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RESEARCH ARTICLE

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DESIGN AND FLOW ANALYSIS OF ELECTROMAGNETIC PLASMA ARC PROPULSION SYSTEM

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ABSTRACT

Electromagnetic plasma arc propulsion is generally defined as the process of changing the propulsion concept to attain high thrust. The objective of Electromagnetic plasma arc propulsion activity is to develop high thrust rocket with engines designed to advanced concept substantially during various thrust conditions. Rocket engines can be generally classified as liquid propellant rocket engine ,solid propellant rocket engine, nuclear rocket engine, Ion rocket engine, plasma rocket engine, solar rocket engine, etc. Most of the rocket engines concepts are based upon solid and liquid propellant (fuel & oxidizer),but never been implemented on magnets , magnet propulsion include the gaseous combustion. There is few researches being carried in rocket engines with new concept. Here,in our design , The propellant(Xe/H_2 Gas) is resistively heated by the magnetic field to high temperatures and ejected with high velocities. In this project, the electromagnetic plasma arc propulsion is investigated. In order to predict the Electromagnetic plasma arc propulsion, the numerical analysis of the electromagnetic plasma arc Propulsion System carried out using commercial numerical codes. The increment of thrust will be expect by using the electromagnetic plasma arc propulsion system, which means it attains more Thrust.

Keywords: Xenon gas, Plasma Arc, Thrust.

INTRODUCTION

A rocket engine, or simply "rocket", is a jet engine that uses only stored propellant mass for forming its high speed propulsive jet. Rocket engines are reaction engines and obtain thrust in accordance with Newton's third law. Since they need no external material to form their jet, rocket engines can be used for spacecraft propulsion as well as terrestrial uses, such as missiles.Rocket engines as a group have the highest exhaust velocities, are by far the lightest, but are the least propellant efficient of all types of jet engines.

2.Need of Plasma Arc Propulsion

We identify that most of the propulsion process comes under liquid and solid propulsion, but never been implemented on magnet or solar saving fuel systems. Usually solid and liquid propellant produces high thrust, but the problem of solid and liquid propellant is high cost and produce environment effect. In that time very high thrust can be produced by the magnetic plasma arc propulsion system and also it should not affect an environment because inert gases are used in this system. In these system an electromagnetic fields are accelerates the positive and negative charged particles (Plasma) to a very high velocity.

3.Modeling Process

Electromagnetic plasma arc propulsion an advanced modeling apart from the solid and liquid propellant. The propulsion systems were designed according to the same principle of solid and liquid propellant. Most of the rocket engine, the solid has gradient and the liquid has oxidizer and fuel tanks, but the Electromagnetic plasma arc propulsion works on the principle of magnetic principle were coils are made surrounded in Quartz Tube and fuel are converted to energy and and release the plasma arc. We look the studies of these propulsion and compared that electromagnetic plasma arc propulsion is the best and designed it in CATIA software.The full design of Electromagnetic plasma arc propulsion system is shown in figure 1.

Table.1 Specifications

S.No	Parts	Dimensions(mm)
1	Hose Diameter	20
2	Quartz tube Diameter	60
3	Magnet with coil Length	380
4	Throat diameter	20
5	Throat Length	50
6	Nozzle Diameter	60

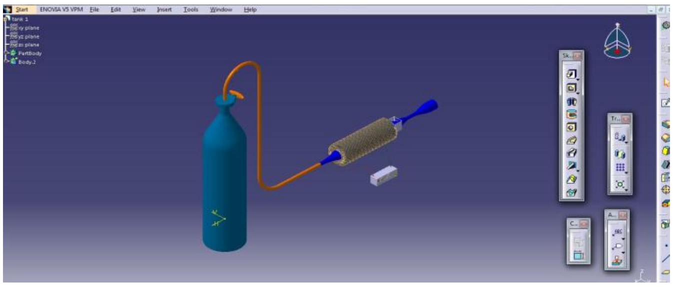


Figure.1 Electromagnetic Plasma Arc Propulsion System

4.Analysis Process

Electromagnetic Plasma Arc Propulsion flows are practically done through flow analysis techniques. These process can be done through flow analysis in fluent software. Fluent is compared to be the best analysis for the electromagnetic plasma arc propulsion, because the accuracy of the flow as shown the maximum percentage. All the difficult processes are done through Fluent , because in our analysis we are convert magnetic field into pressure field.

