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DESIGN & ANALYSIS OF ROCKET NOZZLE

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Abstract

In this paper CFD analysis of pressure and temperature for a rocket nozzle with two inlets at Mach 2.1 is analyzed with the help of fluent software. When the fuel and air enter in the combustion chamber according to the x and y plot, it is burning due to high velocity and temperature and then temperature increases rapidly in combustion chamber and convergent part of the nozzle and after that temperature decreases in the exit part of the nozzle. It is concluded in this paper that two inlet rocket nozzle is having better performance than single inlet. We know that the driving forces such as conversation, pressure and temperature gradient can causes species transport, momentum transport and energy transport respectively. Scientist have been worked on ―Comparison of the rocket engines efficiency in the case of low thrust orbit-to-orbit transfers‖ and their findings are the following: The main task of this paper is to compare two types of low thrust rocket engines: constant thrust vs. variable-thrust engines. They are concerned with efficiency, where efficiency is evaluated in the case of the orbit -toorbit transfer with maximum payload mass in the central Newtonian gravity field.

Key Words: Ansys, Design, Rocket nozzle, Designmethodology, Simulation, Bell nozzle, Rao’s Nozzle.

1. INTRODUCTION

A jet engine uses a nozzle to accelerate hot exhaust to supply thrust as delineated by Newton'sthird law of motion. The study of the high-temperature gas flow in a nozzle has led to thedefinition of a certain number of parameters, characteristic serve as a basis for evaluation of arocket motor and, alsofor comparison between different systems. So, as to attain theseparametersmathematically.A nozzleisatubeofvaryingcross-sectionalarea(usuallyaxisymmetric) aiming at increasing the speed of an outflow, and controlling its direction andshape.Inthesimplestcaseofarocketnozzle, relativemotioniscreatedbyejectingmassfromachambermberbackwardsthroughthenozzle,withthereactionforcesactingmainlyontheoppositechamber wall, with a small contribution from nozzle walls. Two types of nozzle,

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ConvergingnozzlesandConverging-Divergingnozzle.Convergingnozzlesareusedtoaccleratethefluidin subsonic gas streams (and in liquid jets), since at low speeds density do not vary too much,and$m$=ρvA=constcanbeapproximatedbyvA=const.LiquidjetsandlowspeedgasflowscanbestudiedwithclassicalBernoulliequation(untilcavitation effectsappearinliquidflows),but high-speed gas dynamics is dominated by compressibility effects in the liquid.(1)Thrust istheforcethatpropelsarocketspacecraftandismeasuredinpounds,kilogramsorNewtons.

Objectives

Todesignanozzleforanidealrocketthathastooperateathighaltitudehavingthetargetedthrustandthenusageofnozzleforreactioncontrolsystemaswell.

Todesignanozzleusinganalyticalmethod.

StudyofcharacteristicsofNozzleforvariousoperating condition.

FlowanalysisofaxsymmetricusingCFD.

History

De Laval Nozzle Gustaf de Laval, a Swedish inventor, invented the De Laval Nozzle. Theconverging-diverging nozzle, is normally used to supply super-sonic jet velocity at the exit ofthe nozzle. In the convergent section of the nozzle, the pressure of the exhaust gases willincreaseandasthehotgasesexpandthroughthedivergingsectionattaininghighvelocities.Inthe nozzle, the combustion chamber pressure is decreases as the flow propagates towards theexit as compared to the ambient pressure i.e., pressure outside the nozzle. This results inmaximumexpansionknownasoptimumexpansion.

2. IMPLEMENTATION

SchematicDiagram

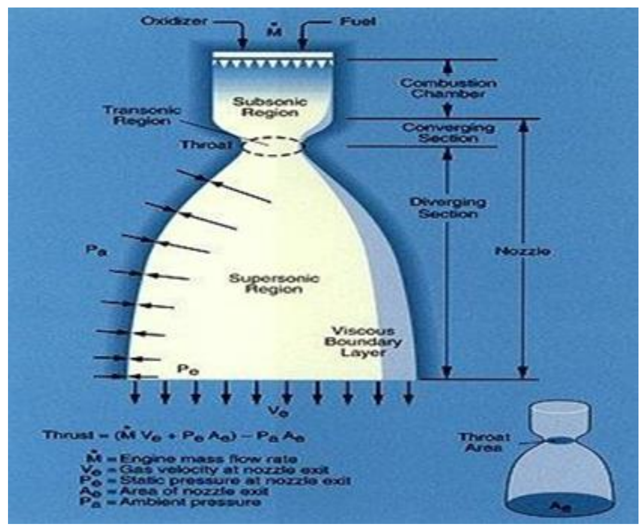

Figure1 Schematicdiagramofrocketnozzle.

