CUBESAT PROPULSION SYSTEM

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The following report summarizes my work done in the making of a water electrolysis cubesat propulsion system.

Cubesats are small satellites composed of cubes of 10x10x10 cm, generally built by universities and startups to test technologies. However, with the miniaturization of electronics, they potentially can serve useful purposes ranging from earth observation, weather monitoring, spy satellites, communications, etc.

However, their small sizes makes it harder to make propulsion systems that give high enough delta-v to sustain them for more than 5 years. Generally, they are launched without a propulsion system into low-earth orbit. Due to the atmospheric drag, eventually after a few months, their orbit decreases and they enter earth's atmosphere and burn up thus ending the mission.

This is where propulsion systems for station keeping come into play. If cubesats are given around 30 m/s per year, they can maintain their orbit.

I thought from first principles and this is how i made a cubesat propulsion system:

In class 10th, I was viewing a lecture on electrolysis of water, and I drifted a bit from it and saw the space shuttle model kept on my table. I knew that the space shuttle used liquid hydrogen and liquid oxygen for its three main engines. I thought: "why not carry water, and with a dense enough energy source, electrolyse it onboard and then combust the H2 and O2 to obtain thrust". It's basically converting electrical energy to kinetic energy.
This seemed so simple I began searching for it more. I realized that electrolysis depends upon the current and to make a rocket engine that utilizes the generated h2 and o2 immediately while producing thrust of the order of even 1 newton, it would require a current of 3000A in order to continuously 'feed' the engine.
I did not give up :)
I thought, ok fine, if not a continuous one and not the one to be used in launch vehicles, let's make a propulsion system to be used in space. In space, water is quite abundant and if we can make a propulsions system that uses only water and the electricity generated from the Sun, it will be quite convenient to colonize space. Given a nuclear power source, a spacecraft can explore bodies that contain water practically indefinitely. Comets, planetary rings contain ice. Given enough energy, we can explore them easily.

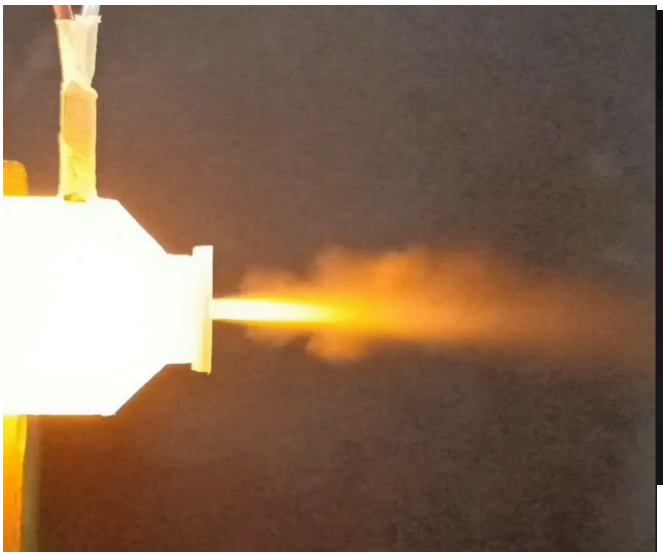
To start with, I decided to put this system into use in cubesats. They generally do not have a propulsions system, and if they do, they contain harmful chemicals that, if things went wrong,

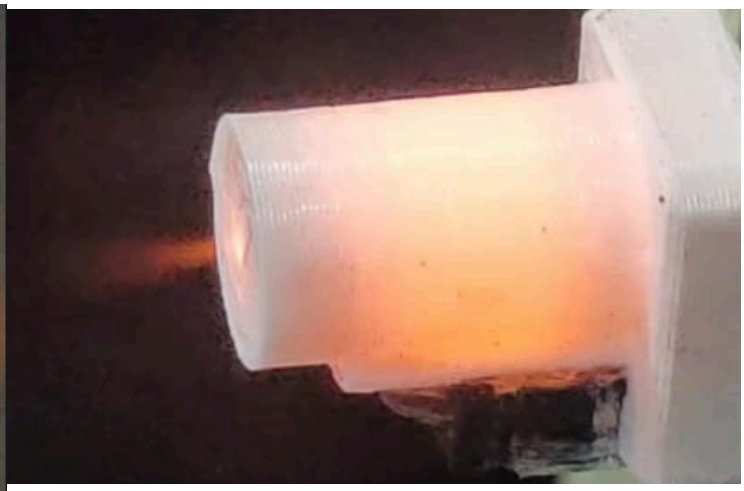
explode and damage the rocket. Ensuring safety comes at the price, which universities and early startups may not be able to pay. Instead, use water!

