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IGNITION SYSTEM ON SOLID ROCKET MOTOR FOR 10000 N THRUST, USING HTPB AS AN FUEL AND OXIDISER

Antony Samuel Prabu G[1], Vishnu Raj[2], Irfan Khan[3], Amogh Balloli[4]

[1] *Aeronautical Department & MVJCE,*
[2]*Aeronautical Department & MVJCE,*
[3]*Aeronautical Department & MVJCE,*
[4]*Aeronautical Department & MVJCE,*

Abstract—In the present study, ignition system on a solid rocket motor is an challenging task. To ignite the solid Rocket propellant Pyrogen technique is been used. Using Catia V5 R21 software, solid rocket motor is modelled & fabricated the same in a scaled down version. HTPB is used as the fuel and oxidiser in the solid rocket motor. Testing of the igniter had been carried out by using different ohms resistors and using the thermal image capture temperature has been calculated around the igniter. Coding is carried out using mat lab software to plot the graph.

Keywords— Pyrogen, HTPB-Hydroxyl terminated polybutadiene, oxidiser.

I. INTRODUCTION

A pyrogen igniter is basically a small rocket motor that is used to ignite a larger rocket motor. The pyrogen is not designed to produce thrust. Heat transfer from the pyrogen to the motor grain is largely convective, with the hot gases contacting the grain surface as contrasted to a highly radiative energy emitted by pyrotechnic igniters. Radiative energy are emitted by pyrotechnic igniters. Bridge wire (0.02 to 0.10 mm) of low-resistance Material. Resistor (61 mm) diameter 1.79 mm.

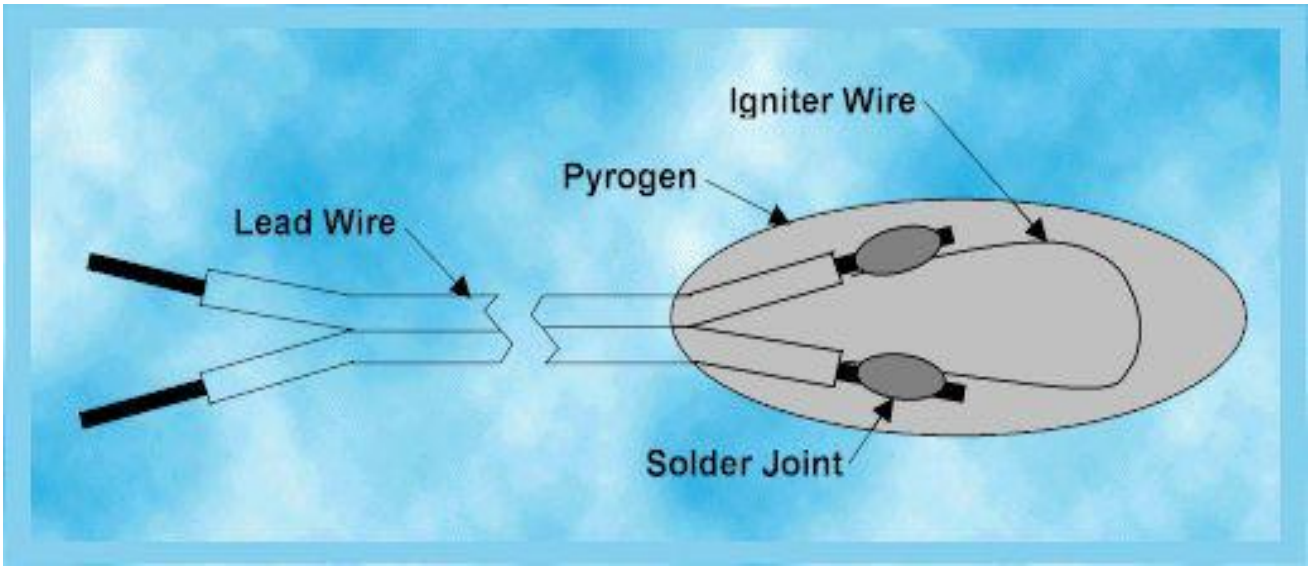

Fig 1. Ignition system of pyrogen igniter

IGNITION PROCESS

- PHASE 1:-**IGNITION TIME LAG**: - The period from the moment the igniter receives a signal until the first bit of grain surface burns.
- PHASE 2:-**FLAME SPREADING INTERVAL**: - The time from first ignition of the grain surface until the complete grain area has been ignited.
- PHASE 3:-**CHAMBER FILLING INTERVAL**:-The time for completing the chamber filling process and for reaching equilibrium chamber pressure and flow.

