

INVESTIGATION OF BURN TIME AND TEMPERATURE ON SOLID PROPELLANT WITH DIFFERENT PROPELLANT AND CATALYST

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Aeronautical Engineering

By

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **ANISH SOLOMAN TIGGA (37260004)** and **B. SAIRAM SURAJ (37260035)** who carried out the project entitled **"INVESTIGATION OF BURN TIME AND TEMPERATURE ON SOLID PROPELLANT WITH DIFFERENT PROPELLANT AND CATALYST"** under our supervision from September 2020 to March 2021.

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ABSTRACT

Solid rocket propellant is simple and reliable. Once they are ignited there is no stopping them as they burn until they ran out and can't be throttled to control thrust. Solid fuel rockets can be stored for a long period of time without much propellant degradation and they almost launch reliable, they have been frequently used in military applications such as missiles. Oxidizers are the main compounds in propellant formations, which can produce high energy on combustion. The most commonly used oxidizer is KNO_3 because of its compatibility with other ingredients and its availability at low cost in fertilizer formation. The main objective of this work is to investigate burning time on solid propellants with different propellant and catalysts. The main oxidizer KNO_3 was taken in the ratio of 65% and fuel at 35%. KNO_3 , fuel ingredients like fructose, glucose and lactose with catalysts copper and aluminium were taken in powdered form. A cylindrical shape stainless steel with one end closed were taken to fill the cavity and a concentric hole was made for static constant burning. This solid rocket propellant was fixed to a holder so that it does not propel during burning of fuel, when thrust is created.

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CHAPTER-1

INTRODUCTION

1.1 ROCKET PROPELLANT:

Rocket propellant is the response mass of a rocket. This response mass is catapulted at the most noteworthy feasible speed from a rocket motor to create push. The energy required can either come from the actual charges, similarly as with a compound rocket, or from an outer source, similarly as with particle motors.

Rockets make push by ousting mass back ward, at high speed. The push created can be determined by duplicating the mass stream pace of the forces by their fumes speed comparative with the rocket (specific impulse). A rocket can be considered as being quickened by the pressing factor of the combusting gases against the burning chamber and spout, not by "pushing" against the air behind or beneath it. Rocket motors perform best in space due to the absence of gaseous tension outwardly of the motor. In space it is additionally conceivable to fit a more drawn-out spout without experiencing stream partition.

Most chemical fuels releases energy through redox science, all the more explicitly ignition. All things considered, both an oxidizing specialist and a diminishing specialist (fuel) should be available in the blend. Decay, for example, that of exceptionally flimsy peroxide bonds in monopropellant rockets, can likewise be the wellspring of energy.

On account of bipropellant fluid rockets, a combination of lessening fuel and oxidizing oxidizer is brought into combustion chamber, ordinarily utilizing a turbopump to defeat the pressing factor. As ignition happens, the fluid fuel mass is changed over into an enormous volume of gas at high temperature and pressing factor. This fumes stream is catapulted from the motor spout at high speed, making a restricting power that impels the rocket forward as per Newton's laws of movement.

Substance rockets can be gathered by stage. Solid rockets utilize force in the solid stage, liquid fuel rockets utilize in the liquid stage, gas fuel rockets utilize fuel in the hybrid stage, and crossover rockets utilize a blend of solid and liquid or hybrid forces.

On account of solid rocket engines, the fuel and oxidizer are joined when the engine is projected. Charge ignition happens inside the engine packaging, which should contain the pressing factors created. Solid rockets ordinarily have higher pushed, less I_{sp} , more limited consume times, and a higher mass than liquid rockets, and moreover can't be halted once lit.

1.2 ROCKET STAGES:

In space, the most extreme change in speed that a rocket stage can confer on its payload is essentially a component of its mass proportion and its fumes speed. This relationship is portrayed by the rocket condition. Exhaust Velocity is subject to the charge and motor utilized and firmly identified with explicit motivation; the complete energy conveyed to the rocket vehicle per unit of fuel mass devoured. Mass proportion can likewise be influenced by the decision of a given fuel.

