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Research Article

Missile Propulsion System

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ABSTRACT

According to Newton's first law of motion, any object which is in steady state , it is necessary to exert an external force to bring it into motion. This force is generated by propulsion inside a missile. Inside this, we will learn how this temptation occurs inside a missile. We will look at all the things that are necessary to perform propulsion and what factors it depends on.

INTRODUCTION

Propulsion is the means giving the body power to reach the required target. There is a large variety of missiles and therefore many different propulsion systems are used. The propulsion of a missile is achieved with the help of a rocket engine. It produces the thrust with help of very hot gaseous matter, called propellant. The hot gases are produced in the combustion chamber of the rocket engine by chemical reactions. The propellant is exhausted through a nozzle at a high speed which help's missile to move in the opposite direction. It's works on the newton third law of motion. Different types of missiles are used for different purposes. The major types of missile is air-to-air, air-to-surface, surface-to-air, anti-ship, and anti-tank which are intended for faraway military or strategic targets. Ballistic missiles are most often categorized as short-range, medium-range, intermediate-range, and intercontinental ballistic missiles. Missiles have four system components: guidance system, flight system, engine and warhead.

HISTORY OF MISSILE

Around 1000AD China and India used rockets for fireworks and war purposes. During the 18th century, unguided rocket propelled missiles were used by Hyder Ali and his son Tipu Sultan against the British. 1There is a reference that two rockets belonging to Tipu's forces were captured during the fourth Mysore war in the siege of Seringapatnam in 1799 by companies of the Bengal and Bombay Artillery of the East India Company. Germany used V1 and V2 missiles during world war 2.

TYPES OF MISSILE

There are many types of Missile.They can be classified on the basis of their features like target, range mode of launching, guidance, aerodynamic and propulsion.

On the basis of target

- Anti-tank/anti-armour
- Anti-personnel
- Anti-missile.
- Anti-ship/anti-submarine
- Anti-satellite

Another classification of missiles is based on the method of launching

- Surface-to-surface-missiles (SSM),
- Surface-to-air missiles (SAM),
- Air-to-air missiles (AAM), and
- Air-to-surface missiles (ASM).

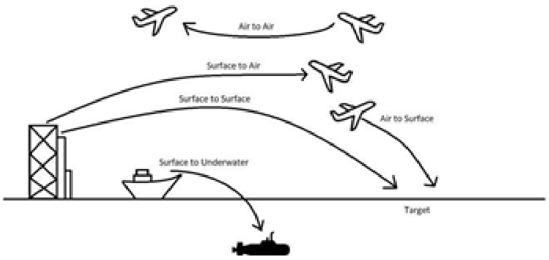

Figure 1: Missile Classification by Method of launching

SSM(Surface to Surface) missile also be launched from a ship to another ship.

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SAM(Surface to Air) are essential complement of modern air defence systems along with anti-aircraft guns which are used against hostile aircraft.

AAM(Air to Air) are for battle among fighter/ bomber aircraft. Mostly it is under the wing of aircraft.

On the basis of range, missiles can be classified as

- Short-range missiles;
- Medium-range ballistic missiles (MRBM);
- Intermediate-range ballistic missiles(IRBM)
- Intercontinental or long-range ballistic missiles(ICBM)

Short-range ballistic missiles, traveling less than 1,000 kilometers ,Medium-range ballistic missiles(MRBM) traveling between 1,000–3,000 kilometers,Intermediate-range ballistic missiles(IRBM) traveling between 3,000–5,500 kilometers and. Intercontinental ballistic missiles (ICBM) traveling more than 5,500 kilometers.

PROPULSION SYSTEM

The function of the propulsion system is to produce thrust.Thrust is the force which moves a rocket through the forward direction. They Work's on the law of conservation of momentum.The thrust of a missile is achieved with the help of rocket engine. thrust produces with the help of very hot gaseous matter, called propellant.

There are many types of propulsion system that are classified as-

Solid propulsion, Liquid propulsion Hybrid propulsion. Gas turbine engine

Ramjets or ram-rockets

Currently, other types of propulsion like ionic, nuclear, plasma, etc. are under research and development but no known missile uses these.