5.Meshing

The entire structure over the propulsion system was meshed with Triangular mesh with an interval of 0.03 . Triangular meshing was chosen because it was finer over the difficult regions when compared to the hexagonal mesh and it is shown in figure. Here applied value of Reynolds number is 50.35.So the laminar model was used in solving all the cases in this problem. The laminar flow was used because the research works suggested that it was more accurate in predicting the compressible flows.

Table 2.Boundary Conditions

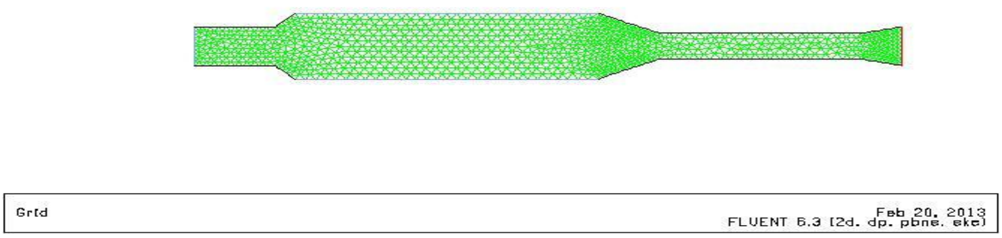


Figure .2 Grid Structure of Propulsion System

S.No	ELECTROMAGNETIC FIELD (A)	MASS FLOW RATE OFPROPELLANT (m/s)
1	10	5
2	20	5

6.Analysis Process

6.1 Analysis of 10A Electromagnetic Field

The pressure contour of the electromagnetic plasma arc propulsion system as shown in figure . This system analysis done by fluent software. Here the red colour indicate high pressure value and blue colour indicate low pressure value. We can identified from figure the pressure value is more in inlet section when compared to the exit nozzle. Because principle of aircraft propulsion, the inlet section (or) diffuser have more pressure and exit section (or) nozzle have more velocity. So the pressure is more in inlet section than exit secton.In throat section the pressure value is constant as shown in figure.3.The velocity contour of the electromagnetic plasma arc propulsion system as shown in figure.This system analysis done by fluent software. Here the red colour indicate high velocity value and blue colour indicate low pressure value. We can identified from figure the velocity value is more in exit nozzle when compared to the inlet section. Because principle of aircraft propulsion, the inlet section (or) diffuser have more pressure and exit section (or) nozzle have more velocity. So the velocity is more in exit section than inlet section. In throat section the pressure value is constant as shown in figure.4.