IGNITER CALCULATIONS
FOR 10 OHM RESISTOR
Ohms Law
RESISTANCE R =V/I
R =10 OHMS
TIME=5s
VOLTAGE V=IR

V=9 V
CURRENT I=V/R
I=9/10
I=0.9 AMPS
POWER=I^2*R
P=0.9^2*10
P=8.1 W

FOR 5 OHM RESISTOR
Ohms Law
RESISTANCE R=V/I
R=5 OHMS
TIME=5s
VOLTAGE V=IR
V=9 V
CURRENT I=V/R
I=9/5
I=1.8 AMPS
POWER=I^2*R
P=1.8^5
P=32 W

ENTHALPY USING CALORIMETER OF COMBUSTION
E = M CpΔT
= 1200*4.184*279 (where ΔT=304-25 =279 c, Cp=4.184 j/kg)
E = 1.400803 MJ

ENERGY TRANSFERED FROM REACTION TO BOMB CALORIMETER
E = BOMB HEAT CAPACITY * ΔT
E = 837(J/K)*279
E = 233.523 KJ

TOTAL ENERGY TRANSFERRED
ΔH = 1400803.2+233523
ΔH = -1.6343262 MJ
ΔH = -1.6343262*10^6*110
ΔH = -179.775882 MJ

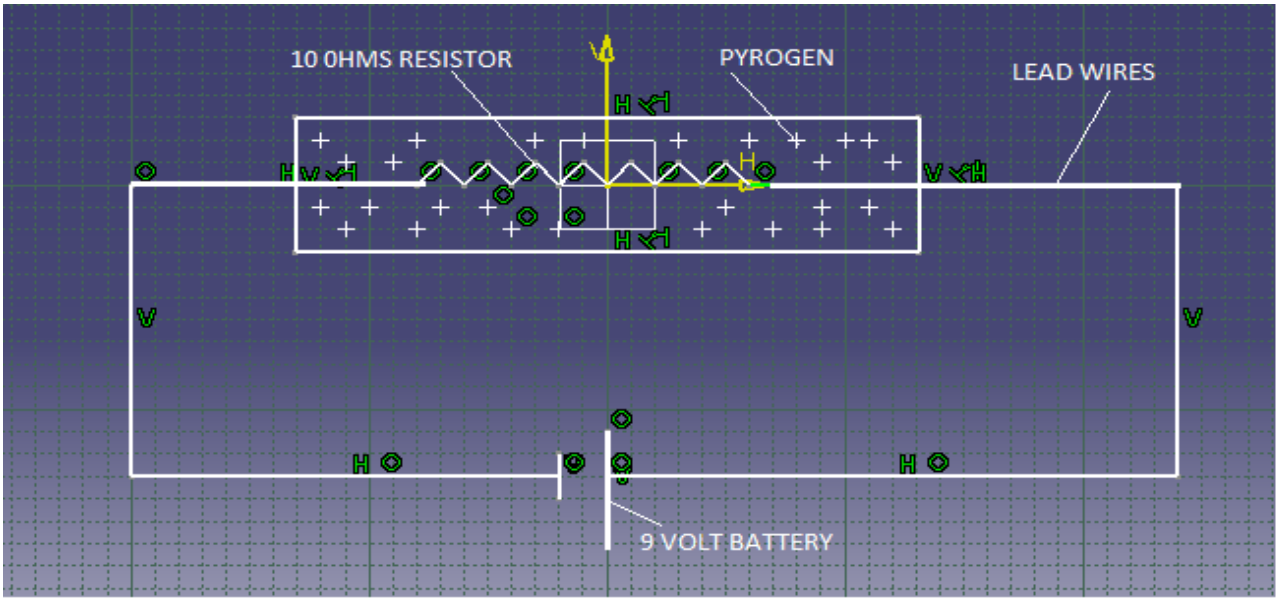

Fig 2. Pyrogen sketch in Catai V5 R21.

