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MAROVER I- A TWO WAY MISSION TO MARS

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Abstract: Searching for extraterrestrial life within or outside of our solar system has been one of the main objectives of the aerospace industry since its inception. One of the most promising planets within our reach with current technology is the planet Mars. There have been quite a few robotic missions to mars, but the world is looking for a manned mission which is not far from present. The main motto of this research is to provide a theoretical concept on the design and deployment of a two way manned mission to the planet Mars. The aim of our conceptual project is to provide an insight on the possibilities on the methods of making a manned two way trip to mars successful. However the first generation of Marover will be unmanned. The main concern in such a mission is the ability to return to earth after work has been done. This requires carrying of fuel from Earth which increases its weight. This problem is addressed in our design. Marover I is a single stage rocket i.e. it has no detachable stages unlike the other conventional rockets.

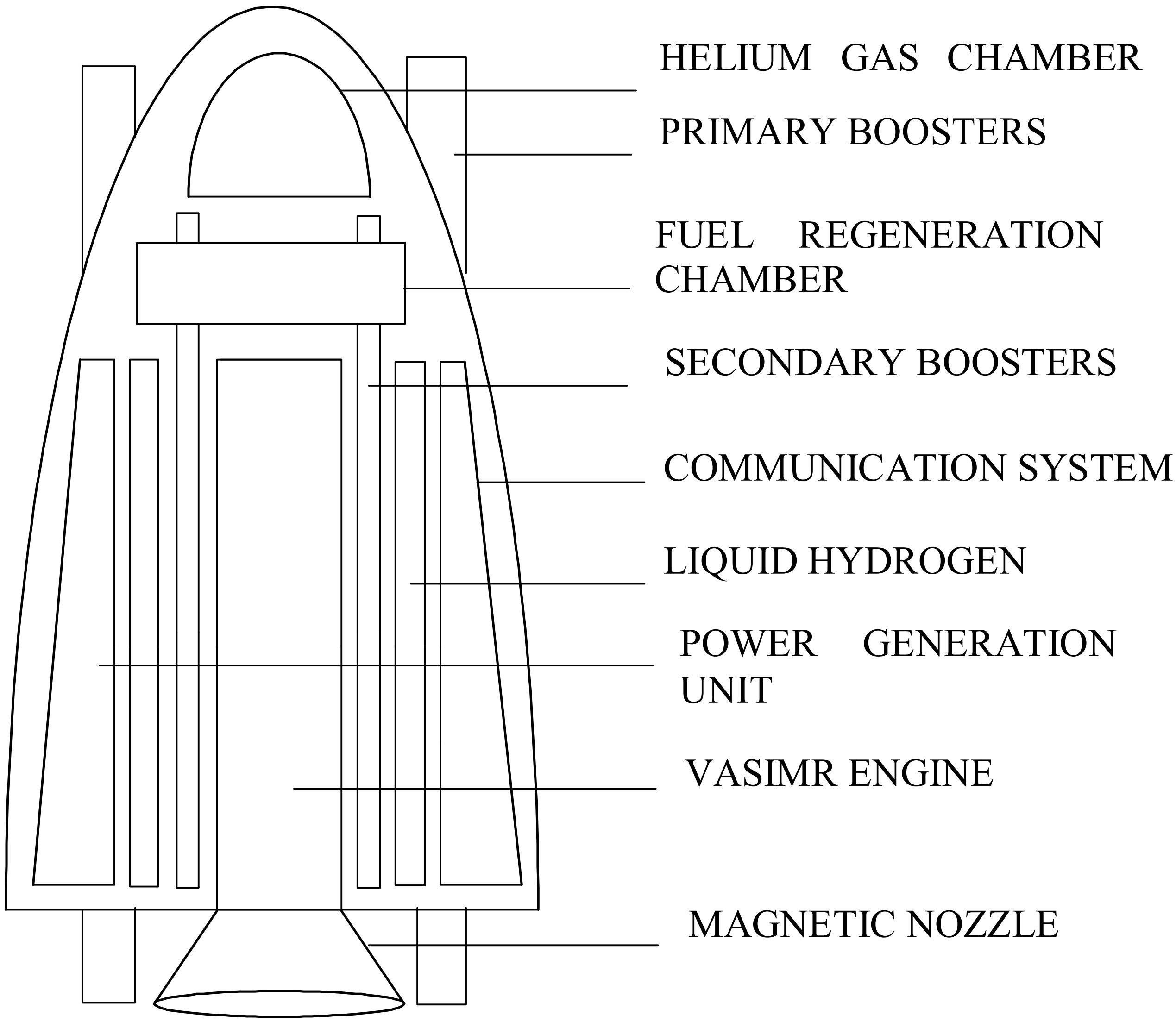
Introduction:

