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PERFORMANCE OF SMALL SIZE AEROSPIKE. ENGINE

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Abstract- **In this paper we are showing how aerospike nozzle can play an important role in rocket INDUSTRY as compare to other nozzles. We are using New rocket designs and increasing the performance of the current rockets But, the aerospike nozzle concept that has been under development since the 1950s is yet to be utilized on a launching. Due to its ability to adjust the environment by altering the outer jet boundary, the aerospike nozzle has better performance compared to present day others nozzle. An aerospike nozzle is designed for 20 bar pressure ratio to improve the performance of the aerospike nozzle for various conditions, some important design parameters and their performances were studied for low temperature flow conditions.**

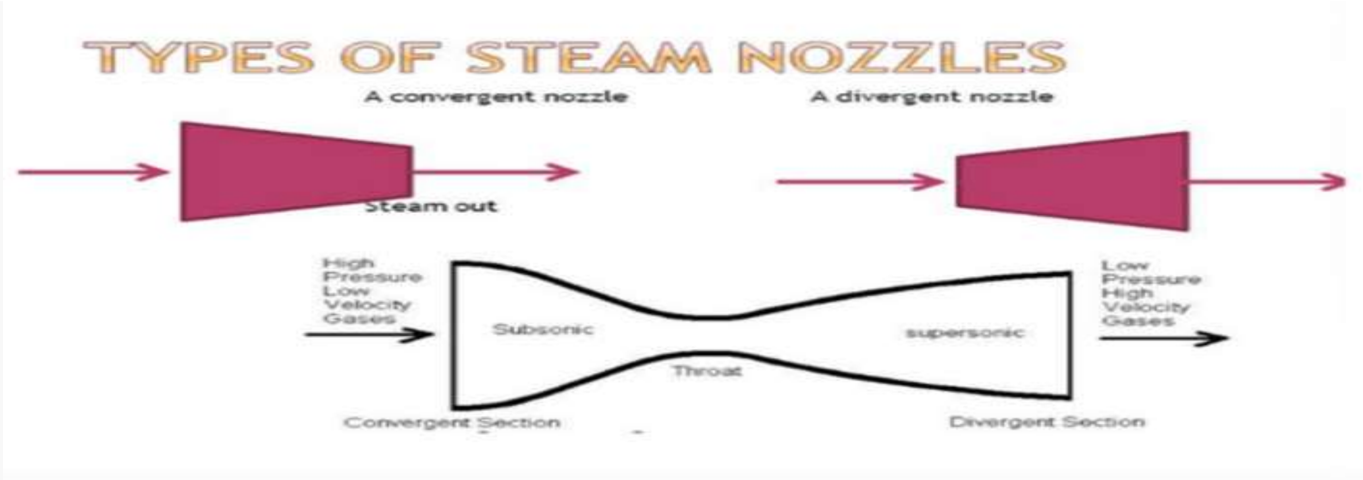
Key Words **- aerospike, performance, altitude, nozzle**

I. INTRODUCTION-

Aerospike nozzle is the most popular altitude compensating nozzle, tThe aerospike engine is being developed from groundwork laid in the mid of the nineteen Rocketdyne Propulsion. Other rocket engines, which feature a bell nozzle that constricts expanding gasses, the basic aerospike shape is that of a bell turned inside out and upside down.

Nozzles-

Nozzles are mechanical device of varying with cross section which control the directions and characteristics of the fluid (Air or Water) flowing through it. It is used in rocket engines to expand and accelerate the combustion gases, from burning propellants, so that the exhaust gases exit the nozzle at supersonic or hypersonic velocities. Basically nozzles are three types convergent, divergent and convergent and divergent (C-D) nozzle. C-D nozzle most usable rocket engine.