All types of propulsion system contain a chamber, a nozzle, and an igniter. The chemical reaction of propellant (usually a fuel and an oxidiser) takes place in the chamber and produces gases. During this chemical reaction the pressure of gases is very high and the product gases to a very high temperature(2000-3500.C).These gases subsequently are expanded in the nozzle and accelerated to high velocities.the nozzle shape and size are critical for the efficient function of the propulsion system.The nozzle is essentially a conduit of varying cross-section from a maximum area to a section of minimum cross-section (called the throat of the nozzle) and again enlarging to larger cross-section3.The nozzle would be subsonic, sonic or supersonic depending upon whether the exhaust velocity is below, equal to or greater than the speed of sound in air.Thus the common shapes of nozzles are convergent type, divergent type, or converging-diverging type. There are also conical and bell-shaped nozzles.

PARAMETERS OF PROPULSION PERFORMANCE

For all types of rocket engines used as standards for gauging.the performance levels of different rocket motors are:thrust, specific impulse, exhaust velocity, specific propellant consumption, mass ratio, factor of safety etc. Burning rate is very important factor in any successful rocket design.The burning surface of a propellant recedes as combustion proceeds.The 4rate of regression is called burning rate (r) and is expressed in cmls. It (r) is a function of propellant.

Missile propulsion will be mainly two types:

- Air breathing
- Non-Air breathing

Air breathing rocket engine's can be used within the earth's atmosphere. Air is very important for the use of it's oxidiser.in non-air breathing engines the rocket engine carries itself fuel and oxidiser on board.it can also be used in space above the earth's atmosphere and it does not depend on the medium of air. the rocket propulsion system is designated as a solid rocket motor, a liquid propulsion system or a hybrid propulsion system.

Solid Rocket Motor

In a solid propellant rocket propellant to be burnt in the combustion chamber or case.The propellant charge or the grain contains the chemical elements for complete burning. Once ignited, it burns at a designed rate till the propellent is completely consumed. Solid rockets motor system are simple as compared to the other systems.

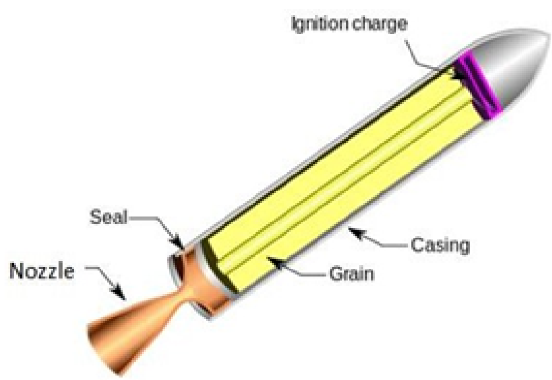

Figure2: Solid Rocket Motor

Casing-In all solid rocket motors, the casing is a pressure vessel designed and fabricated to withstand upto certain internal pressures. Such a casing has low weight and high strength. To protect from hot gases the casing are provided thermal insulation on their inner surface. The casing has provisions for end covers, nozzle and handling etc.

Grain-In Solid propellant, fuel and oxidizer are mixed together in the appropriate proportion. Finished propellant called grain. On the basis of composition propellants are-

- They are so called because in these oxidiser and fuel are at molecular level. Famous example being 'double base' type which is a mixture of nitrocellulose and nitroglycerine in a certain proportion.They have a fairly long shelf life of more than twelve years.
- In this, the oxidiser and fuel are mixed mechanically in a mixer. They are also called composite propellants. Oxidisers are inorganic crystalline salts like perchlorates or nitrates of sodium, potassium or ammonia, while the fuel, which also acts as binder, is organic resin.

Igniter- Igniter is the device that helps to start the burning of the main propellant grain of the rocket motor.Its function is for short interval.The igniter for small motors will be a few grams of grains while it will be a few hundred kilograms for large boosters. 6The initiation is done using electrical power by heating a resistance wire and initiating a primary composition.

Nozzle-nozzle is the component through which the hot gaseous mass in the motor case is expelled out.

This has to be designed to withstand high temperatures and flow of gases at high velocities. The dimensions of the nozzle are critical for the performance and efficiency of the rocket motor.