Mars atmosphere - The atmosphere of Mars is 100 times thinner than that of Earth. The composition of gases is very much different from that present on Earth. The Mars atmosphere consists of

Carbon dioxide	-96%
Argon	-2.1%
Nitrogen	-1.9%
Oxygen	-0.145%
Carbon monoxide	-0.0557%

Observing the composition of gases on Mars, our aim was to utilise Carbon dioxide and Argon to maximum extent and hence decreasing the weight to be carried from Earth. The atmospheric pressure on the Martian surface averages 600 Pascal, about 0.6% of Earth□s mean sea level pressure of 101.3 kilopascals. The escape velocity on the red planet is 5 km/s, which is approximately half compared to the blue planet. Hence the thrust required to escape mars would be much less than that of the earth.

The components of the vehicle are as follows: a Variable specific impulse magneto plasma rocket (VASIMR) engine, fuel regeneration chamber, Helium gas to be filled in balloons, liquid hydrogen cylinders, primary and secondary boosters, communication systems, power generation unit. The design of Marover I takes care of the flight aerodynamics that it needs to face both on earth and mars. Below is a block diagram of Marover I depicting the design and position of the respective components:



BLOCK DIAGRAM

Structure

Marover I will use two primary boosters to lift off from earth and two secondary boosters to lift off from Mars. The interplanetary distance will be covered with the help of VASIMR engine.

Primary Boosters: These boosters would help the spacecraft to lift from earth. Heterogeneous mixtures of oxidizer grains and powdered aluminium fuel, both embedded in a rubber-like binder, which is also a fuel will be used. The most common oxidizer by far is Ammonium Perchlorate. Ammonium Perchlorate is grinded to fine particles of the size 100µm.

The binder is often polybutadiene (synthetic rubber). Aluminium is also ground to similar sizes at the last minute because it is inflammable. Best performance is obtained when the percentage of Ammonium perchlorate is 70%, binder is 14% and Aluminium is 16%.The following reaction takes place,

$$10Al + 6NH_4ClO_4 \longrightarrow 4Al_2O_3 + 2AlCl_3 + 12H_2O + 3N_2 + \text{Energy}$$

Ammonium perchlorate composite propellant (APCP) is a modern solid rocket propellant (oxidiser). It can be cast into shape that allows manufacturing regularity and repeatability. Specific impulse (Isp) of this composition ranges from 180-260 seconds. APCP was also used in space shuttle, and during retro braking in curiosity rover at mars.

Engine

The engine used to cover the interplanetary distance will be VASIMR engine. VASIMR stands for "Variable specific impulse magneto plasma rocket". A VASIMR consists of three main sections, a plasma source, a plasma accelerator and a magnetic nozzle. Magnetic fields tie the three stages together.

The gas (usually hydrogen or any noble gas) is stored in a storage tank. The gas passes through the Helicon coupler that ionizes the gas converting it into plasma; ICH (Ion cyclotron heating) coupler heats the plasma to a very high temperature causing an increase in the kinetic energy of the plasma. The energised plasma comes out of the magnetic nozzle that further accelerates the plasma and adiabatic expansion produces the required thrust for the rocket. The magnetic field confines the plasma throughout the engine. The basic principle is that, when charged particles travel perpendicular to magnetic field, they experience circular motion, the radius of the circular path is given by Lorentz force,

$$r = \frac{mv}{qB}$$

Where 'm' is the mass of the ion, 'q' is the charge, 'v' is the velocity component, 'B' is the magnitude of the magnetic induction.