PYROGEN IGNITER DIMENSIONS

Emissivity of black powder = 0.96
Emissivity of resistor = 1
Mass inside the pyrogen igniter = 30 gm
Resistor temperature = 70 c
Ignition flame temperature of pyrogen =335 c
Length of the flame arc = 33-44 mm
Ignition time delay = 3 sec
Flame spreading interval = 5 sec
Inner diameter of the pyrogen igniter = 22 mm
Outer diameter of the pyrogen igniter = 24 mm
Length of the pyrogen igniter = 129 mm

PYROGEN RESISTOR DIMENSIONS

Pyrogen resistor length = 61 mm
Diameter of pyrogen igniter = 1.79 mm
Copper wire diameter = 1.01 mm
Copper wire length = 153 cm

TABLE 1 DIFFERENT OHMS RESISTOR CALCULATIONS

5 OHMS RESISTOR	10 OHMS RESISTOR	15 OHMS RESISTOR
CURRENT (I) = 1.8 AMPS	I = 0.9 AMPS	I = 0.8 AMPS
POWER (P) = 32.4 WATTS	P = 8.1 WATTS	P = 9.6 WATTS
MASS OF BLACK POWDER INSIDE PYROGEN (M) = 30 GM	M = 30 GM	M = 30 GM
FLAME TEMPERATURE (T) = 323 C	T = 335 C	T = 340
RESISTOR TEMPERATURE (RT) = 70 C	RT = 72 C	RT = 74 C
LENGTH OF THE ARC = 3 CM	ARC = 3.5 CM	ARC = 4 CM
EMISSIVITY OF BLACK POWDER (E) = 0.96	E = 0.96	E = 0.96
EMISSIVITY OF RESISTOR (R) = 1	R = 1	R = 1
TIME (TI) = 5 SEC	TI = 5 SEC	TI = 5 SEC

Fig 3 Resistor Pyrogen Igniter

Fig 4 Thermal Image Capture

```
File  Edit  Text  Go  Cell  Tools  Debug  Desktop  Window  Help
Stack: Base
1.0   1.1
 1 —    x=[5 10 15]
 2 —    y=[9 9 12]
 3 —    z=[1.8 0.9 0.8]
 4 —    a=[32.4 8.1 9.6]
 5 —    b=[325 333 340]
 6 —    figure(1)
 7 —    plot(x,y)
 8 —    figure(2)
 9 —    plot(x,z)
10 —    figure(3)
11 —    plot(x,a)
12 —    figure(4)
13 —    plot(x,b)
14 —    xlabel('resistance')
15 —    ylabel('voltage')
16 —    zlabel('current')
17 —    alabel('power')
18 —    blabel('temperature')
```