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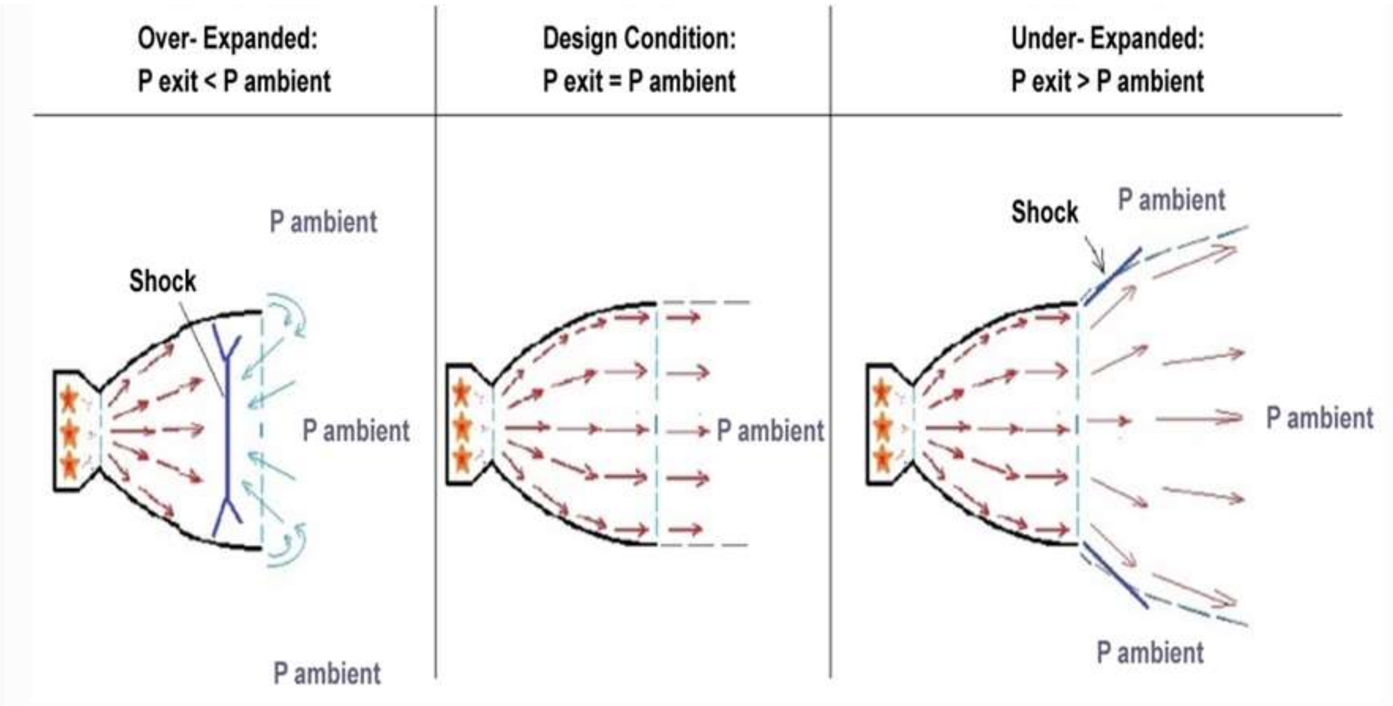
When the fluid flows through the nozzle it exits velocity higher than inlet velocity because conservation of mass which states that the rate of change of mass equals to the density, area and velocity.

m = *A*V
m =mass flow rate
A= area of flow
V = velocity

Aerospike nozzle-
The aerospike nozzle profile turned inside out. Flow of combustion gases is directed radially inward towards the nozzle axis. Flow is directed inward toward the nozzle axis. This concept is the opposite of a bell nozzle which expands the flow away from the axis along diverging nozzle wall sand in an aerospike nozzle expansion process originates at a point on the outer edge of the annulus which is referred to as the "cowl-lip." In a standard bell nozzle, flow expansion continues regardless of what the ambient pressure is, and the flow can continue to over-expand until it separates from the nozzle walls. The linear aerospike, spike consists of a tapered wedge- shaped plate, with exhaust exiting on either side at the "thick" end.

Working Principle and flow of Aerospike nozzle-
Basically all rocket engines follows newton's third law action reaction and the function of a rocket nozzle is to direct all gases, generated in the combustion chamber of the engine and accelerated out of the nozzle. The aerospike engine is that, as the launch vehicle ascends during its trajectory, the decreasing ambient pressure allows the effective nozzle area ratio of the engine to increase. An aerospike nozzle is often referred to as an altitude-compensating nozzle, because of its specific design capability of maintaining aerodynamic efficiency as altitude increases and thus throughout the entire trajectory. At the outer cowl lip, the gas expands to the atmospheric pressure immediately, and then causes serious expansion waves propagating inward at an angle through the gas stream. At the location where the last expansion wave intercepts the spike, the gas pressure is equal to the atmospheric pressure. For the over expanded case, the spike changes the gas to be directed outward, and thus compression waves form and propagate outward at an angle and reflect off the jet boundary as expansion waves. This process then begins again. The aerospike features a series of small combustion chambers along the ramp that shoot hot gases along the ramp's outside surface to produce thrust in a spike- shaped plume, hence the name "aerospike."