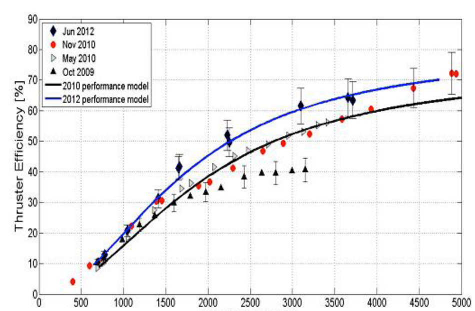


Fig: Graph of Thruster Efficiency and Specific impulse, Source: Ad astra company

The propellant (a neutral gas such as argon or xenon) is first injected into a hollow cylinder surfaced with electromagnets. Upon entry into the engine, the gas is first heated to "cold plasma" by a helicon RF antenna (also known as a "coupler") which bombards the gas with electromagnetic waves, stripping electrons off the argon or xenon atoms and leaving plasma consisting of ions and loose electrons to continue down the engine compartment. By varying the amount of energy dedicated to RF heating and the amount of propellant delivered for plasma generation. VASIMR is capable of either generating low-thrust, high–specific impulse exhaust or relatively high-thrust, low–specific impulse exhaust

The essential feature of the VASIMR concept is the specific impulse that can be easily varied over a wide range at constant power. Trajectory studies have shown that such a propulsion system offers substantial savings in system mass and flight time relative to fixed Isp thrusters

Fuel Regeneration chamber: The fuel regeneration chamber consists of the following units-

- Absorber: This chamber would absorb the gasses from the Martian atmosphere.
- Sprinkler: This chamber will filter the dust particles from the air.
- Filter: This chamber would separate Carbon dioxide from the rest of gasses available.
- Sabatier Reaction Chamber: Here the CO2 would react with the Hydrogen to produce Methane and bi products along with energy.
- Electrolysis chamber: Here the water will be electrolysed to produce Hydrogen and Oxygen.

Once the takeoff position is achieved the absorbers will start absorbing the air from the atmosphere. The air will be first sent to the sprinkler that would remove any presence of dust particles. The air will be further passed on to the filter that would separate carbon dioxide from the rest of gases. Carbon dioxide will be sent to Sabatier reaction chamber where the following reactions will take place. The rest of mixture (majority being Argon) will be pumped to the fuel tank of the VASIMR engine. Argon can act as a good plasma source for the thrusters while covering the interplanetary distance.

The Sabatier reaction involves optimum temperature of about 200-300 degree Celsius that can be achieved easily.

Firstly the carbon dioxide reacts with hydrogen gas to produce methane, along with water and energy. This is an exothermic reaction. It requires initial energy to start the reaction whereas the temperature for the further reaction will be maintained by the reaction itself.

$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O + \text{energy}$

The above synthesised methane gas will be pumped to secondary boosters that will help to takeoff from Mars. The water will be sent to electrolysis chamber where water is hydrolysed to give hydrogen and oxygen.

$2H_2O \rightarrow 4H_2 + O_2$

The hydrogen will be sent back to Sabatier reaction chamber and the oxygen is sent to the secondary boosters where it will act as oxidiser in the form of LOX.

EDLT(Entry, Descent, Landing and Takeoff):

EDL is designed for a spacecraft that enters a foreign atmosphere. The EDL of this spacecraft is a little different from the previous robotic missions.

Both orbital capture (entering the orbit) and orbit trim (achieving desired orbit) will be done by the thrusters in co-ordination with the computer system. The spacecraft would contain an aero shell and thermal protection that would prevent the damage of any components while entering into the mars atmosphere. The spacecraft would try to glide through the air while the radar system begins to calculate speed, altitude which decides when to start the power descent. The computer program searches for the ideal (perfect) landing site. The drogue parachute kicks in to slow down the spacecraft. The landing of this craft would be similar to the aeroplane landing on a runway except that we do not have a runway on mars. The spacecraft with its high thrust retro braking would just slowly kiss the mars surface similar to a helicopter landing. The retro braking will be done by the engines present on the lower surface of the aircraft. As the retro braking will cause a lot of dust airborne, the spacecraft would remain idle for certain time. The spacecraft lands in the horizontal position, it is then brought to the vertical position by Helium gas balloons. Once in Vertical position it would start its operation of fuel synthesis.

Takeoff: The spacecraft will contain a helium tank with a helium balloon. The helium balloon will be filled with a high pressure helium gas, this would slowly start lifting the aircraft and when the aircraft is off the ground the temperature in Helium balloon decreases and the spacecraft is landed in a vertical position. This is achieved by the spider hydraulic legs like structures on the spacecraft. This task will be performed when there are no dust storms. Once this position is achieved the balloons are discarded and the absorbers will open up and the fuel regeneration chamber will start performing its task.

Conclusions

After the analysis of the design and the data, Marover I promises to be the most efficient and economic vehicle of all time. The reusability of this spacecraft provides the greatest advantage for it to form the vehicle of the future.

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