Experimental Study on High Powered Rocket with SS Motor & Parachute Ejection System

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Abstract:- A solid rocket is a high powered solid propellant-driven rocket which has a motor with no movingparts. But mostly, it is used for single use purposes. So, we have designed a high-power solid propulsion rocket SS motor with parachute ejection system. Parachute ejection system refers to usage of parachutes namely, a main parachute, which deploys at the apogee, due to the max apogeerocket tilts and takes instantaneous recordings, and a main parachute which deploys at a pre-programmed altitude. The propellant of the rocket solid fuel which give high thrust ratio and couldlift the rocket at distant apogee. The motor is made up of Stainless steel and nozzle was made up of mild steel. The main aim of this experimental rocket is to ensure that the rocket parts was 3dprinted and ss motor with mild steel nozzle for experimental purposes, this rocket motor can be reuse it again and again. This paper deals with experimental work on rockets and ss motor.

***Keywords**:- High Powered Rocket, Propellant, Deployment, Motor.*

I. INTRODUCTION

This paper deals with the experimental study on the High-powered rocket with parachute ejection system. A high-power rocket is a high-powered solid propellant driven rocket which has a solid motor with recovery system. The main parachute deploys at a preprogrammed altitude. The motor of the high-powered rocket is made up of stainless steel and nozzle is made up of Mild steel. The high-powered rocket sets an altitude which could reach its apogee up to 5km from ground surface. In comparison to the previous century, the importance of rocket science is fast increasing. Modern technology is of a high standard. The High-powered Motor Rocket is a solid propellant rocket thatcan reach a height of less than 10 kilometers from the ground, and it helps students in their rocketry projects. For the prototype, motor tests, and to launch into low altitude for the companies, high power rockets are essential. Building a rocket with solid or liquid propellant is a difficult task that must correspond to International Space Law and specific guidelines. Developing and building cost-effective rockets in the future is made possible by building High Powered Motor Rocket with various motors. Building Sounding rocket or High-powered rocket is crucial as they have several benefits, including the potential to carry the main payload to the max apogee for the experimental studies, easy fabrication, short manufacturing times, and ability to transport numerous small satellites on a single rocket. Offering numerous benefits and future potential for HPMR.

High power rockets assist in the research and development of rocket motors, hand tools, CAD designs, sensors, and microprocessors and microcontrollers; however, we used pre-programmed sensors that can analyze altitude, temperature, and distance. The rocket's proposed use is to launch it at a height of 5 kilometers using a single parachute recovery mechanism.

The High-powered rocket which we built was like the parts bulkhead, Centering was 3D printed with the help of ABS filament. ABS can endure high temperatures due to its high heat tolerance. ABS printing products are exceptionally durable and able to withstand several impacts. Even at low temperatures, it possesses good impact resistance. The complete mass of the rocket is less in weight and with 3d printed. The rocket has been attached with parachute which could able to recover the rocket. Because of the parachute ejection system, the main payload slow down to the earth and soft landing. The rocket was completely build for the experimental purposes, where 3d printing technology and parachute ejection system also included. With the help of 3d printing machine, the centering and bulkhead has been made. The rocket parts include like nosecone, airframe, centering, bulkhead, fins, avionics system and motor. Normally for solid rocket motor ismade up of aluminum and nozzle is made up of copper alloys by combining copper with other metals such as titanium for various properties. But for future and advance use, the motor was made up of stainless steel where it has more corrosion resistance, and it is durable withstanding of higher temperatures. This motor can be built very cost effective and depends upon the size and payload of the rocket.

II. METHODOLOGY

- *Airframe of rocket and recovery system*

The Airframe and Recovery Systems is about designing the airframe and integrating it with the High-Powered Model Rocket's overall mechanical structure for the Major Qualifying Project (HPMR). Included in this is the incorporation of a cutting-edge recovery system for a rocket that is ready for flight. The airframe acts as the model rocket's "main structure”

[1]. It includes the space for the nose cone, the electronics bay, the motor bay, and any prospective payloads. It also functions as the model rocket's body. The bulkheads, couplers, and epoxy used to link the materialsections that make up the airframe in most cases. The airframes of model rockets frequently have large length to diameter ratios [2]. The airframe of a model rocket has thin walls, and the payload and electronics compartment are frequently located nearer the centre of gravity than the motor, which is located towards the rear of the aircraft. A coupler is joined to the rear end of the airframetube using the coupler that is built into the nose cone of a rocket.