ADVANTAGE OF AEROSPIKE NOZZLE-
The aerospike nozzle has 90% overall better performance than the bell shaped nozzle. The efficiency at low altitudes is much higher because the atmospheric pressure restricts the expansion of the exhaust gas. A vehicle using an aerospike nozzle also saves 25-30% more fuel at low

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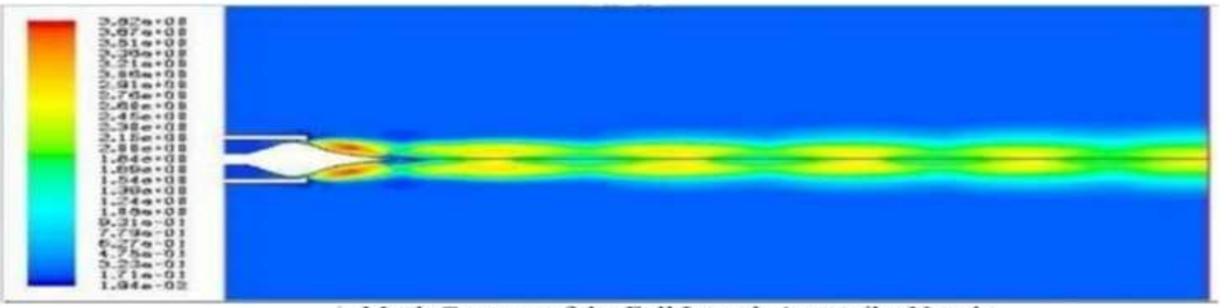
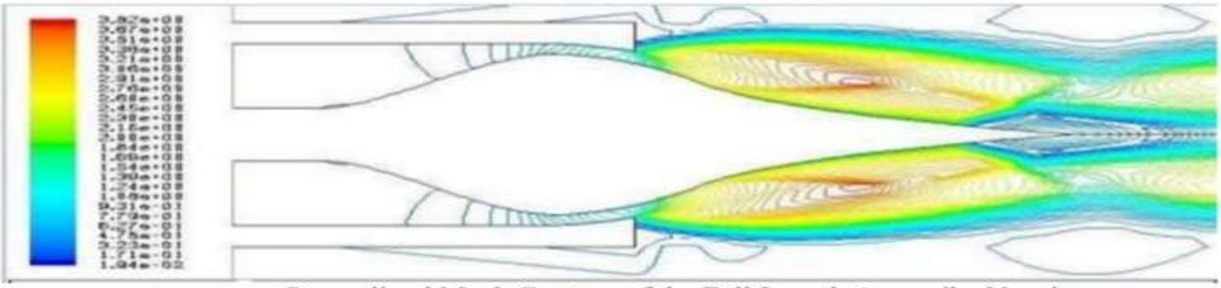
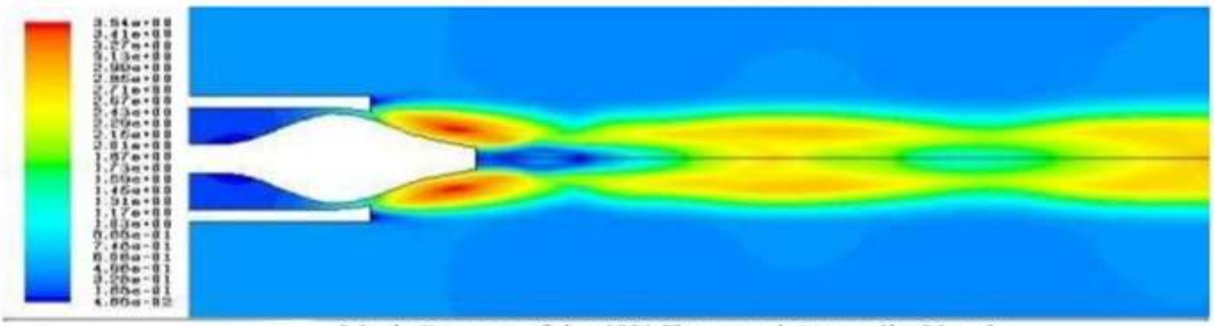
altitudes. At high altitudes, the aerospike nozzle is able to expand the engine exhaust to a larger effective nozzle area ratio. An aerospike nozzle with an expansion ratio of 200:1 to 300:1 can increase the thrust and specific impulse by five to six percent. Specific impulse is the total impulse per unit weight of propellant. As of now, the most widely used nozzle type is the bell-shaped nozzle. It has a high-angled expansion section, usually 20-50°, right behind the nozzle throat, which is then followed by a gradual reversal of nozzle contour slope so that the nozzle exit divergence angle is small, usually less than a ten-degree half angle.