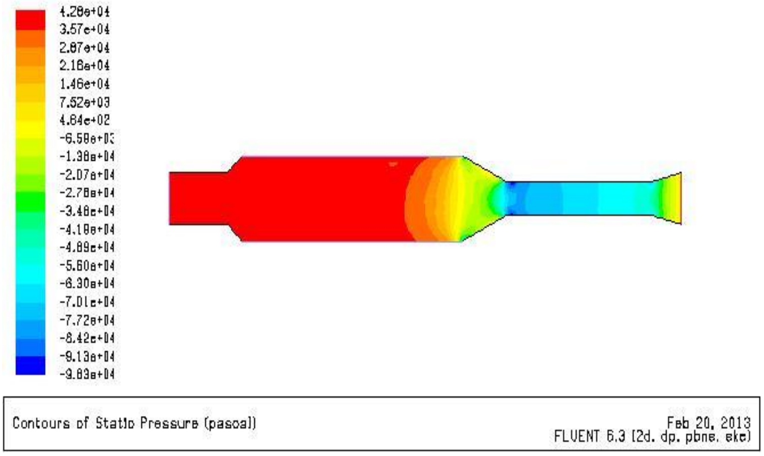


Figure .3 Pressure Contour of 10A Electromagnetic Field

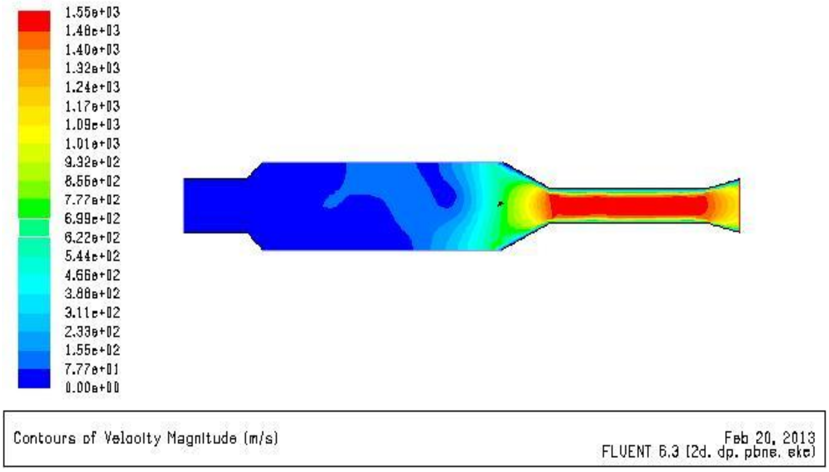
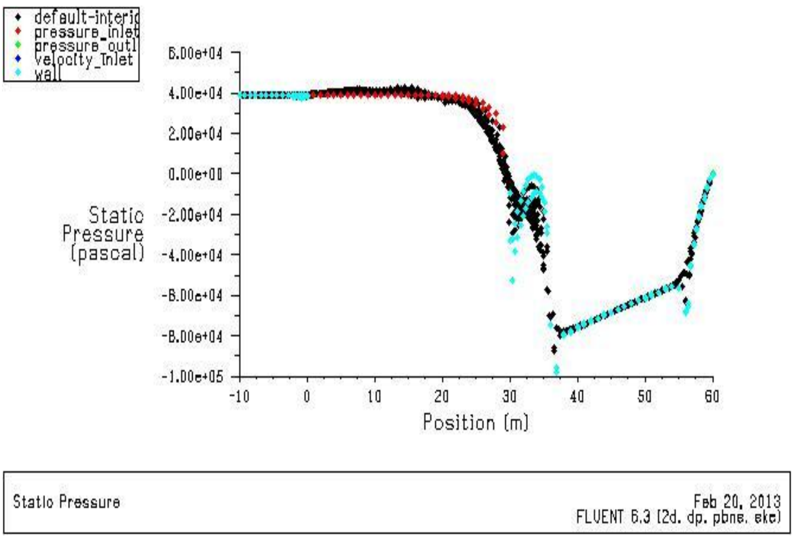
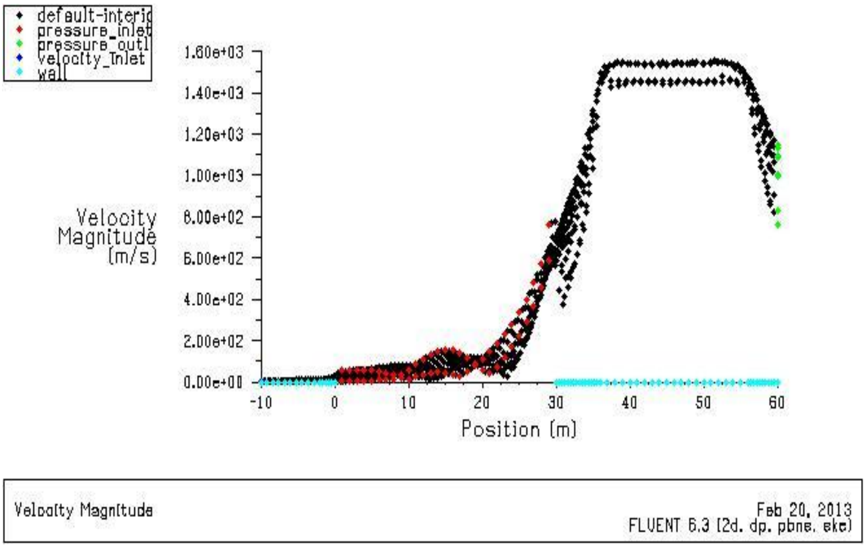


