

**National University of Sciences & Technology**

**MASTER'S THESIS WORK**

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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 perchlorate
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
$\rho_p$	-----	Propellant density
$\delta \ln p$	-----	Percent change of chamber pressure
$\delta T$	-----	Degree change in propellant temperature
$\delta \ln r$	-----	Percent change in burning rate
$\pi_k$	-----	Temperature sensitivity of pressure

$\sigma_p$	-----	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
$\gamma$	-----	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
$\Delta H_c$	-----	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