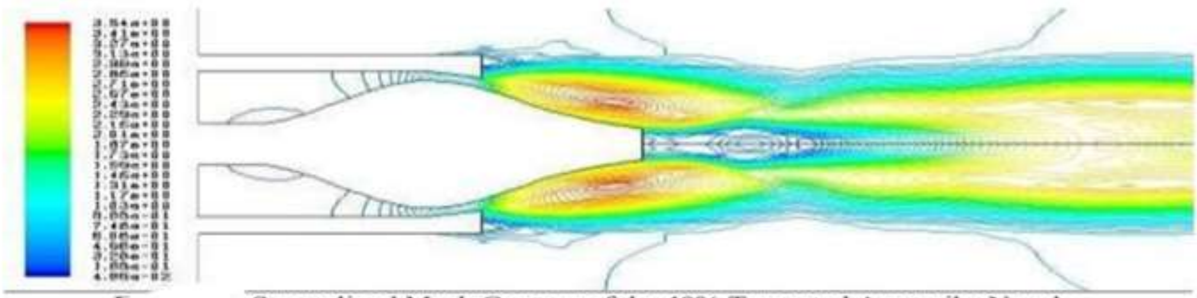
Mach Contour of the Full Length Aerospike Nozzle



Streamlined Mach Contour of the Full Length Aerospike Nozzle



Mach Contour of the 40% Truncated Aerospike Nozzle



. Streamlined Mach Contour of the 40% Truncated Aerospike Nozzle.

We can see the changes in flow in two different- different types of nozzles.

After modelling and meshing the nozzle in GAMBIT 2.3, CFD analysis made by using FLUENT to solve the Navier-Stokes Equations. Air is used as the fluid medium. The material property of the gas is ideal gas. Since, the Mach No > 0.3, The ambient conditions are supposed at the far field.

Design Parameters: -

The input parameters for the design of the annular aerospike nozzle are,

Exit Area ratio (Ae/At) = 2.68
Exit diameter Re = 16mm
Chamber Pressure = 20 bar
Exit Pressure = 1 bar
Mass Flow Rate = 1.988Kg/Sec

From the given interval of design parameters, some of the values that are used for the design are,

Length of the nozzle = 557.mm
Thrust = 1.268E3N
Coefficient of thrust (CF) = 1.446
Mach No at the end of the ramp = 2.601

Boundary Conditions.

FLUENT Boundary Conditions used for simulations are given below,

i. Solver = Density based
ii. Space = Axisymmetric
iii. Viscous model = Spalart – Allmaras
iv. Operating Pressure

Boundary conditions –
Pressure Inlet = 0 Pa

i. Gauge total pressure = 8 bar
ii. Total temperature = 300 K
iii. Direction Specification
Pressure Outlet Normal to boundary
i. Gauge total pressure = 1 bar
ii. Backflow total temperature =300K

Far Field Conditions –
i. Gauge pressure = 1 bar
ii. Mach Number = 0.4
iii. Temperature = 300K

II. CONCLUSION

The procedure to design an aerospike nozzle and design parameters that governs the aerospike nozzle design is discussed here. The designed value of the exit velocity (Mach No 2.5) is achieved with only 2.1% of error. The exit velocity of the air from FLUENT calculation is 2.36. A comparison between the results of experimental and computational analysis of aerospike nozzle and also the performance of a full-length aerospike nozzle, a nozzle truncated at 60% of the full nozzle length& the same with the base bleed effect were done. For a single flow and boundary condition, the maximum Mach No attained at the end of the 40% truncated & Base bleed spike nozzle is 3.44 & 4.58respectively.

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