Rocket Fuel Analysis

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0.1 Aim

The report evaluates performances of paraffin based rocket fuels of various composition, against oxidiser.

0.2 Conditions

Following are the conditions against which the evaluations have been made
Fuel type = Paraffin based fuels with additives
Chamber pressure = 15 to 40 bars
Area Ratio = 5 to 15
I_{sp} desired = 2400 m/s

0.3 Evaluation

Fuel type used: Paraffin(0.75) + Aluminum(0.15) + C_2H_4(0.1): The fractions are the mass fractions.

Oxidizer

1.LOX

Using LOX with the given fuel and keeping the chamber pressure to be 25 bar, at a oxidizer by fuel ratio of 2.6 and a pressure ratio of 5, we can see from the report attatched with the folder that the I_{sp} has achieved the desired value.
Following are the observation taken after varying various quantities:

- Keeping the pressure conditions and the pressure ratio to be the same, as we change the oxidiser by fuel ratio the I_sp tends to decrease. Link of the report.
- Keeping the pressure conditions, and the oxidiser by fuel ratio to be the constant, we found that the I_{sp} for increasing area ratio increases considerably. Link of the report.

Benefits

- Given the high density of the Liquid Oxygen a large amount of it can be stored in very compact manner, thus making the storage and transportation easy.
- The liquid Oxygen supports complete combustion of the fuel, thus making it a very efficient oxidiser.

- Given its wide applications espicially in aerospace industries, LOX is readily available fuel. And given the fact the after combustion products formed when the oxidiser used is LOX, are less hazardous to environment as compared to some other oxidisers.

Shortcomings

- LOX is required to be kept at very low temperatures of the ranges of 90K, whcih are difficult to maintain, as it requires special cryogenic equipment, this leads to an increase in cost of the rocket operations.
- In smaller scale rocket, the LOX burns very quickly, thus it cannot be deployed efficiently for tasks requiring relatively longer flight interval.
- The combustion with LOX tends to have instabilities and oscillations making it difficult to control them .
- LOX can be very reactive with certain materials and thus it makes the choice of materials for the components of rocket engines and the machinery deployed to transport the LOX from the its storage tank, to the combustion chamber, very critical, adding complexity to the rocket design.

2.Nitrous Oxide

It is one of the commonly used oxidizers, stored as a liquid at room temperature, and having various benefecial properties.

Experimental obervations
From the CEA analysis the following observations have been made:

- Keeping the chamber pressure to be at 25 bars and area ratio to be 5, as we change the O/F ratio the I_{sp} does not tend to change a lot (though a slight decrease can be seen) as evident from the report attached, which can be accessed by this link.
- Keeping the chamber pressure to be same as before and O/F ratio to be 2.6, we can see that there is a noticable increase in I_{sp} popellant as we increase the area ratios. Link of the report.

Benefits

- As Nitrous Oxide can be stored as liquid at room temperature, it makes it storage efficient, easy and cost effective. Furhter more it is stable, and non-flammable.
- Nitrous oxide can be stored as liquid under its own vapour pressure, thus making the design of the oxidizer feed system in the rocket.

- Nitrous Oxide is also easily ignitable, and can sustain the ignition as the by products of its combustion support it.

Shortcomings

- Though the given oxidiser provides good perfromance it may fall behind in terms of specific impusle, when compared with some other oxidisers like LOX.
- N_2O is classified as a hazardous substance by the authorities of governments and specail regulations are required to be followed when it is being used for the rocketry purposes.

3. Hydrogen Peroxide

It is a powerful oxidizer though its use is not as popular as the two mentioned above. It is geneallly used at very high concentrations when it comes to its use for rocketry purposes. It works as an oxidiser and felicitate combustion when it decomposes.

Experimental Obeservations
The pressures taken for the calculations is 25 bar.

- When we kept the area ratio to be 5, then even for same O/F ratio the I_{sp} tends to be higher than the given value of $2400ms^{-1}$, and it tends to decrease as we increaset the O/F ratio. Link for he r
- For a given O/F ratio the I_{sp} tends to increase with increasing area ratio, and with in the given range of area ratios it the I_{sp} exceeds the value expected. The report can be accessed from the following link.

Benefits

- H_2O_2 being a self decomposing oxidizer. It decomposes easily when as it comes into contact with fuel making it good for propulsion.
- It can be stored into room tempertatures and at lower pressures, making the storage simple and cost effective.
- Hydrogen peroxide is less toxic than some of the other oxiidzers, thus the availability and regulations related to it, are not very hard and strict. This simplifies logistic requirements for the oxidizer.
- Compact rocket design can be achieved using hydrogen peroxide, given its density making it easir to store.

Shorcomings

- H_2O_2 espically in the high concentrations used in the rocket propulsion, is very prone to contamination, which can lead to accidents, and thus an extra level of complexity gets added when it is used.
- Hydrogen peroxide is prone to getting poisoned by some metals reducing its effectiveness as an oxidizer. Thus purity control add a level of complexity it the design.
- Hydrogen peroxide giving out nascent oxygen, can lead to corrosion of many metals thus the choice of meterials becomes very critical while designing the engines infrastructures.

0.4 Choice of fuel

Taking into consideration the cost, availability and safety measures I think H_2O_2 (Hydrogen Peroxide) will be a good oxidiser option for the fule I have chosen,