Review of Advance Rocket Engine

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Abstract: ***The rocket engine is the main and very important part of the space transportation system. In this paper an attempt has been made about the history of Rocket Engine, types of Rocket Engines and future scope in the technology of theRocket Engines. Also, an attempt about physics behind the jets, and advantages and disadvantages of every rocket engine is made in this review paper.***

1. Introduction

Rocket Engines are basically used to store the rocket mass of rocket propellant for forming its high speed propulsive jet. Those vehicles which are propelled by rocket engines are commonly known as rockets. Rockets function on the principle of Newton's 3rd law of motion. We always see that most of the rocket engines use combustion, but non-combusting (such as cold gas thrusters) forms also exist.

In comparison, of rocket engine to other types of jet engines, rocket engines are by far the lightest, have the highest thrust and have least propellant efficiency. Rocket engines become more efficient with higher velocities, due to greater propulsive efficiency and the Oberth effect. Since they do not require any atmosphere, they are well suited for uses at very high altitudes and in space.

2. History of Rocket Engine

According to ancient Roman writings, AulusGellius, Inc. 400 BC, a Greek Pythagorean named Archytas, propelled a wooden bird along wires using steam.[41][42] However, it would not appear because it did not have so much amount of thrust.

In the 13th century, a turning point in rocket technology emerged with a short typescript entitled LiberIgniumadComburendos Hosts (abbreviated as The Book of Fires). The typescript is composed of recipes for creating incendiary weapons from the mid-eighth to the end of the thirteenth century—two of which are rockets. The first recipe calls for one part, which is sulfur, added to six parts of saltpeter (potassium nitrate) dissolved in laurel oil, then inserted into hollow wood and lit to actually fly away whenever you want, to whatever destination you wish and burn up everything. The second recipe combines a pound of sulfur, two pounds of charcoal, and six pounds of saltpeter—all finely powdered on a marble slab. Then this powder mixture is packed firmly into a long and narrow case. The saltpeter's introduction into pyrotechnic mixtures connected the shift from hurled Greek fire into self-propelled rocketry.

Rocket type engines were also used by Tippu Sultan, the king of Mysore. These rockets could be of various sizes, but commonly consisted or used of a tube of soft hammered iron about 8 in (20 cm) long and 1 1⁄2–3 in (3.8–7.6 cm) diameter, closed at one end and strapped to a shaft of bamboo about 4 ft (120 cm) longer. The iron tube which was used acted as a combustion chamber and it contained well packed black powder propellant. A rocket carries about one pound of powder which could travel almost 1,000 yards (910 m). These 'rockets', fitted with swords used some different type of sharp objects and had a long peak which could travel long distances, several meters above in air before coming down with sword edges facing the enemy. These rockets were used against the British empire very effectively.
Here is the history of Rocket engines, described in Table.[1] which were as follows :-

name of Scientist	Description	Use of its application	Limitation
Archytas (400 BC)	using steam	____	It did not produce much amount of thrust, to fly somebody.
Aeolipile	Hero's Engine(Steam Rocket)	Steam rocket on bearing	The principle behind it was not well understood, and its full potential was not realized for a millennium.
Chinese Taoist alchemists	Black Powder	Fire arrows	It was only used for small objects.
Liber IgniumadComburendos Hosts	It has recipe that combines one pound of sulfur, two pounds of charcoal, and six pounds of saltpeter—all finely powdered on a marble slab.	Use for creating incendiary weapons.	_____
Conrad Haas(German military engineer in (159-1576))	Construction to multistage rockets.	Use as missiles	______
Konstantin Tsiolkovsky (19th century)	Liquid-fueled rocket engines.	Tsiolkovsky rocket equation.	Is was not published for a long time
Robert Goddar (American Physicist –(in 20th century))	Modern Liquid-fueled rocket engines.	First to use a De Laval nozzle and this was the birth of modern	______

		Rocket engine	
Wernher von Braun and Hellmuth Walter (German scientists in (1930))	Liquid fueled rocket engine	Installing liquid fueled rockets in military aircraft	Higher temperature is a big problem for the nozzle.
Alexey Isaev (in 1949)	Staged combustion	Used in Soviet planetary rockets	
Nikolai Kuznetsov	Close cycle engine	Used in formation of NK-9 ,NK-15,NK-33 engine	Unsuccessful Lunar N1 rocket
Ludwig Boelkow (in 1963)	Combustion test engine	_____	_____
Gamma (British scientist)	Hydrogen Peroxide / Kerosene fueled engine	This gave the efficiency advantage of staged combustion	_____
American scientist (1962)	Liquid Hydrogen Engine (RL-10)	Hydrogen engine were use in Apollo program.	_____
Scientist of NASA (2016)	Black Brant XII	Most popular sounding Rockets	_____

Here in Table[1]. There are names of scientists with their rocket experiments and their limitations.