Rocket stages that fly through the atmosphere typically use lower performing, high sub-atomic mass, high-thickness forces because of the more modest and lighter tankage required. Upper stages, which for the most part or just work in the vacuum of room, will in general utilize the high energy, superior, low thickness liquid hydrogen fuel.

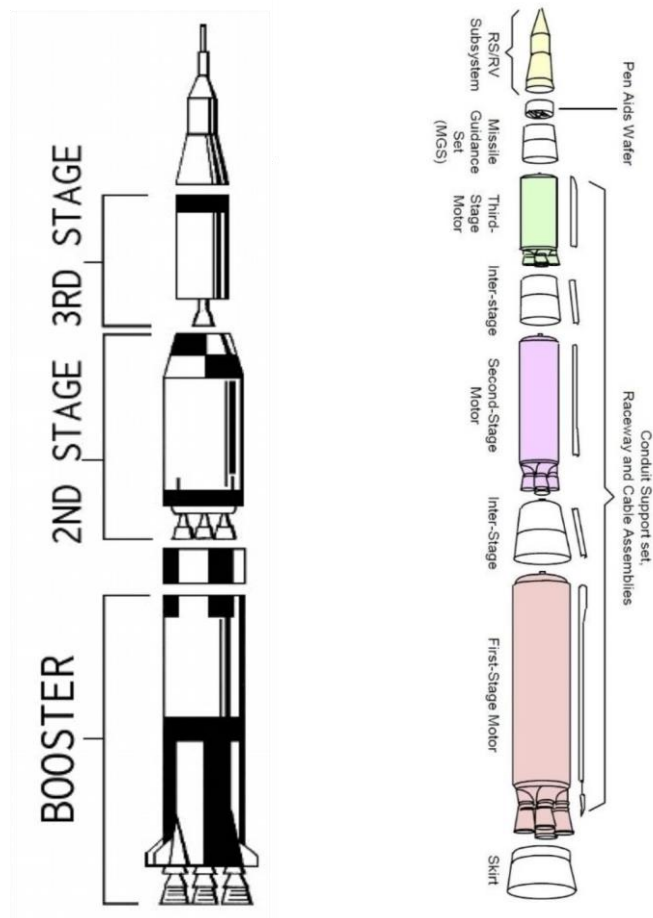


Fig 1.2 Rocket Stages

1.3 TYPES OF ROCKET PROPELLANTS:

1.3.1 SOLID PROPELLANT:

Solid Propellant rocket are the rocket motors that utilizes solid propellant (F/O). The most punctual rockets were solid rockets controlled by black powder; they were utilized in fighting by the Chinese, Indians, Mongols and Persians, as ahead of schedule as the thirteenth century.

All rockets utilized some type of solid or powdered fuel up until the twentieth century, when liquid force rockets offered more effective and controllable other options. Solid rockets are as yet utilized today in military combat hardware around the world, model rockets, solid rocket supporters and on bigger applications for their straight forwardness and unwavering quality.

Since solid fuel rockets can stay away for quite a while absent a lot of propellant corruption and in light of the fact that they quite often dispatch

dependably, they have been often times utilized in military applications like rockets. The lower execution of solid forces (when contrasted with fluids) doesn't support their utilization as essential drive-in present-day medium-to enormous dispatch vehicles usually used to circle business satellites and dispatch significant space tests. Solids are, nonetheless, as often as possible utilized as tie on promoters to build payload limit or as turn balanced out add-on last stage when higher-than typical speeds are required. Solid rockets are utilized as light dispatch vehicles for Low Earth Orbit payloads under 2 tons or break payloads as much as 500 km.

1.3.1.1 BASIC CONCEPTS:

A solid rocket engine comprises of a packaging, nozzle, grain, and igniter. The solid grain mass consumes in an anticipated design to deliver exhaust gases, the progression of which is portrayed by Taylor–Culick stream. The nozzle measurements are determined to keep a plan chamber pressure, while delivering push from the exhaust gases.