Figure .4Velocity Contour of 10A Electromagnetic Field

The pressure graph of the electromagnetic plasma arc propulsion system as shown in graph 1.This system analysis done by fluent software. Here the red colour indicate pressure value in inlet section and blue colour indicate pressure value in wall of this system. We can identified from graph the pressure value is more in inlet section. Then constant in inlet section. After combustion takes place in magnet with coil. Then decreases in throat section of the system, then constant in throat section. Finally pressure value decreases in nozzle section. Because principle of aircraft propulsion, the inlet section (or) diffuser have more pressure and exit section (or) nozzle have more velocity. So the pressure is more in inlet section than outlet section. In throat section the pressure value is constant as shown in graph1. The velocity graph of the electromagnetic plasma arc propulsion system as shown in graph 2 .This system analysis done by fluent software. Here the red colour indicate pressure value in inlet section and blue colour indicate pressure value in wall of this system. We can identified from graph the velocity value is low in inlet section. After constant in inlet section, then combustion takes place in magnet with coil .Then increase in throat section, become constant in throat section. Finally velocity value increases in nozzle section. Because principle of aircraft propulsion, the inlet section (or) diffuser have more pressure and exit section (or) nozzle have more velocity. So the velocity is more in outlet section than inlet section. In throat section the velocity value is constant as shown in graph2.



Graph .1 Pressure Graph of 10A Electromagnetic Field



Graph .2 Velocity Graph of 10A Electromagnetic Field

6.2 Analysis of 20A Electromagnetic Field

Final analysis of pressure contour of the electromagnetic plasma arc propulsion system as shown in figure7. Here increase the electromagnetic field but mass flow rate of propellant is same. so here more pressure occur in inlet section and low pressure occur in nozzle section. The analysis of velocity contour of the electromagnetic plasma arc propulsion system as shown in figure 8. Here change an electromagnetic field compared to previous analysis. We can identified from figure the velocity value is more in exit nozzle when compared to the inlet section. So turbulence flow occur in exit of the quartz tube .Here very high velocity produced in nozzle section due to increase an electromagnetic field.