Different type of Rocket engines

On the different type of power source the rocket engines are different which was given as follows:-

2.1 Physical powered

Type	Description	Advantage	Disadvantage
Water rocket	Partially filled pressurized carbonated drinks container with tail and nose weighting	Very simple to build.	Altitude typically limited to a few hundred feet or so (world record is 623 meters or 2,044 feet)
Cold gas thruster	A noncombusting form, use for Vernierthrusters	Non-contaminating exhaust	Extremely low performance

2.2 Chemically Powered

Type	Description	Advantage	Disadvantage
Solid rocket	Ignitable, self-sustaining solid fuel/oxidizer mixture ("grain") with the central hole and nozzle	Simple, often no moving parts, reasonably good mass fraction, reasonable I_{sp}. A thrust schedule can be designed into the grain	Throttling, burn termination, and reignitionrequires special designs. Handling issues from ignitable mixtures. Lower performance than liquid rockets.
Hybrid rocket	Separate oxidizer/fuel; typically the oxidizer is liquid and kept in a tank and the fuel is solid.	Quite simple, solid fuel inert without oxidiser & is safer; cracks do not escalate, throttleable and easy to switch off.	Some of the oxidizers, which are monopropellant type& canalso be exploded in own right; mechanical failure of the solid propellant can also block the nozzle (very rare with rubberized propellant), central hole widens over the burn and negatively affects mixture ratio.
Monopropellant rocket	Propellant (such as hydrazine, hydrogen peroxide or nitrous oxide) flows over a catalyst and exothermically decomposes; hot gases are emitted through the nozzle.	Simple in the concept, is throttleable& low temperatures in combustion chamber.	Catalysts can be contaminated easily, monopropellants can detonate if they are contaminated or provoked, I_{sp} is perhaps 1/3 of best liquids
Bipropellant rocket	Two fluid propellants, which are mostly liquid, introduced through injectors into combustion chamber and burnt further	Up to ~99% efficient combustion with excellent mixture control, throttleable, can be used with turbopumps which permit incredibly lightweight tanks, can be safe with extreme care	Pumps needed for high performance are expensive to design, huge thermal fluxes across combustion chamber wall can impact reuse, failure modes have major explosions, a lot of plumbing is needed.
Turborocket	A combined cycle turbojet/rocket where an additional oxidizer such as oxygen is added to the airstream to increase maximum altitude	Very close to existing designs operate in a very high altitude, wide range of altitude and airspeed	Atmospheric airspeed limited to same range as turbojet engine, carrying oxidiszer like LOX can be dangerous. Much heavier than simple rockets.

2.3 Electric power

Atmospheric airspeed which is limited to same range, as the turbojet engine is, carrying oxidizers like LOX can be dangerous. Much heavier than the simple rockets.

Type	Description	Advantage	Disadvantage
Resistojet (Electric heating)	Energy is imparted to a usually inert fluid serving as reaction mass via Joule heating of a heating element. May also be	Efficient where electrical power is at a lower premium than mass. Higher I_{sp}than monopropellant alone, about 40% higher.	Requires a whole lot of power &energy therefore, typically yields low thrust.

	used to impart extra energy to a monopropellant		
Arcjet rocket (chemical burning aided by electric discharge)	Identical to resistojet except the heating element is replaced with an electrical arc, eliminating the physical requirements of the heating element.	1,600 seconds	Very low thrust and high power, performance is similar to ion drive.
Pulsed plasma thruster	Plasma is used to erode a solid propellant	High I_{sp}, can be pulsed on and off for attitude control	Low energetic efficiency
Variable specific impulse, magnetoplasma type rocket	Microwave heated plasma with magnetic throat/nozzle	Variable I_{sp} from 1,000 seconds to 10,000 seconds	Similar thrust/weight ratio with ion drives (worse), thermal issues, as with ion drives very high power requirements for significant thrust, really need advanced nuclear reactors, never flown, requires low temperatures for superconductors to work

3. Jet Physics

Rocket jets were dependent on the rocket engine's design altitude, thrust and other factors. Exhausts having rich Carbon is from kerosene fuels & are often orange in colour due to the black body radiation of the unburnt particles. Peroxide oxidizer-based rockets and hydrogen rocket jets have high amount of steam and are nearly invisible to the naked eye but shine brightly in the ultraviolet and infrared. Jets from solid rockets can be highly visible as the propellant frequently contains metals such as elemental aluminum which burns with an orange-white flame and adds energy to the combustion process.

The shape of the jet varies by the design altitude: at high altitude, all rockets are grossly under-expanded, and a quite small percentage of exhaust gases actually is getting end up expanding forwards.

4. Conclusion and Future Scope

Today, human culture or scientists have discovered the new type of rocket engine which consumes less amount of money and having high-efficiency comparing to the startup by the formation of the Rocket engine. Hence in the future, there is a lot of amount of Innovation which will happen in the field of the rocket engine. Today's scientist was getting work on the new type of rocket engine which gets work on the phenomena plasma.

Today NASA and some other organization get work to send the rocket to Mars which required a heavy amount of fuel to getting cover the distance up to mars. Which increase the mass of rocket so, scientists are getting to work on different type of rocket engines such as plasma type.

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