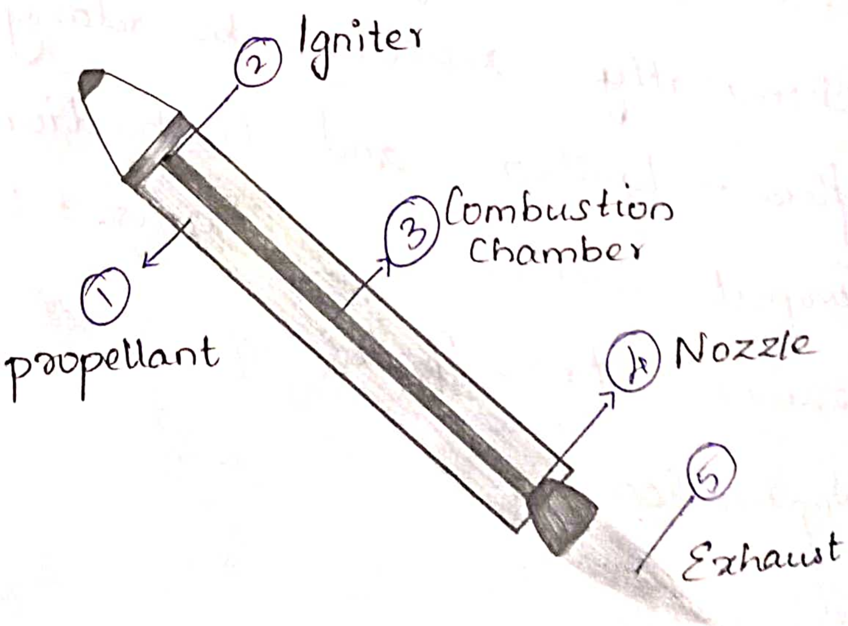
UNIT : 5

COMBUSTION CHARACTERISTIC OF PROPELLANTS

I. Solid propellent

* A solid propellant rocket is a rocket with a rocket engine that uses <u>solid propellants</u>

* solid rocket are used as light launch vehicle for low Earth orbit (LEO) payloads under 2 tons or escape payloads upto 500 kg.



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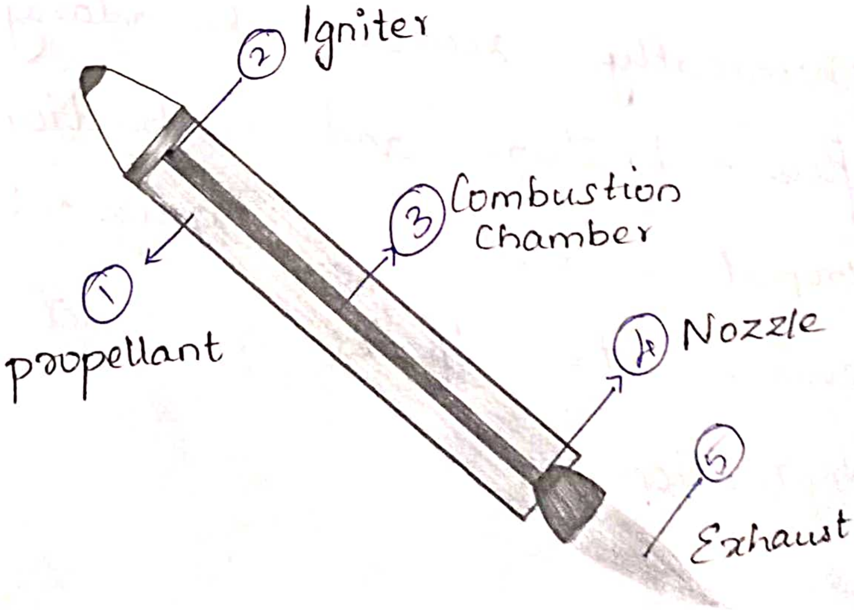

① → A solid fuel-oxidizer mixture (propellant) is packed into the rocket, with a Cylindrical hole in the middle.

② → An igniter combust the surface of the propellant.

③ → The cylindrical hole in the propellant acts as a Combustion chamber.

④ → The hot exhaust is choked at the throat, which among other things, dictates the amount of thrust produced.

⑤ → Exhaust exits the rocket.

Basic Concept :-

A simple solid rocket motor consits

1. Casing
2. nozzle
3. grain (propellant charge)
4. Igniter.

The solid grain mass burns in a predictable fashion to produce exhaust gas, the flow of which is described by Taylor - Culick flow.