Nozzles are also used for producing control force for the missile.

Liquid Propulsion System

In liquid propulsion, oxidiser and fuel (both liquid propellant are stored in separate tanks of the missile.Liquid propellants used in rocketry can be classified into three types: petroleum, cryogenic, and hypergolic.

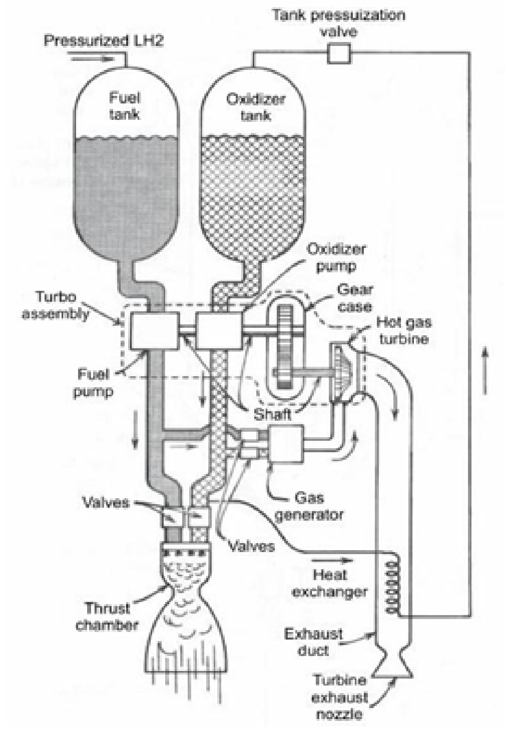

Figure3: Diagram of a liquid propellant rocket engine with

The engine here is relatively small size and is designed to withstand hot gases. The engine has an injector through which propellants are injected at high speed. thrust chamber where the propellants react and produce hot gases.The propellants are expelled from the tanks under moderate pressures to a turbine-driven system from where they are fed to the injector.

Liquid propellants, especially with cryogenic propellants, give better specific impulse and better 3stage mass ratio for the same thrust force and duration of burn as compared to solid propellants.

Hybrid Propulsion system

In this system one of the propellants is solid while the other is liquid. Usually the oxidiser is in liquid state.

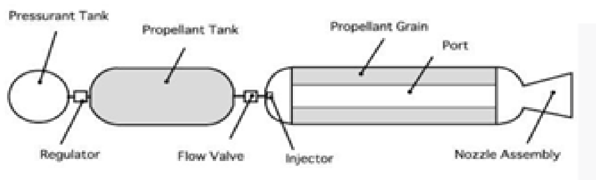

Figure4: hybrid rocket

Hypersonic Air-breathing Propulsion System

Hypersonic airbreathing propulsion systems offer the potential to enable new classes of flight vehicles that allow rapid response at long range, more maneuverable flight, better survivability, and routine and assured access to space.rocket boosters have been used to propel hypersonic vehicles for applications such as space launch, long-range ballistic flight, and air-defense interceptor missiles.airbreathing system will provide a means for sustained and accelerating flight within the atmosphere at hypersonic speeds. Potential mission areas include long-range cruise missiles for attack of time-sensitive targets, flexible high-altitude atmospheric interceptors, responsive hypersonic aircraft for global payload delivery, and reusable launch vehicles for efficient space access.In particular, the technology to support a baseline hypersonic propulsion system exists that will allow operation at speeds up to Mach 6 with conventional liquid hydrocarbon fuels.

The hypersonic propulsion system can be classified as liquid- and solid-fueled rockets, turbojets, ramjets, ducted rockets, scramjets, and dual-combustion ramjets. All current hypersonic systems use liquid or solid rockets as their propulsion systems.

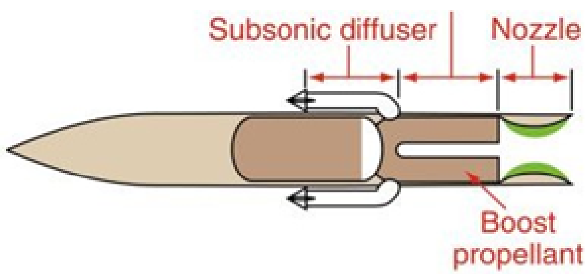

Figure5: Solid Fueled Ducted rocket

In Solid Fueled ducted rocket where the fuel rich effluent of a rocket motor is mixed in a downstream combustor with air captured from the atmosphere to improve the efficiency of the engine cycle.

