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CONSTRUCTION OF SOLID REACTION ENGINE FOR CRITICAL PURPOSE

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Abstract

Rocket engines powered by solid propellant are the engine of choice for this research work, which is under the category of reaction engines. Since it optimizes the benefit of solid fuel propellant of black solid propellant composed of potassium nitrate (KNO_3), Carbon (C) and Sulphur (S). Galvanise pipe was used as the body to convene the rocket engine and a launcher, where the rocket was launched. The burning of the propellant led to generating of large volume of hot gases which produces a forward reaction force that propelled the rocket. A cardboard cut-out method was used to determine the centre of pressure of the rocket. From the obtained result, stability of the reaction engine in space was achieved, in making sure the centre of gravity was above the centre of pressure i.e (CG > CP), for the design and construction of the rocket model engine of; DIC 001, DIC 002 and DIC 004 ignited at the nozzle that shows high performance launched, while DIC003 was ignited from top of the rocket body. The developed technical appearance of Solid Rocket Propulsion System (SRPS) provides increased reliability, resource, simplicity, and efficiency of a reaction engine in the design and construction of a rocket, which is an essential part of military weapons such as, air to surface missile, surface to air missile, and so on.

Keywords: Rocket, Propellant, Ignited, Stability, Construction

INTRODUCTION

Rocket engines are under the category of engines known as reaction engines. A reaction engine is a device in which chemical energy of fuel is converted into kinetic energy of jet propulsion of a working medium (gas) expanding in the Nozzles. The jet creates thrust because of the reactive or back action, of the working medium, flowing from the engine backwards relative to aircraft motion. The rocket engine work by a scientific rule of action and reaction; Newton's third laws motion and push rockets forward simply by expelling their exhaust in the opposite direction at high speed. Typically, a rocket consists of a Rocket motor (engine) and fuel or propellant (figure.1).

The objective of this project is to develop an efficient solid propellant reaction engine that will transport usable payload to its destination. Rocket finds critical applications in both military and civilian settings. In military, when a rocket carries a warhead, it becomes a missile [1]. From the civil perspective such applications are geared towards carrying Communications Satellite (SATCOM) equipment into orbit; used for weather forecast, agriculture study, mapping of the earth surface and subsurface and global television broadcasts, as well as transporting equipment.

MATERIALS AND METHOD

Black power was used as the propellant which is a formulation consisting of Potassium nitrate, Sulphur, and Carbon. The formulation was mixed to form a homogeneous mixture, casted into the Rocket Engine; casting forming a single continues propellant grain. The engine casing is made up of a mild steel tube with 2 mm thickness. Plastic of Paris (P.O.P) was the primary raw material, used for forming the Nose Cone and Aluminium plane sheet to form the mould of the Cone. The condition for stability states that for a rocket to be stable in flight the Centre of gravity must be above the Centre of pressure. To establish the Centre of pressure, light rays were used to cast a shadow of the rocket on a board and the outline

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of the shadow traced and cut. While the Centre of gravity was determine using the principle of moment. Below are the following parts and functions of the rocket constructed;

Nose cone: Refers to the forward most section of a rocket, guided missile or aircraft. It gives the rocket its characteristic shape, it offers minimum aerodynamics resistance (minimize the drag coefficient of the rocket as it travels in the atmosphere) and is used to carrying the rocket payload (Warhead), Satellite, Instruments etc.

The Fins: Fin was made by cutting 0.5mm flat iron sheet, using theoretical calculation to design the shape out (parallelogram), which was mounted by welding it on the body of the rocket made up of steel pipe at the bottom of the rocket frame to provide stability during flight.

Rocket engine: Uses store rocket propellants as the reaction mass for forming a high-speed propulsion jet fluid, usually high-temperature gas. Rocket engine are reaction engines producing thrust by ejecting mass rearward, in accordance with Newton's third law.

The propellant: Is a substance or combination of substance used as a source of energy and as a source of working fluid for a rocket engine. In other words, it is a substance such as; an explosive charge/rocket fuel (Mixture of fuel and oxidizer) that propel or provides thrust for a rocket.

