were considered as a fuel. As an oxidizer the liquid oxygen (LOX) was the first choice for V2 and for Russian ballistic missiles, but also nitric acid, nitrogen oxides, hydrogen peroxide and even exotic oxidizers such as ozone, fluorine and fluorine related substances. Most of the possible combinations of fuels and oxidizers were only tested in laboratories. Only few selected combinations were used in military and space rockets. Today space boosters use mostly kerosene with LOX and also more efficient propellants such as liquid hydrogen (LH2) and LOX. Recently, new propellants based on liquid methane and LOX are under development. But some countries like Russia and China, are still using toxic and corrosive propellants based on hydrazine and it's derivatives such as MMH, UDMH and others with Nitrogen Tetroxide and other nitrogen related toxic and corrosive oxidizers such as Nitric Acid or MTO. The most important benefit of those propellants is that they can be stored for many years, which is very important for military applications and long duration space missions. Application of those propellants to space rockets and spacecraft is very effective in long duration space missions, especially for attitude control, spacecraft trajectory correction as well as for landing vehicles. Despite of benefits there are many difficulties in production process, storage and handling of these energy effective fuels. Additionally, spacecraft's system design to resist corrosive properties and to keep effective operation capability of all subsystems in a long duration space mission is a challenge. Due to these problems a new initiative to eliminate toxic and corrosive propellants was announced and development of the new substitutions for those propellants started in Europe. One of possible substitution of oxidizer is highly concentrated hydrogen peroxide with other green fuels. About 15 years ago at the Institute of Aviation in Poland, a new and very effective production process of highly purified Hydrogen Peroxide, or so called, High Test Peroxide (HTP) was developed and patented. Using this process it is possible to obtain even 99,99% purity of the HTP, but the recommended application is 98% HTP for practical use as space propellants. Unlike recently used by some other countries HTP with concentration of 87%, the 98% product contains basically only 2% of water but no impurities, which are usually responsible for uncontrolled decomposition. The 98% HTP is non-toxic and non-corrosive with combination of many materials and can be stored for many years with minimum degradation during that time. So it is a very good substitution of toxic and corrosive oxidizers and also mono propellant. In our Institute many green propellants based on HTP for space application engines were selected and tested, ranging from monopropellant engines for small satellites, larger bi-propellants engines with hypergolic capacity for larger satellites and rockets as well as hybrid rocket with HTP as an oxidizer. In this paper a detailed description of purifying technology to obtain HTP, analyses of developed green liquid propellants based on the HTP as well as the tests of all kinds of engines/rockets using such green propellants will be presented.

References:

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