Form TH-4

National University of Sciences & Technology

MASTER'S THESIS WORK

We hereby recommend that the project work carried under our supervision by: **Ansar Yasmin** Registration # 2009-NUST-MS-M&S-09

Title: **Design of Solid Propellant Grain for Boost-Sustain-Boost Rocket Motor Profile Using Different Propellants** be accepted in partial fulfillment of the requirement for the degree of Master in Information Technology.

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Declaration

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IN THE NAME OF ALLAH

THE BENEFICENT,

THE MERCIFUL

"Allah bears witness that none has the right to be worshipped but He, and the angels, and those having knowledge (also bear witness to this); (He is always) maintaining His Creation in justice. None has the right to be worshipped but He, the Almighty the All Wise."

(Al-Quran 3-18)

Dedicated to

My grand Parents, my Parents, my whole family, my

Teachers

&

My Fiends

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Abstract

Research conducted starts from the basics of Solid fuel rocket motors (SRM). As SRM are used for various applications for their high reliability and simplicity. Shaped mass of solid fuel is known as propellant grain. As the design of a propellant grain plays vital role in solid rocket motor operation. In this study grain configurations are designed to produce boost-sustain-boost (thrust-time) profile. Three different configurations are used to obtain the required thrust-time profile. Boost-sustain-boost profiles of grain configuration using grain having different burning areas with internal burning and grain configuration in which burning takes place in two steps are compared using four type of propellants (DB, MDB, CMDB, Composite) and a grain configuration in which a grain producing dual level of thrust is used with the combination of six different burning rate propellants.

In this study the 3-D grain burn back analysis of the propellant grain is performed. Solid modeling of the 3-D propellant grain is chosen as the design methodology for predetermined burn steps. Pro Engineering, Wildfire 4.0, CAD software is used as parametric modeling tool. By changing parameters (grain length, inner diameter, fin length etc) for each web step, new grain model is created and surface area is obtained which is used to compute chamber pressure and burn rate to predict performance.

Results show that grain configurations with two step burning and grain producing dual level of thrust with different burning rate propellants combination are preferable. Comparison of propellants shows CMDB propellant is more efficient than DB, MDB, composite propellants and MDB-CMDB combination is preferable.

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Nomenclature

A_b ------------------------------------ Burn area

C^* ------------------------------------ Characteristic velocity

A_{th} ------------------------------------ Throat area

P_c ------------------------------------ Chamber pressure

r_b ------------------------------------ Burn rate

a ------------------------------------ Temperature coefficient

n ------------------------------------ Pressure exponent

AP ------------------------------------ Ammonium perchalorate

Al ------------------------------------ Aluminum

HTPB --------------------------------- Hydroxyl terminated polybutadiene

DB ------------------------------------ Double base

MDB ----------------------------------- Modified double base

CMDB --------------------------------- Composite modified double base

F ------------------------------------ Thrust

I_{sp} ----------------------------------- Specific impulse

D_{port} ----------------------------------- Port diameter

D_{out} ---------------------------------- Outer diameter

ρ_p ------------------------------------ Propellant density

$\delta \ln p$ ----------------------------------Percent change of chamber pressure

δT ------------------------------------ Degree change in propellant temperature

$\delta \ln r$ ------------------------------------ Percent change in burning rate

π_k ------------------------------------ Temperature sensitivity of pressure

σ_p ---------------------------------- Temperature sensitivity of burning rate

K ----------------------------------- Ratio of burn area to throat area

C_f ----------------------------------- Thrust coefficient

P_a ----------------------------------- Atmospheric pressure

P_e ----------------------------------- Nozzle exit pressure

A_e ------------------------------------Exit area

γ -------------------------------------Specific heat ratio

R -------------------------------------Universal gas constant

g_0 -------------------------------------Gravitational constant

V_e -------------------------------------Actual exhaust velocity

T_c ------------------------------------- Combustion chamber temperature

R_g ---------------------------------------Exhaust flow specific gas constant

L ---------------------------------------Length

GUIPEP-----------------------------------Graphical user interface for propellant evaluation program

CO_2 --------------------------------------Carbon dioxide

N_2 --------------------------------------Nitrogen dioxide

CO -------------------------------------Carbon monoxide

H_2O -------------------------------------Water

ΔH_c -------------------------------------Heat of combustion

H_f ---------------------------------------Heat of formation

T_d --------------------------------------Adiabatic flame temperature

C_p ---Specific heat capacity at constant pressure

C_v --Specific heat capacity at constant volume