Workingprinciple

A rocketengineusesanozzletoacceleratehotexhausttoproduce thrustasdescribedbyNewton'sthirdlawofmotion.Theamountofthrustproducedbytheenginedependsonthemass flow rate through the engine, the exit velocity of the flow, and the pressure at the exit ofthe engine. The value of these three flow variables are all determined by the rocket nozzledesign.Anozzleisarelativelysimpledevice,

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justaspeciallyshapedtubethroughwhichhotgasesfl ow. Rockets typically use a fixed convergent section followed by a fixed divergent sectionforthedesignofthenozzle.Thisnozzleconfi gurationiscalleda**convergent-divergent**,or **CD**, nozzle. In a CD rocket nozzle, the hot exhaust leaves the combustion chamber andconvergesdown to theminimum area, or **throat,** of thenozzle.Thethroatsizeischosento**choke**theflow andsetthemassflowratethroughthesystem.Theflo winthethroatissonicwhich means the Mach numberis equal to one in the throat. Downstream of the throat, thegeometry diverges and the flow is isentropicallyexpanded to a supersonic Mach number thatdepends on the area ratioof the exit to the throat. The expansion of a supersonic flow causesthestaticpressureandtemperatureto decreasefromthethroattotheexit,sotheamountofth eexpansion also determines the exit pressure and temperature. The exit temperature determinesthe exit speed of sound, which determines the exit velocity. The exit velocity, pressure, andmassflowthroughthenozzledeterminesthe amount ofthrustproducedbythenozzle.On this swe derive the equations which explainanddescribe why a supersonicflowaccelerates in the divergent section of the nozzle while a subsonic flow decelerates in adivergentduct.Webeginwiththeconservationofm assequation:

3. RESEARCHMETH ODOLOGY

In ANSYS, the nuts and bolts of FEA ideas, displaying and the breaking down of designingissue utilizing ANSYS workbench. Likewise, portray of significance instruments and ideasgivenatwhateverpointrequired.thisfollowin g reproductionsurgesofANSYS.Structuralanalysis: StaticstructuralanalysisModalanalysisTransientst ructuralanalysisThermalanalysis: SteadystatethermalanalysisTransientthermalanal ysis.

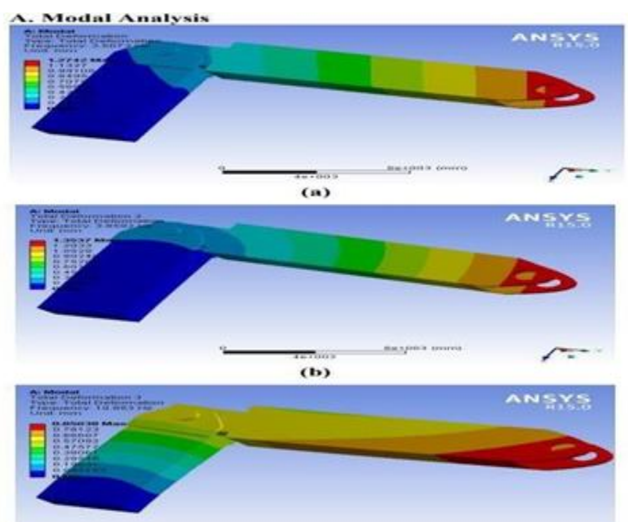

Fig2displayinganalysis ofANSYS.

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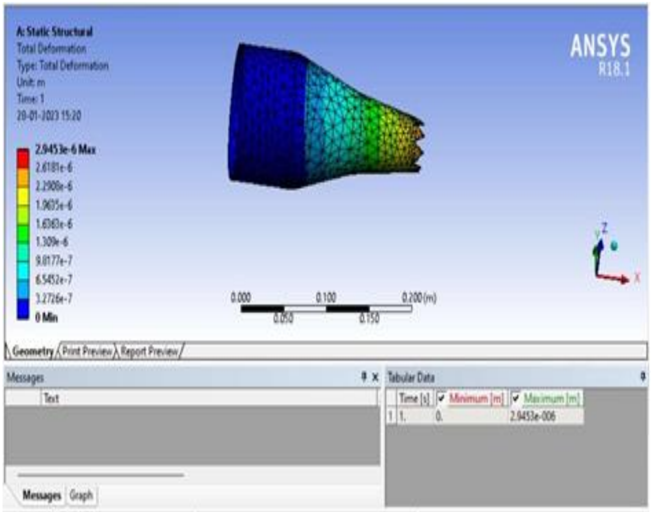