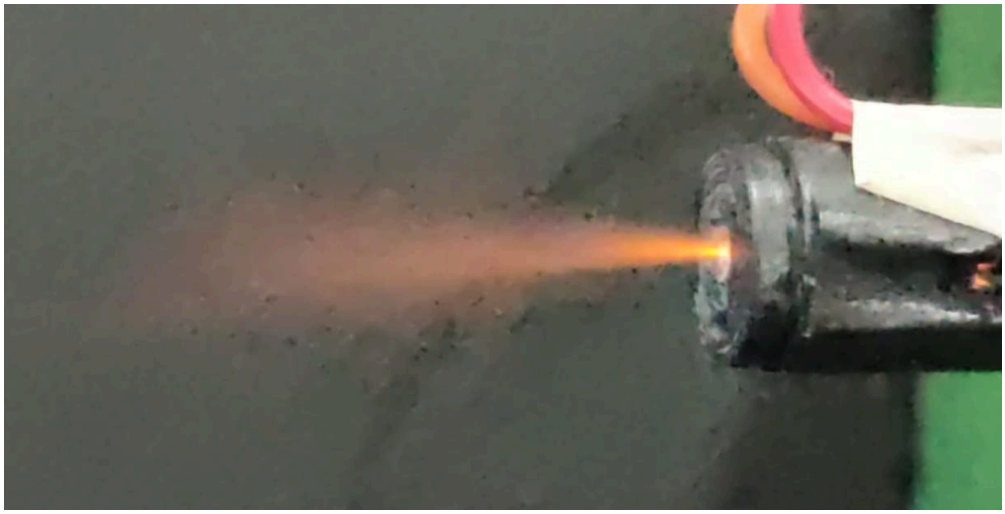
Water is carried onboard in the cubesat. It is then launched and placed into an orbit. Whenever required, a small quantity of water can be electrolysed. The accumulated gasses h2 and o2 are then stored at a high pressure. When required, valves are opened and these glasses are injected into the combustion chamber where they are combusted. A nozzle then accelerates the gas to supersonic speeds. This results in thrust.

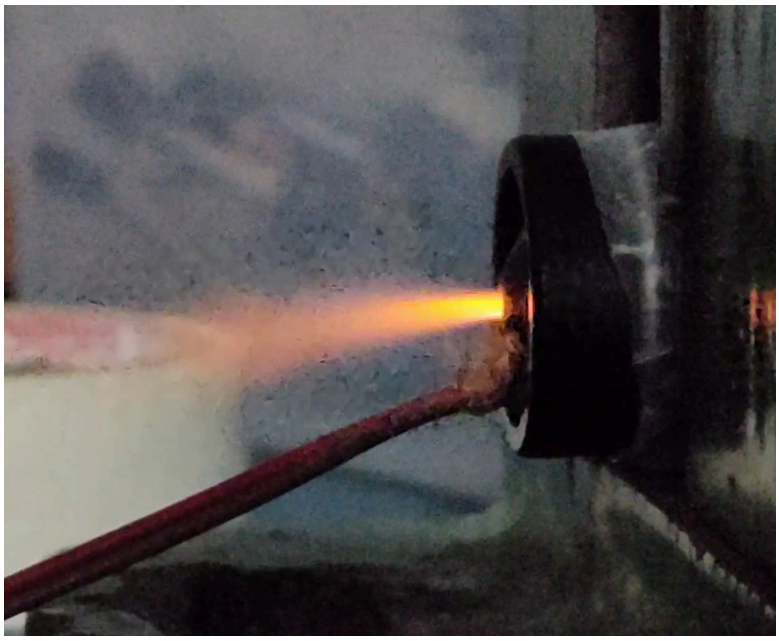
Given the lack of resources, I decided to go even simpler. Water gets electrolysed, the gasses are stored at 1 bar not separately but together. They are then detonated in pulses.
The sequence is : valve open, valve close, spark, combust, delay…. (loop)

