Rocket Fuel

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The fuel that will power the core (or the middle unit of the lower part) of the **GSLV Mk-III,** the rocket to be used in the **Chandrayaan-2 mission** is UDMH (Unsymmetrical Di-Methyl Hydrazine).

- The **Indian Space Research Organisation(ISRO)** is using the highly toxic and corrosive fuel UDMH **(Unsymmetrical Di-Methyl Hydrazine),** along with the oxidiser nitrogen Tetroxide. This is called a **"dirty combination".**
- Elsewhere in the world, space programmes have moved to a cleaner and greener fuel — liquid methane or kerosene.
- Shifting to liquid methane would mean bringing in cryogenic engine because any gas would need to be kept in extremely low temperatures to stay liquefied.

- **GSLV Mk III** is a three-stage heavy-lift launch vehicle developed by ISRO. The vehicle has two solid strap-ons, a core liquid booster and a cryogenic upper stage.
- GSLV Mk III is designed to carry 4 ton class of satellites into **Geosynchronous Transfer Orbit (GTO)** or about 10 tons to **Low Earth Orbit (LEO)**, which is about twice the capability of GSLV Mk II.

Propellant Used in Rocket

- The propellant is the chemical mixture burned to produce thrust in rockets and consists of a **fuel and an oxidizer.**
    - **Fuel** is a substance that burns when combined with oxidiser for propulsion.
    - **The oxidizer** is an agent that releases oxygen for combination with a fuel. The ratio of oxidizer to fuel is called the mixture ratio.
- Propellants are classified according to their state - **liquid, solid, or hybrid.**
- **Liquid Propellants:** In a liquid propellant rocket, the fuel and oxidizer are stored in separate tanks and are fed through a system of pipes, valves, and turbopumps to a combustion chamber where they are combined and burned to produce thrust.
    - **Advantages:** Liquid propellant engines are more complex than their solid propellant counterparts, however, they offer several advantages. By controlling the flow of propellant to the combustion chamber, the engine can be throttled, stopped, or restarted.
    - **Disadvantages:** The main difficulties with liquid propellants are with oxidizers. Storable oxidizers, such as nitric acid and nitrogen tetroxide are extremely toxic and highly reactive, while cryogenic propellants being stored at low temperature and can also have reactivity/toxicity issues.
    - Liquid propellants used in rocketry can be classified into three types: **petroleum, cryogens, and hypergolic.**
        - **Petroleum fuels** are those refined from crude oil and are a mixture of complex hydrocarbons, i.e. organic compounds containing only carbon and hydrogen. The petroleum used as rocket fuel is a type of highly refined kerosene.
        - **Cryogenic propellants** are liquefied gases stored at very low temperatures, most frequently liquid hydrogen (LH2) as the fuel and liquid oxygen (LO2 or LOX) as the oxidizer. Hydrogen remains liquid at temperatures of -253 oC (-423 oF) and oxygen remains in a liquid state at temperatures of -183 oC (-297 oF).
        - **Hypergolic propellants** and oxidizers that ignite spontaneously on contact with each other and require no ignition source. The easy start and restart capability of hypergolic make them ideal for spacecraft manoeuvring systems.

            Since hypergolic remain liquid at normal temperatures, they do not pose the storage problems like cryogenic propellants. Hypergolic are highly toxic and must be handled with extreme care. Hypergolic fuels commonly include hydrazine, monomethyl-hydrazine (MMH) and unsymmetrical dimethyl-hydrazine (UDMH).
- **Solid propellant:** These are the simplest of all rocket designs. They consist of a casing, usually steel, filled with a mixture of solid compounds (fuel and oxidizer) that burn at a rapid rate, expelling hot gases from a nozzle to produce thrust. When ignited, a solid propellant burns from the centre out towards the sides of the casing.

- There are two families of solids propellants: **homogeneous and composite.** Both types are dense, stable at ordinary temperatures, and easily storable.
  - **Composites** are composed mostly of a mixture of granules of solid oxidizers, such as **ammonium nitrate, ammonium dinitramide, ammonium perchlorate, or potassium nitrate** in a polymer binding agent.
  - Single-, double-, or triple-bases (depending on the number of primary ingredients) are **homogeneous mixtures** of one to three primary ingredients.
- **Advantages:** Solid propellant rockets are much easier to store and handle than liquid propellant rockets. High propellant density makes for compact size as well.
- **Disadvantages:** Unlike liquid-propellant engines, solid propellant motors cannot be shut down. Once ignited, they will burn until all the propellant is exhausted.
- **Hybrid propellant:** These engines represent an intermediate group between solid and liquid propellant engines. One of the substances is solid, usually the fuel, while the other, usually the oxidizer, is liquid. The liquid is injected into the solid, whose fuel reservoir also serves as the combustion chamber.

  The **main advantage** of such engines is that they have high performance, similar to that of solid propellants, but the combustion can be moderated, stopped, or even restarted. It is difficult to make use of this concept for very large thrusts, and thus, hybrid propellant engines are rarely built.

Cryogenic Rocket

- A cryogenic rocket engine is a rocket engine that uses a cryogenic fuel or oxidizer, that is, its fuel or oxidizer (or both) are **gases liquefied and stored at very low temperature.**
- A Cryogenic rocket stage is more efficient and provides more thrust for every kilogram of propellant it burns compared to solid and earth-storable liquid propellant rocket stages. **Specific impulse** achievable with cryogenic propellants (liquid Hydrogen and liquid Oxygen) is much higher compared to earth storable liquid and solid propellants, giving it a substantial payload advantage.
- Oxygen liquefies at -183 deg C and Hydrogen at -253 deg C also entails complex ground support systems like propellant storage and filling systems, cryo engine and stage test facilities, transportation and handling of cryo fluids and related safety aspects.

Specific Impulse

- The gauge for rating the efficiency of rocket propellants is **specific impulse**, stated in seconds. Specific impulse indicates how many pounds (or kilograms) of thrust are obtained by the consumption of one pound (or kilogram) of propellant in one second.
- Specific impulse is characteristic of the type of propellant, however, its exact value will vary to some extent with the operating conditions and design of the rocket engine.

Source: THBL