7Further improvement in efficiency is achieved by using pure airbreathing engines, which capture all of their needed oxygen from within the atmosphere instead of carrying oxidizers. This results in more efficient engine operation and the ability to use conventional hydrocarbon fuels..Pure airbreathing engines can be subdivided into turbojets, ramjets, scramjets, DCRs, and turbo-ramjets.

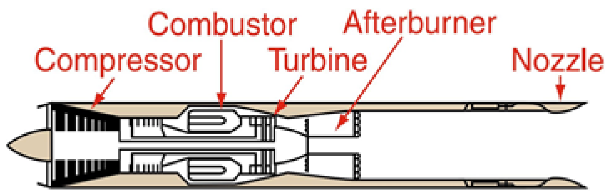

Figure6: Turbojet

Conventional turbojets use mechanical compression in the inlet, driven by a turbine located downstream of the combustion process, to provide a portion of the airstream compression.the maximum speed of a turbojet is usually limited to about 3.5 .

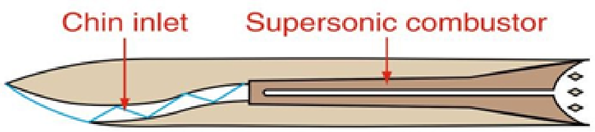

Figure7: Integral rocket liquid-fueled supersonic combustion ramjet

In the scramjet engine , the captured airstream is still compressed by the inlet, but the combustion is allowed to occur at supersonic speeds.Ramjets and scramjets can operate efficiently at supersonic and hypersonic speeds, but there tend to be limitations to the range of Mach numbers over which they can operate.The inefficiencies of slowing the flow down to subsonic speeds makes the ramjet difficult to use for speeds exceeding Mach 5.Scramjets can be used above approximately Mach 5.h the ramjet and scramjet must be coupled with some additional form of propulsion (for missiles) to accelerate the vehicle to its "take-over" Mach number.

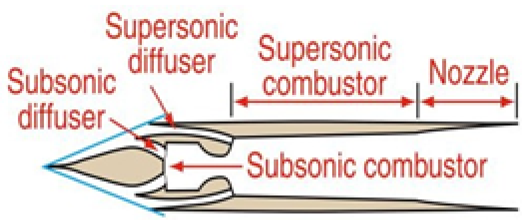

Figure8: Liquid-fueled dual-combustor ramjet

The DCR and turbo-ramjet, offer design features that enhance engine performance and operability over a wide range of flight conditions.In the DCR, a subsonic combustion ramjet is used as the pilot to a scramjet engine, enabling efficient operation over a wider range of supersonic and hypersonic Mach numbers using logistically suitable fuels.8 In the turbo-ramjet, an integral turbine-based core engine provides acceleration up to supersonic speeds, at which point the engine transitions to ramjet operation. This engine enables a vehicle to accelerate from a standing start to high supersonic Mach numbers.

Testing of Propulsion System

The rocket engine is tested before use. Some of the tests are as follows-

- Manufacturing, inspection and fabrication tests (pressure tests, bursts tests, leak tests, electro-mechanical checks).
- Component tests (functional and operational tests on igniter, valves, injectors, structures, etc.)
- Static rocket systems tests (with complete rocket engine on test stand) : (a) simulated rocket operation (for proper function, calibration, ignition, operation-usually without establishing full combustion or nuclear reactivity); (b) complete engine tests (under rated conditions, off design conditions with intentional variations in environment or calibration).
- Static vehicle tests (when rocket engine is installed in a restrained non-flying vehicle).
- Flight tests: (a) on a specially instrumented flight test range with special flight test vehicle
- (b) With production vehicle.

CONCLUSION

Missiles are harmful to human life, but in today's world it is important to have such weapons to protect against terrorism. We learned about the propulsion system of the missile inside it, how the propulsion works inside a missile and at the same time we also learned what kind of propulsion we use according to different needs.

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