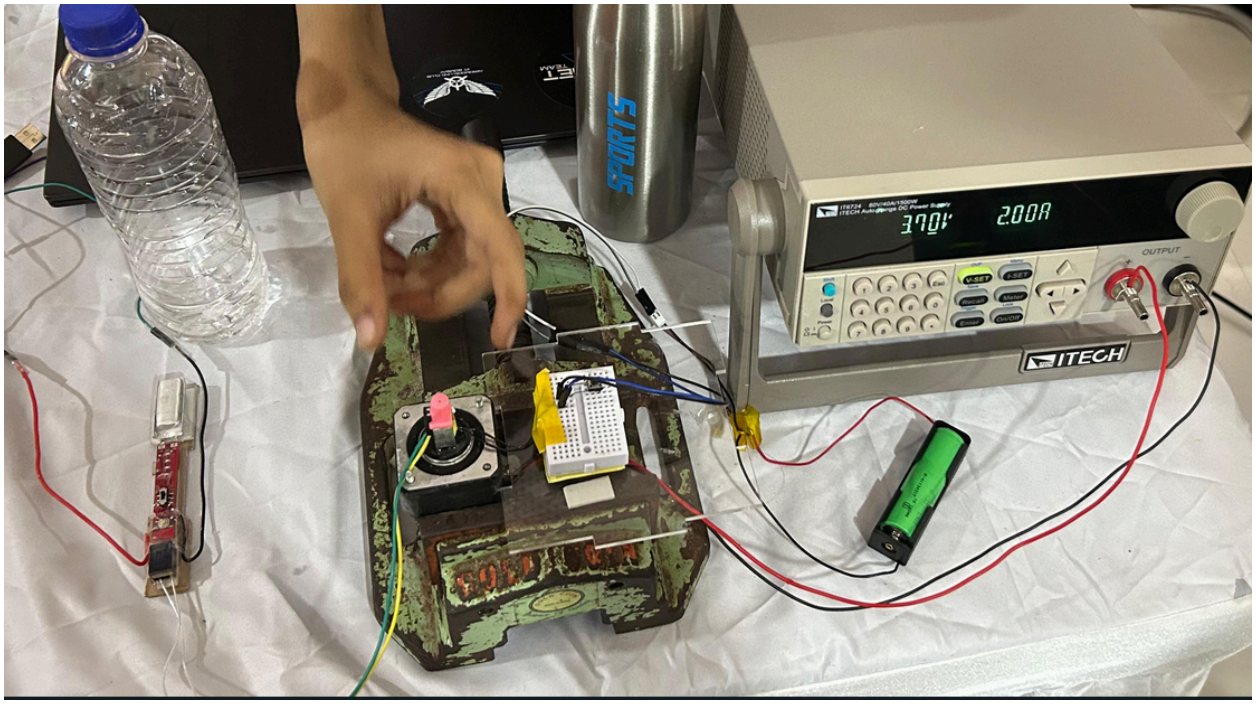
I tested out various combustion chambers and nozzles. These were made out of PLA, a plastic.yes, they were 3d printed. **I made the first 3d printed rocket engine in IIT Bombay!**
They operate in pulses with a frequency of 2Hz.
H2 and O2 in stoichiometric mixture are injected into the combustion chamber and the valve is closed. A spark triggers the combustion and the hot gasses are ejected at supersonic speed of 3000m/s through the nozzle.