* The nozzle dimension are ~~called~~ calculated to maintain a design chamber pressure, while producing thrust from the exhaust gases.

* Once ignited, the solid rockets motor cannot be shut off.

Design :

* The grain burns at a predictable rate, gn its surface area and chamber pressure.
* The chamber pressure is determined by the nozzle throat diameter and the grain burn rate.

* Allowable chamber pressure is a function of casing design.

* The length of burn time is determined by the grain "web-thickness".

Common modes of failure in Solid rocket motors include :

* fracture of grain
* failure of case bonding
* air pockets in the grain
* Case sealing failure

Grain Geometry :

Several geometry configurators are often used depending on the application and desired thrust curve :

a. Circular bore Stimulation :

* If in BATES Configuration produces progressive - regressive thrust curve.

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a. Circular bore Stimulation :

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b) End burner :

* propellant burns from one axial end to other producing steady long burn, though has thermal difficulties, centre of gravity shift

c) C - slot

* propellant with large wedge cut out of side, producing fairly long regressive thrust, though has thermal difficulties and asymmetric CG characteristics.

d) Moon burner :

* off - centre circular bore produces progressive - regressive long burn, though has slight assymmetric CG characteristic.

e) finocyl:

* usually a 5 - 6 legged star like shape that can produce very level thrust, with a bit quicker burn than Circular bore due to increased surface area.

Uses :

1. Sounding Rockets :

Almost all sounding rockets use solid motors.

- Astrobee
- Black Brant
- S-310, S-520
- Skylark
- VSB-30

2. Missiles :

Due to reliability, ease of storage and handling solid rockets are used on missiles and ICBMs.

3. Orbital Rockets :

Solid rockets are suitable for launching small payloads to orbital velocity.

The most widely used solid rockets propellant for space applications consits of ammonium perchlorate (70%), aluminium (16%) and binder (14%).

1. Thermal decomposition combustion of Nitramines.

The thermal decomposition of nitramine compounds, also known as nitramines typically involves the releases of various gases and the formation of new compounds that contain the nitro functional group (NO_2). and amine group (NH_2). Common nitraamine Compounds include RDX (cyclotrimethylene-trinitramine) and HMX (cyclotetramethylenetrinitramine). which are used as powerful explosives.

When nitramines are heated, they decompose through a Complex series of chemical reactions. The specific decomposition products and their reactions pathway can vary depending on factors like temperature pressure, and the presence of other substances. In general, the decomposition of nitramines involves the release of gases such as nitrogenoxide (NOx), water vapour, and carbon dioxide, along with the formation of new compounds

The Combustion of Nitramine Compounds such as RDX and HMX result in :

* Carbondioxide (CO_2)
* Water Vapour (H_2O)
* Nitrogen Oxides (NOX)
* CarbonMonoxide (CO)
* Hydrocarbons

III Burning characteristic of propellant

The burning characteristic of a propellant refer to how the propellant burns and the key factors that influence its combustion behaviour. propellants are commonly used in rocket engine and firearms, and their burning characteristic are crucial for understanding and optimizing their perfomance. Here are some key aspects of burning characteristic for propellants.

1. Burn Rate :

It is a speed rate of propellant at which it consume and release energy. It can be affected by factors such as propellan't's composition, grain geometry and pressure.

2. pressure Sensitivity :

Some propellants exhibit pressure sensitivity, which means that the burn rate changes as a function of pressure. This can influence the performance and stability of the propulsion system.

3. Tempreture Senstivity : The burn rate of a propellant can also be sensitive to tempreture. variation in temperature can affect the propellant's combustion rate, which needs to be considered in propellant design and operation.

4. Regress Rate : The rate at which the propellant surface regresses or erodes during combustion is known as the regress rate. It is an important parameter in rocket motor design.

5. Burn Rate Profile : The burn rate profile refers to how the propellant burns throughout the combustion chamber. It ca be tailored to achieve specific thrust and pressure characteristi

6. Smoke and Emissions : The emission produced during propellant combustion, such as smoke and particular matter can impact environment and safety considerations.

7. Stability : The stability of a propellant's combustion is crucial to ensure that it burns predictbabily and controllably. Stability is related to the propellant's formulation and design.

8. Specific Impulse : The specific impulse is measure of a propellant's efficiency and