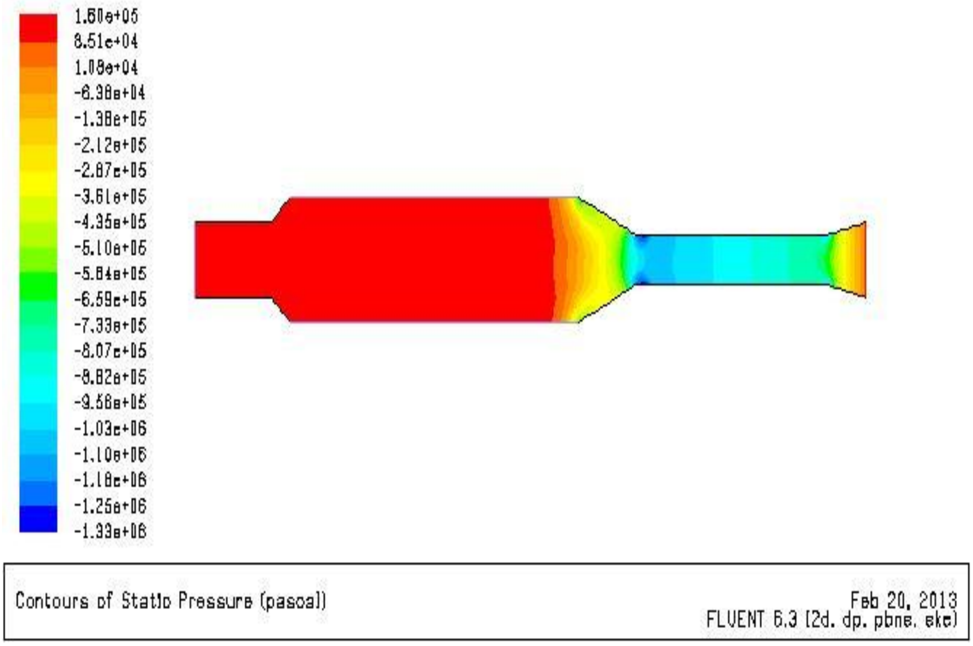


Figure.7 Pressure Contour of 20A Electromagnetic Field

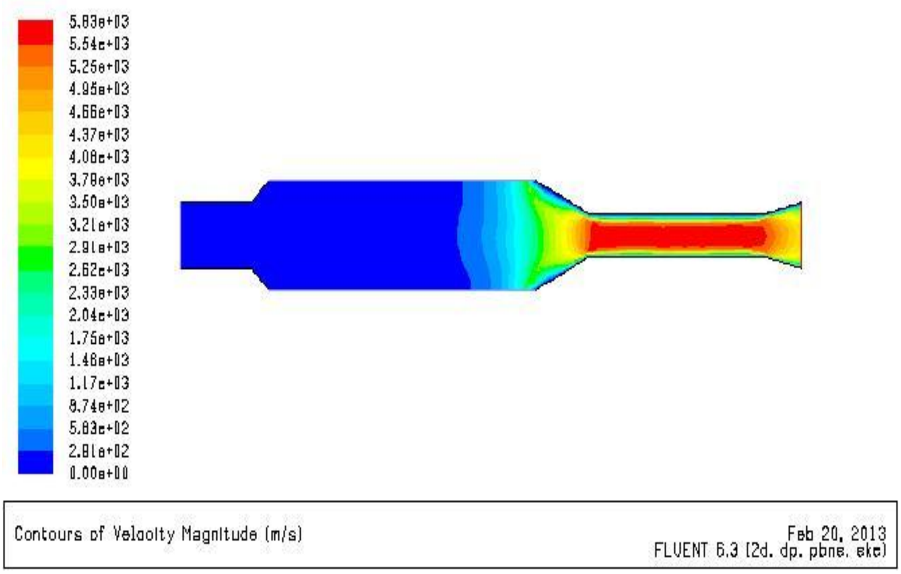
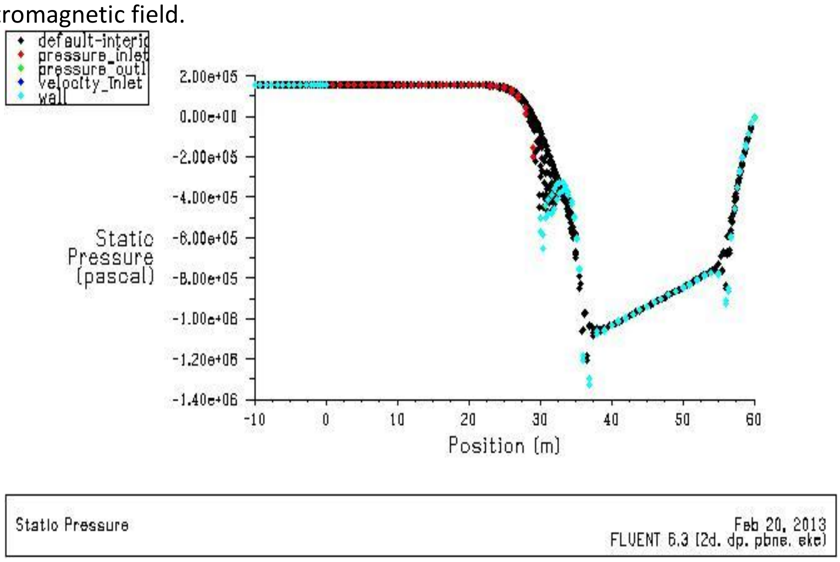
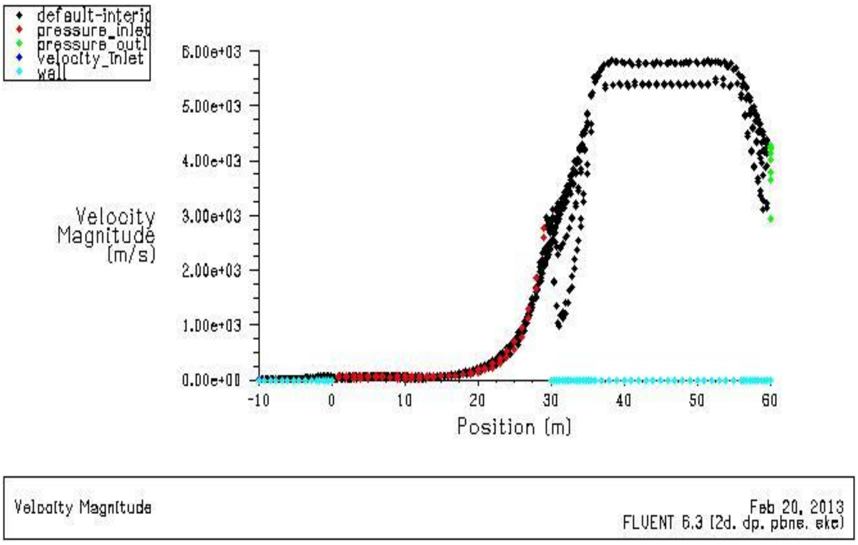