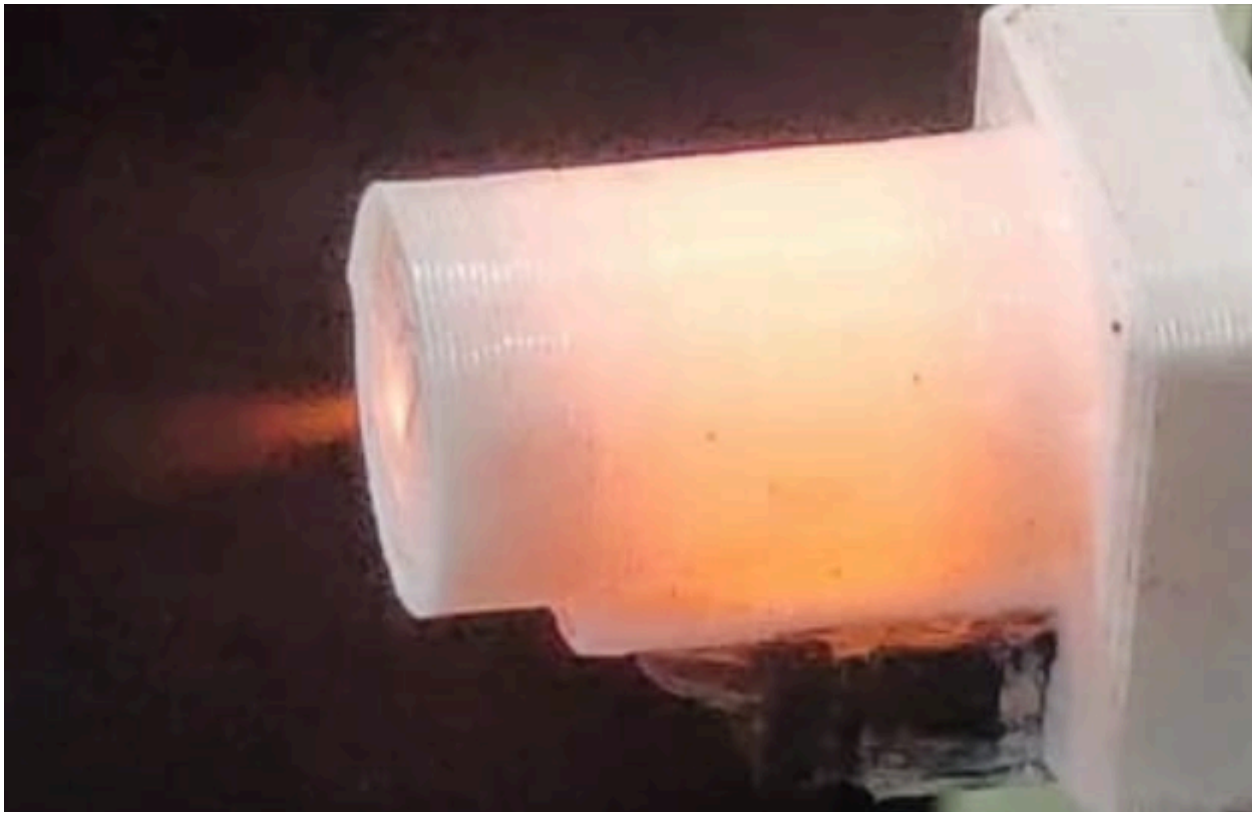












The final design consisted of the above setup. The nozzle in the second picture was selected given its small size.

2A current was supplied at 3.7V to the electrolyser. Water gets electrolysed. A solenoid valve (which needs to be supplied 4V, by the green cell) is opened, gasses are introduced in the pink thrust chamber and then closed. A spark is produced inside the thrust chamber and the gasses thus ignite and eject out of the nozzle (made into the pink 3d printed part).

Stoichiometric combustion of h2 and o2 result in an exhaust velocity of 3500m/s. For a 3U cubesat with this system, it would weigh not more than 4kg. With 20 mL water, it would provide a delta v of 17.5 m/s delta-v. With 100 mL water and initial mass 4kg (thus final mass 3.9 kg), it will give a delta-v of 88 m/s. A 3U cubesat in a 500 km orbit experiences drag and needs about 30 m/s delta v to compensate for the drag. Without any means, it will get deorbited in 2 months. But with this propulsion system (100 mL water) it can stay for almost 3 years!

Thus, I'm working on improving this system and eventually implementing it in actual cubesats, saving costs, and improving everyone’s lives!