Sabre-Rocket

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ABSTRACT

An informative paper on the saber-rocket, a new type of rocket engine currently in development at Reaction Engines inc in the UK.

1 Introduction

This report aims to introduce and explain the concept of a new type of rocket currently in development by Reaction Engines inc in the UK. The Sabre which stands for “synergetic air-breathing rocket engine” is easiest explained as a sort of hybrid between a normal jet engine and a rocket engine meaning that it can operate at higher speeds than normal engines and works both within our atmosphere and in space [1]. This technology has the opportunity to drastically help evolve both planetary and space travel.

2 History

Reaction Engines inc was formed by three former Rolls Royce workers that previously had been assigned to work on the HOTOL project. The HOTOL project was a horizontal take-off and landing spaceplane designed in the late 80s, it is also the predecessor to the Skylon space plane currently in development wich will in fact use the SABRE engine. [2]. It was during the HOTOL project that the use of an air breathing engine was going to be developed and used. When the project was cancelled the three workers went on to form Reaction Engines and started working on the new SABRE Rocket using the knowledge from the previous air breathing engine work to assist in the development of this new revolutionary engine. Right now the rocket is in the testing phase of the development [1].

3 Function

The saber engines main function is that it has the ability to switch between two different engine modes. The two modes are open cycle and closed cycle. When in open cycle mode the rocket functions more or less like a normal jet engine and the air intake at the front is open and allows air to freely flow through the rocket, in this mode the rocket is capable of operating at speeds up to mach 5. The second mode is closed cycle mode where the rocket closes the air intake at the front and uses hydrogen and liquid oxygen as fuel. This allows the engine to function more or less like a normal rocket engine and it can reach a speed up to mach 25.

One of the main problems that the sabre rocket is currently faceing is the fact that when you approach hypersonic speeds the air flowing into the air intake gets extremely hot, around 1000 celsius[3]. To cope with this issue the saber rocket uses a pre cooler that is located between the air intake and the rocket engine itself. The way this pre cooler works is that it recirculates Helium between the precooler and the cryogenically cooled hydrogen pumped from the tanks [4]. This process is so fast that it occurs within 1/100th of a second [3].

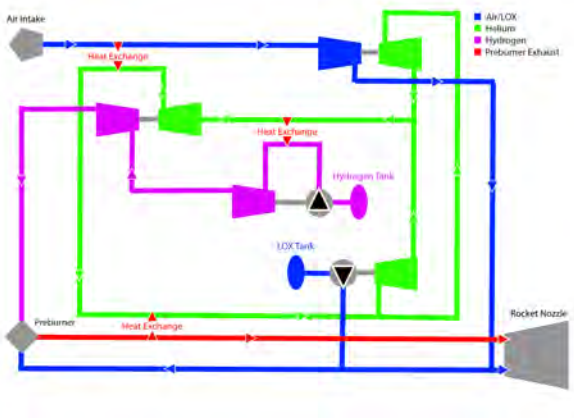

Fig. 1 Schematic of fluid flows in SABRE engine [4]

4 Innovation

The greatest innovation of the SABRE system is the precooler. The capacity to provide atmospheric properties akin to sea level subsonic speeds while flying at 20 000 meters approaching mach 5. This capacity allows the airframe to save weight on liquid oxygen, increasing the effective payload capacity. This effectiveness can most easily be shown in the Specific Im-

pulse of the engine, which in open cycle is near 22 000 sN/kg at Mach 5, compared to the closed cycle capacity of 4500 sN/kg in the vacuum of space. This effectiveness is the main point of the SABRE [1].

The engine core is also innovative utilizing the heat coming from the precooler to drive itself, mainly having an impact during open cycle. With pumps driven with the excess heat [5], using the coolant of the hydrogen to attain a temperature differential, it saves on fuel by not wasting the propulsive energy to drive itself, as is common in other types of engines, both jet and rocket [4].

Another important feature of the SABRE is the fact that the design is completely modular. This means that each key part of the rocket can be removed by it self. This greatly enhances the ability to exchange malfunctioning parts but it, also allows for the development team to test each part of the rocket by it self in different straining environments and situations akin to the expected working conditions [3].

5 Problems

Currently the main obstacle is the engine core, which is still to be tested successfully. When that have been achieved the next step is the full system, combining the four components of the engine. The Shock cone, which is of a proven design, the precooler which has been tested successfully, the engine core and last the rocket exhaust.

As late as Aug 7, the precooler was undergoing high mach number testing, and has , among other, successfully proven it's innovative frost control system, according to Adam F. Dissel [5].

6 Future

The near future of the SABRE engine is looking promising. With the successful test of their precooler in their LA based high temperature test Facility as mentioned above. They intend to perform a system test of their engine core during 2019, with a test of the system in its entirety, precooler and engine core combined, by 2020 [6]. The 2020 test will see the entire system tested from static at sea level to mach 5 at 25 km to prove the systems viability.

Beyond this, the precooler stage of the engine has plenty of other potential uses. As a precooler it can be used on regular turbofan engines to expand their working envelope and increase the effectiveness of the engines [1].

Reaction Engines have also explored the Scimitar engine, a derivative of the SABRE designed to be utilized in a new supersonic passenger aircraft [7].

7 Conclusion

Because of how new this technology is and with parts of the engine still in testing and development there isn't very much specific information about the engine and how exactly each part functions. This is because much of the development is still very secret and there's only so much information available. This paper has brought forward as much information as possible to provide greater insight into the SABRE project. Hopefully more information will be released as new progress is made and the rocket moves forward to full flight testing. We believe that the SABRE is a very innovative piece of technology and will be a big leap forward in rocket development and future space and planetary travel.

Terminology

Specific Impulse: The energy released for every unit of mass of fuel

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