Figure.8 Velocity Contour of 20A Electromagnetic Field

Final analysis of pressure graph of the electromagnetic plasma arc propulsion system done by 20A electromagnetic field. We can identified from graph the pressure value is more in inlet section. After constant in inlet section. The electromagnetic field applied in magnet with coil,so combustion takes place. Finally pressure value decreases in nozzle section. The analysis as shown in graph 5.The analysis of the velocity contour of electromagnetic field as shown in graph 6 . This will enable us to compare the results various conditions. Here mass flow rate of propellant is same but change the magnetic field (pressure field) 90 $\times 10^3$ N/ mm^2 into154 $\times 10^3$ N/ mm^2 applied in magnetic coils. The graph 6 indicate the velocity value is low in diffuser section, constant in inlet section. Finally suddenly increase the velocity in an exit section. We can identified from figure the velocity value is more in exit section when compared to previous analysis due to increase an electromagnetic field.



Graph.5 Pressure Graph of 20A Electromagnetic Field



Graph.6 Velocity Graph of 20A Electromagnetic Field

7. RESULT AND DISCUSSION

We are calculated propulsion parameters for various electromagnetic fields. Also compare propulsion parameter with liquid Rocket propulsion and that is listed below.

Table .3 Comparison of Various Electromagnetic Fields

Current	10A	20A
Thrust(N)	7750	29150
Specific impulse(I_{SP})	158	594.3
Specific Propellant Consumption(S^{-1})	6.4×10^{-3}	1.6×10^{-3}
Speed Ratio	1.792	0.47
Propulsive Power(W)	21.52×10^{6}	80.96×10^{6}
Propulsion Efficiency	85.1%	98.3%
Thermal Efficiency	35.6%	72.4%
Overall Efficiency	30.3%	71.1%
Thrust Coefficient	18.2	68.5
Weight Flow Coefficient	1.19×10^{-3}	1.19×10^{-3}

Table .4 Comparison of Propulsion System

ELECTRO MAGNETIC PLASMA ARC PROPULSION SYSTEM		LIQUID PROPELLANT PROPULSION SYSTEM	
PERFORMANCE	Value (FOR 20A)	PERFORMANCE	Value
Thrust(N)	29150	Thrust(N)	14075
Specific Impulse(S)	594.3	Specific Impulse(S)	286.9
Specific Propellant Consumption(S^{-1})	1.6×10^{-3}	Specific Propellant Consumption(S^{-1})	3.4×10^{-3}
Speed Ratio	0.8	Speed Ratio	0.97
Propulsive Power(W)	80.96×10^{6}	Propulsive Power(W)	39.1×10^{6}
Propulsive Efficiency	98.3 %	Propulsive Efficiency	91.2%
Thermal Efficiency	72.4%	Thermal Efficiency	58.7%
Overall Efficiency	71.1%	Overall Efficiency	61.2%
Thrust Coefficient	68.5	Thrust Coefficient	35.7
Weight Flow	1.19×10^{-3}	Weight Flow	1.02×10^{-3}