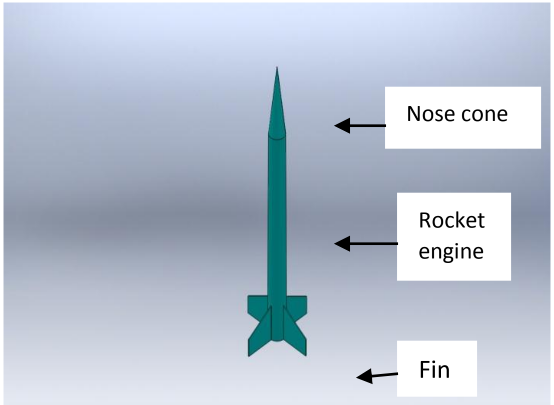

Figure.1: Showing typical rocket

THEORY

As a basic principle of rocket flight, it can be said that for a rocket to leave the ground, the Engine must produce a thrust that is greater than the total mass of the vehicle. For a typical rocket, the total mass of the vehicle might be distributed in the following way; of the total mass, 90% is the propellant, 6% is the structure and 4% can be the payload [2]. The solid propellant burning rate is controlled by chamber pressure [3] shown in equation 1, by Vieille or de Saint Robert's law.

$$r = ap^n \quad (1)$$

Where 'a' and 'p' are empirical coefficients derived experimentally for specific propellant formulations, 'r' is the burn rate, p is the chamber pressure.

The calculated results of the basic design parameters (BDP) of Solid Rocket Propulsion System (SRPS) optimized for this rocket engine is shown in equation (2)

$$\frac{L_I}{C.P_I} = \frac{L_{actual}}{C.P_{actual}} \quad (2)$$

Where, L_I is the length of image, $C.P_I$ is the Centre of pressure of image; L_{actual} is the actual length of rocket and $C.P_{actual}$ is the actual Centre of pressure of rocket.

From the total impulse I_t which is the force F integrated over the burning time t by [4].

$$I_t = \int_0^1 F dt \quad (3)$$

For constant thrust and negligible start and stop transients, equation 3 become

$$I_t = Ft \quad (4)$$

I_t, is proportional to the total energy released by all the propellant in a propulsion system.

The specific impulse I_s is the total impulse per unit weight of propellant, it is an important aspect to the performance of a Rocket Engine (rocket propulsion system), is given below as;

$$I_s = \frac{\int_0^1 F dt}{g_o \int \dot{m} dt} \quad (5)$$

Equation (5) gives the time – average specific impulse value for any Rocket propulsion system.
For constant thrust and propellant flow, the equation can be simplified below, where m_p is the total effective propellant mass.

$$I_s = \frac{I_t}{(m_p g_O)} \quad (6)$$

For constant propellant mass flow $\dot{m}$, constant thrust F, and negligible short start or stop transients, we have it as;

$$I_s = \frac{F}{(\dot{M}_p g_O)} = \frac{F}{\dot{W}} \quad (7)$$

$$\frac{I_t}{(m_p g_O)} = \frac{I_t}{w} \quad (8)$$

The product $m_p g_o$ is the total effective propellant weight w and the weight flow rate is $\dot{w}$
In a solid propellant rocket, it is difficult to measure the propellant flow rate accurately; therefore, the specific impulse is often calculated from total impulse and the propellant weight.

Figure.3: Test fire of the rocket engine work

RESULTS

Figure.2: Completed rocket work set for launching

Four (4) Rocket Engine label as DIC 001, 002, 003 and 004 were constructed to test run the efficiency of the solid propellant made of Potassium nitrate, Sulphur and Carbon and the stability of the Rocket Engine. The Rockets were launched on a moveable launch pad, designed to fire at different angles of projection as showed in fig 3. Three of the Rockets were ignited at the Nozzle; while the other one was ignited at the top of the Rocket motor. They all gave a good performance burn rate and flight height, an indication of a high effective propellant.

DISCUSSION AND CONCLUSION

In the cause of this research work, different model of solid propellant rockets was constructed (DIC 001, DIC 002, DIC 003, DIC 004) and a rocket launcher to test firer the rockets. Knowledge of burning rate of solid propellants (steady or unsteady) under a variety of operating conditions; was critically important to the rocket constructed. The stability of the rocket was achieved by making sure the Centre of gravity (CG) must be greater than the Centre of pressure (CP). Care was taken during the selection of the propellant and metal casing; wrong choice of propellant and metal casing could be dangerous. Refinement of current techniques, development of innovative techniques and necessary theoretical accessories will provide excitement and improved solid rockets in the future. Detailed solid rocket simulations in progress will assist the development of rocket.

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