6.1TOTAL DEFROMATION OF STATIC STRUCTURAL :

Table 6.1.1 Total Deformation, Stress, strain and life

Modal 1		
Types	Units	Maximum
Total Deformation	Mm	23.352
Equivalent Stress	Mpa	27948
Equivalent Strain	Mm/Mm	0.14823
Life	Hours	1000000
Damage	Positions	1000
Safety Factor		0.0003084

Modal 2		
Types	Units	Maximum
Total Deformation	Mm	23.35
Equivalent Stress	Mpa	24992
Equivalent Strain	Mm/Mm	0.1322
Life	Hours	1000000
Damage	Positions	1000
Safety Factor		0.0003449

4. CONCLUSION

This paper was a detailed study on the design of a bell type nozzle using G.V.Rao method.To verify whether our design could sustain the stresses without suffering any major deformation and the stresses produced doesn't produce any significant change in the contour of the nozzle. We have found out from this work that the stresses produced are much below the limit. We have performed the analysis to get a stable structure

5. REFERENCES

[1] Sreenath K R, Mubarak A K, Design and analysis of contour bell nozzle and comparison with dual bell nozzle. "International journal of research and engineering" Vol 3 No 3 ,June 2016

[2] Mohan Banoth, Structural Analysis of Rocket Nozzle, "International Journal of Science and Research" Volume 7 Issue 7, July 2018

[3] Wikipedia, RS 25

[4] E.V. Morozov,*, J.F.P. Pitot de la Beaujardiere Numerical simulation of the dynamic thermostructural response of a composite rocket nozzle throat.

[5] G.V.R. Rao, Exhaust Nozzle Contour for Optimization thrust, jet propulsion, June, 1958, PP 34-38, PP 40-42

[6] G. V. R. Rao, Rocketdyne Division Rockwell International Corporation Canoga Park, CA and A. L. Dang Physical Research Inc. Irvine, CAAI, "Thrust Optimization of Nozzle Contour

Including Finite Rate Chemical Kinetics", AIAA 92-3729, PP 11

[7] Venkateshwarlu M., Reddy M.N., Kumar A.K., "A case study on assessment of ground water quality parameters in and around Lambapur Area, Nalgonda District, Telangana State", International Journal of Civil Engineering and Technology, 2017, Vol. 8-Issue 7.

[8] Venkataiah V., Mohanty R., Pahariya J.S., Nagaratna M., "Application of Ant Colony Optimization Techniques to Predict Software Cost Estimation", Lecture Notes in Networks and Systems, 2017, Vol. 5-Issue.

[9] Mahender K., Kumar T.A., Ramesh K.S., "Performance study of OFDM over multipath fading channels for next wireless communications", International Journal of Applied Engineering Research, 2017, Vol. 12-Issue 20.

[10] Kumar D.S., Mukhopadhyay S., Chatterjee A., "Magnetization and susceptibility of a parabolic InAs quantum dot with electronâ€"electron and spinâ€"orbit interactions in the presence of a magnetic field at finite temperature", Journal of Magnetism and Magnetic Materials, 2016, Vol 418-Issue.

[11] Paturi U.M.R., Maddu Y.R., Maruri R.R., Narala S.K.R., "Measurement and Analysis of Surface Roughness in WS2 Solid Lubricant Assisted Minimum Quantity Lubrication (MQL) Turning of Inconel 718", Procedia CIRP, 2016, Vol. 40-Issue.

[12] Tippani R., Prakhya L.J.S., Porika M., Sirisha K., Abbagani S., Thammidala C., "Pterostilbene as a potential novel telomerase inhibitor: Molecular docking studies and its in vitro evaluation", Current Pharmaceutical Biotechnology, 2014, Vol. 14-Issue 12.

[13] Jetley S., Belhe S., Koppula V.K., Negi A., "Two-stage hybrid binarization around fringe map based text line segmentation for document images", Proceedings - International Conference on Pattern Recognition, 2012, Vol. –Issue.

[14] Koppula V.K., Negi A., "Fringe map based text line segmentation of printed Telugu document images", Proceedings of the International Conference on Document Analysis and Recognition, ICDAR, 2011, Vol. –Issue.

[15] Koppula V.K., Atul N., Garain U., "Robust text line, word and character extraction from telugu document image", 2009 2nd International Conference on Emerging Trends in Engineering and Technology, ICETET 2009, 2009, Vol. –Issue.