Fig 5 Matlab Program

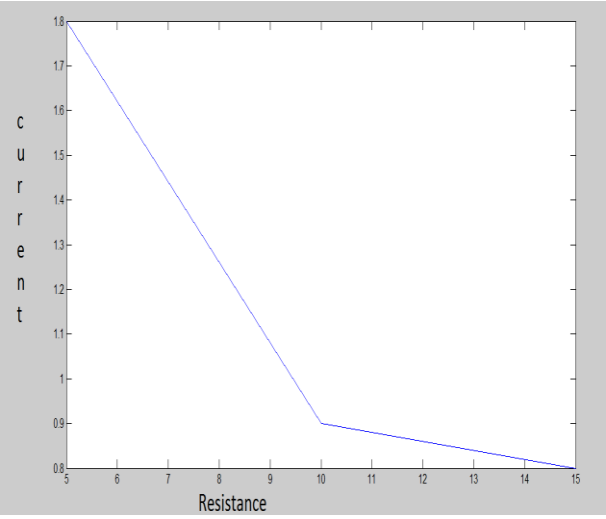

Fig 6 Plot Current Vs Resistance

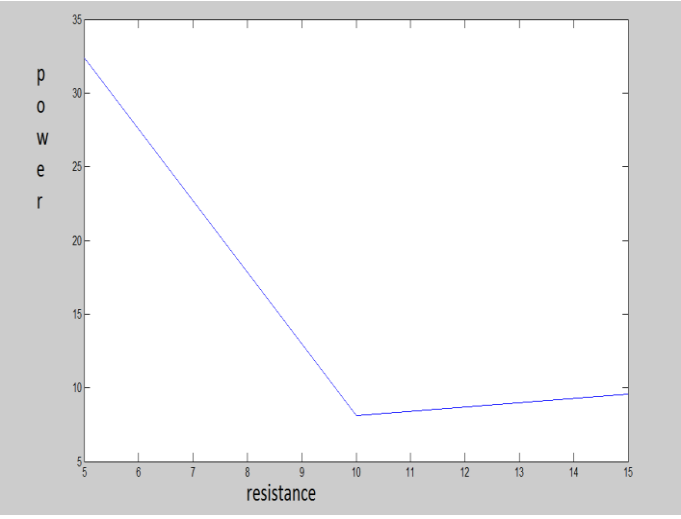

Fig 7 Plot Power Vs Resistance

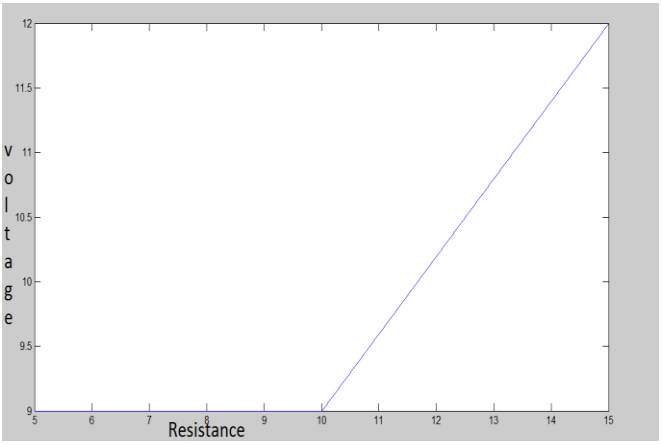

Fig 8 Plot Voltage Vs Resistance

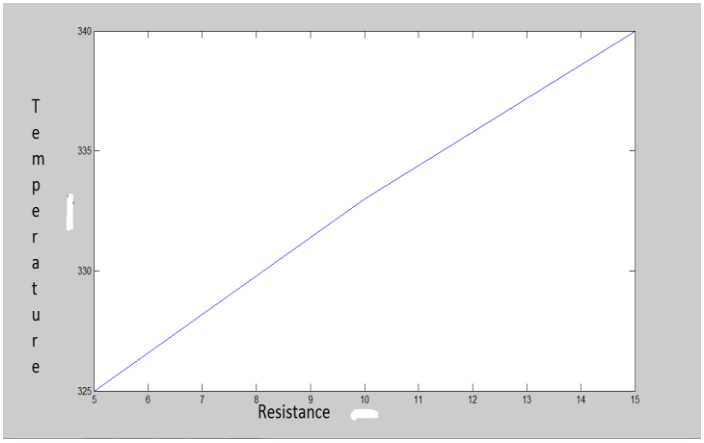

Fig 9 Plot Temperature Vs Resistance

II. CONCLUSIONS

Thus the ignition system on solid Rocket motor had been modelled and analyzed with different ohms resistors, which has been operated by the external power and identified each ohms burning efficiency. With the help of thermal imager the temperature in the resistor and the propellant is captured and from the captured results it's been identified that which resistor can be used to ignite the propellant with their material properties. The radius of burning propellant is captured so that the radius of burning is sufficient enough to burn the surrounding propellant in the solid rocket motor. Finally the results are plotted in the graph using mat lab program and it has been validated with the previous published results. The exact resistor pyrogen igniter is made to burn the htpb propellant with the desired dimensions. The required ignition temperature is taken from the resistor pyrogen igniter. And the flame arc radius is measured from the testing.

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