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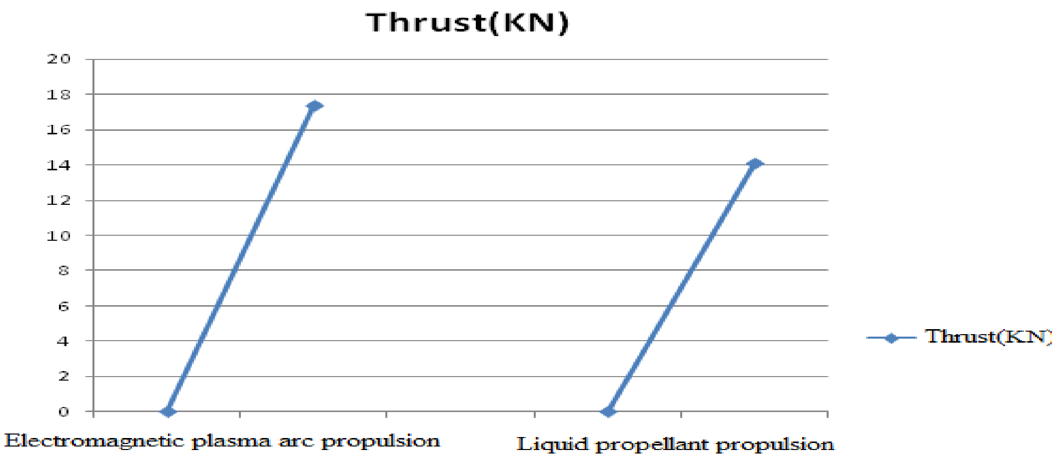
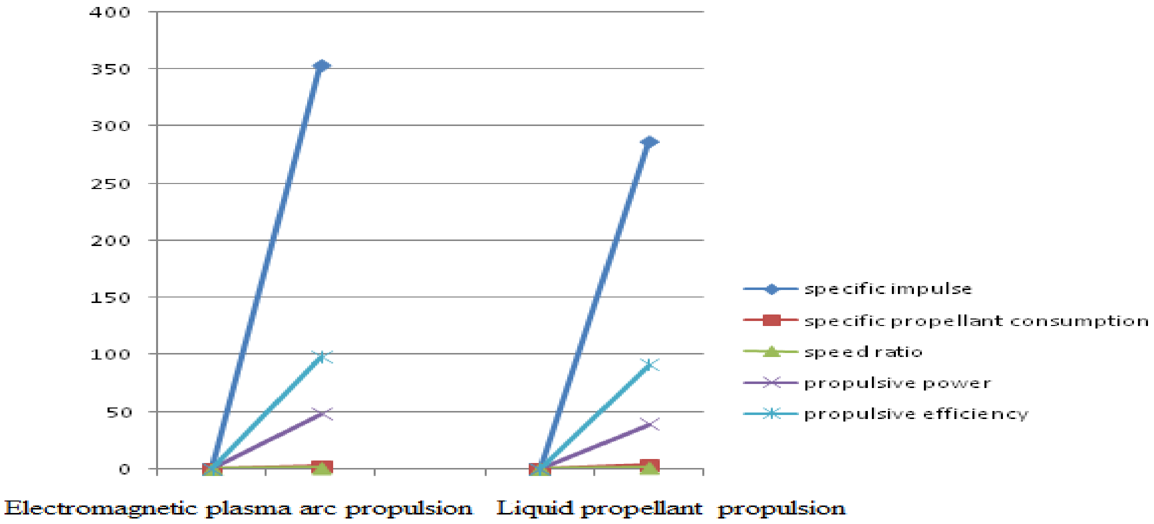
We are plotted thrust graph for electromagnetic plasma arc propulsion system and liquid propellant propulsion system and also the graph shown below. The graph indicate an electromagnetic plasma arc propulsion produce thrust in linearly, after thrust suddenly increases. The liquid propulsionProduce thrust linearly, but produce rate of thrust is low than electromagnetic plasma arc propulsion system as shown in graph 7.We are plotted propulsion parameters graph for electromagnetic plasma arc propulsion system and liquid propellant propulsion system and also the graph shown below. Identified from graph an electromagnetic plasma arc propulsion parameters are produce linearly ,after parameters are suddenly increases. The liquid propulsion parameters are produce linearly, but produce rate of parameters are low than electromagnetic plasma arc propulsion system as shown in Graph 8.



Graph .7 Comparison of Graph of Thrust



Graph .8 Comparison of Graph of Propulsion Parameters

CONCLUSION AND FUTURE WORK

The Electromagnetic Plasma Arc Propulsion system used in Rockets or Missiles, because it will give moreThrust (F) and Specific Impulse (I_{SP}).The Propellant (Xe/H_2 Gas) is a noble or inert gas, so this system will not failure in Space.If this system was implemented in Missiles ,it will reach the Target within seconds.The Electromagnetic Plasma Arc Propulsion system is produce more Thrust (F) when compare to Liquid propellant Rocket Engines and other Rocket Engines.We can use this system especially in missiles. Because we are considered and need, short time attack in missiles. This system produce more thrust, if thrust is more, automatically short time attack is more. so we can used in missiles. This propulsion system of conventional model used in rockets and especially missiles. Because of this system produce more thrust. If we are implement this system in future for missiles, we can develop our country defense field when compared to other countries and also we can face and overcome the war problems in war sessions.

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