- *Payload Bay*

In a model rocket, the payload bay is normally found in the upper airframe part [3]. It serves to contain the payload (if any) inside the airframe and secure the nose cone to the rocket. Dependingon the size of the rocket, the payload bay may be a separate rocket subsystem or integrated into the airframe tube [3]. On high-powered model rockets, the payload bay is often designed as a separate component to speed up construction and give a separate electronics bay. The payload bay's size is determined by the payload's size.

- *Motor Bay*

The motor bay is located near the end of the HPMR. It serves as the motor's home, keeps theengine in the bay after a burnout, and structurally supports the fins. The size of the motor has a significant impact on the motor bay's dimensions. The motor's diameter and length are the two geometrical dimensions that define motors. It is necessary to know these two measurements to calculate the motor bay's size. In motor bay designs, a central tube (motortube) with an inner diameter equal to the motor's outer diameter is a typical element. The motor tube is connected to three regularly spaced centering rings that span the annular area between the motor tube and the airframe. Circular 3D-printed bulkheads with a hole drilled through the center that is scaled to fit the diameter of the motor tube are used to create the centering rings. A central tube (motor tube) with an inner diameter equal to the motor's outerdiameter is a common component of motor bay designs. Three regularly spaced centering rings that span the annular gap between the motor tube and the airframe are attached to the motor tube. The centering rings are composed of spherical ABS bulkheads that were 3D printed, with a central hole that was sized to suit the motor tube.

- *Nose cone*

The primary aerodynamic surface for dragging reduction is found on the rocket's nose cone, which is situated at the forward end of the rocket. Nose cones can be made in a variety of shapes, including parabolic, long elliptical, long cone, and solid cylinder [5]. All nose cones made for model rockets have a smaller diameter part at their base to better link to the airframeand more reliably eject, when necessary.

- *Recovery System*

The safe retrieval of a rocket after launch is a key objective in model rocketry. "Any equipment that is incorporated into the model rocket to return it safely to the earth" is the definition of a recovery system [6]. The way recovery systems function is by creating an upward drag force to counteract gravity, which then slowly causes the rocket to descend. In addition to increasing safety, adding a recovery system to model rockets enables the rocket to be reused if it lands unharmed. The standard recovery technique in model rocketry uses parachutes. A parachute is released from the airframe at apogee by the system, enabling a safe landing for the rocket. Since parachute recovery is the most typical type of recovery. Acrucial system used in actual launch vehicle stages and spacecraft recovery, as well as modelrocketry, is parachute recovery [9]. Below the nose cone, inside the airframe, mercury tube has been connected to the wires, when the rocket reach its apogee, it tilts and mercury tube produce electric discharge which causes the gun powder to burst out where the nose cone separates and the main parachute comes out which could end up recovery system. The parachute recovers the main payload and the parts of the rocket [7].

III. PROPULSION SYSTEM AND MOTOR PERFORMANCE ANALYSIS

The propellant of the rocket is the solid propellant where the mixture of Kno3 and $C_{12}H_{22}O_{11}$.

Where it heated with more than 58 degrees. When a mixture of fuel and oxidizer is ignited, a quick chemical reaction known as combustion takes place. The fuel and oxidizer are pre- mixed and react in the combustion chamber of a solid composite rocket engine, for example, before the pressure drop over the nozzle pushes the burning gas out of the nozzle and generates thrust [10]. It is frequently desirable to understand the properties of the combustion reaction mixture once it has reached chemical equilibrium because these features suggest thebeginning condition for the fluid flow through the motor nozzle. Chemical equilibrium problems are notoriously difficult to solve, especially when there are many species of unidentified product involved [11].

- *Temperature Distribution analysis*

More details on any structural degradation caused by heat produced by the engine during the rocket's flight can be obtained by estimating the temperature distribution around the motor during flight. It's crucial to pinpoint any areas of the structure where there may be a higher danger of structural failure as a result of the motor's surrounding components melting from an excess of heat [13]. By utilizing a variety of add-on physics modules, the COMSOL Multiphysics programme can be used as a tool to do finite element analysis and provide answers for a wide range of engineering issues. The curriculum includes modules in electromagnetics, acoustics and structural mechanics, heat transfer and fluid motion, and chemical technical analysis. Conduction is the main internal heat transmission process in solids, whereas convection dominates heat transfer in fluids (advection due to bulk motion and conduction due to temperature gradients) [14].

- *Existing Methods of separation:*

No matter how complicated a rocket is, certain procedures must be carried out for it to function properly while in flight. One Section separation, one of these processes, is putting pressure within the rocket to break it into two or more parts. When a rocket reaches apogee,or its highest point, separation often takes place as the rocket starts to descend. The rocket'snose cone is frequently pushed outward, allowing a parachute to escape and create drag. In more complex rockets, a separation event can also be utilized to separate a stage from the rocket when using a multistage system or to deploy an internal payload. The most common method for producing the force required for separation events is pressurizing an interior compartment with ignited black powder. A considerable pressure difference between the interior of the rocket and the atmosphere can be created via the combustion of black powder. Black powder can be burned to produce the atmosphere and interior of the rocket. A black powder cap [15], which can later be mounted to a bulkhead inside the rocket, can be filled with a precise amount of powder to achieve this easily.

- *Aerodynamic analysis*

All high-powered motor rockets are having suitable attention towards the aerodynamics. When the rockets take off due the flow of wind the direction of the rocket changes it angles. All HPMRs are designed with an attention on aerodynamics. To construct a stable rocket, one must understand how the wind around it will behave in the air. Any person who builds a rocket represents a significant money and time investment that would be wasted if there was a crash landing due to a loss of stability. Therefore, it is important to investigate the rocket's passively controlled stability when developing an HPMR by carefully analyzing its aerodynamic behavior. Students at Worcester Polytechnic Institute have worked on several rocket design projects, each utilizing a different method of aerodynamic analysis.

- *Flight dynamics and Analysis*

A collection of state vectors and their derivatives, whose components change as the rocket travels across space. Can be used to mathematically represent the current state of a rocket, something at some point in time is defined by its position, velocity, attitude, etc. The body frame of the rocket has definitions for the vector quantities presented in this table. The "Stochastic Six-Degree of Freedom Flight Simulator for Passively Controlled High-Power Rockets" by Box et al. offers one solution for this system. Assumptions include that the rocket is an axisymmetric body, moments of inertia are constant throughout flight, gravity only acts at the center of mass, and the center of pressure does not change over time or with altitude. With a rocket travelling under relatively strong aerodynamic drag forces to a heightof around 2,000 feet, any gravity gradient is regarded as inconsequential. The present state and state derivatives of a rocket can be statistically calculated at regular intervals throughouta range of flight times to simulate the rocket's trajectory.

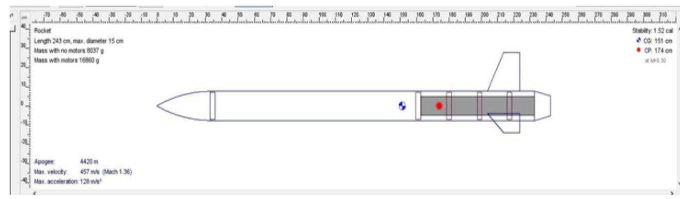

Fig 1 Software analysis

IV. CONCLUSION

This experimental paper describes the design, build and launching of HPMR. The high-powered rocket was designed, build, and launched with some advanced technology like parachute ejectionsystem and with ss motor. As of now in 21st Century, building high powered rockets or sounding rocket was not that much complex, if the rocket scientist or engineers are well trained and experienced to build these types are rockets will lead to high success ratio. The rocket parts include like nose cone, airframe, centering, bulkhead, fins, avionics system and motors are built with basicmaterials which is very low cost and easy to build. We team IndoplanetX build and tested the rocket with different advanced technology. We have used ss (stainless) motor with nozzle made up of mild steel for experimental purpose and the result was like as expected, where it sustains the high temperature. The rocket was aerodynamically perfect where we attached the complete integrated system with avionics system. As it was preprogrammed system as expected it reach uptothe maximum apogee.

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