When ignition, a basic solid rocket engine can't be closed off, on the grounds that it contains every one of the fixings vital for ignition inside the chamber in which they are singed. Further developed solid rocket engines cannot exclusively be choked yet additionally be extinguished and afterward retouched off by controlling the nozzle math or using vent ports. Likewise, rocket engines that consume in sections and that can be ignited upon order are accessible.

Current plans may likewise incorp time a steerable nozzle for direction, flying, recuperation equipment, fall to pieces instruments, APUs, controllable strategic engines, controllable redirect and demeanour control engines, and thermal materials.

1.3.1.2 HISTORY:

The middle age Song tradition Chinese developed an exceptionally crude type of solid propellant rocket. Illustrations and portrayals in the fourteenth century Chinese military composition Huolongjing by the Ming administration military author and savant Jiao Yu affirm that the Chinese in 1232 utilized proto solid propellant rockets at that point known as "fire arrows" to drive back the

Mongols during the Mongol attack of Kaifeng. Each arrow took a crude type of a solid propellant rocket tube that was loaded up with black powder. This prompted the primary mechanical production of military rockets with the Congreve rocket in 1804.

Current castable composite solid rocket engines were imagined by the American aeronautics' designer Jack Parsons at Caltech in 1942 when he supplanted twofold base fuel with material black-top and potassium perchlorate. Atlantic Research Corporation fundamentally supported composite force Isp in 1954 by expanding the measure of powdered aluminium in the charge to as much as 20%.

Solid propellant rocket innovation got its biggest lift in specialized advancement, size and capacity with the different mid-twentieth century government activities to grow progressively able military rockets. After beginning plans of ballistic rocket military innovation planned with liquid propellant rockets during the 1940s and 1950s, both the Soviet Union and the United States set out on significant activities to create strong fuel nearby, provincial, and intercontinental ballistic rockets, including solid propellant rockets that could be dispatched from air or ocean. Numerous different governments additionally built up these military advances throughout the following 50 years.

By the later 1980s and proceeding to 2020, these administrations grew exceptionally fit solid rocket advancements have been applied to orbital spaceflight by numerous administrations coordinated projects, regularly as supporter rockets to add additional push during the early rising of their basically liquid propellant rocket dispatch vehicles. Models flying during the 2010s Incorporate time the Russian Proton, European Ariane 5, US Atlas V and Space Shuttle, and Japan's H-II.

The biggest strong rocket engines at any point constructed were Aerojet's three 6.60-meter solid rocket engines cast in Florida. Motors 260 SL-1 and SL-2 were 6.63 meters in width, 24.59 meters since a long time ago, weighed 842,900 kilograms, and had a most extreme pushed of 16 MN.

1.3.1.3 INTERNAL BALLISTICS OF THE ROCKET:

Internal ballistics (additionally inside ballistics), a subfield of ballistics, is the investigation of the propulsion of a projectile. In firearms, inner ballistics covers the time from the propellant's start until the propellant leaves the gun barrel. The investigation of inner ballistics is imperative to designers and firearms of guns, all things considered, from little bore rifles and guns, to cutting edge cannons. For rocket-pushed shots, interior ballistics covers the time frame during which a rocket engine is giving pushed. There is a wide utilization of solid rocket forces in impetus frameworks and gas generators. In such frameworks, there are testing issues including many muddled air thermo substance measures. Arrangements of such muddled frameworks require a decent comprehension of numerous cycles like heat transfer, turbulence combustion, diffllision, compound responses and so on. The ignition interaction in a solid rocket chamber assists with picturing the consuming time conduct of strong fuel. Since the response times during ignition are a lot quicker than those of generally noticed compound responses and on the grounds that actual changes like speed, temperature and pressing factor during ignition, an information on aerothermochemistry is required to comprehend ignition wonders. It is the reason here to introduce propels in ignition phenomena of various kinds of fuels and to introduce the aero thermochemical conditions appropriate to solid forces.

1.3.1.3.1 PIOBERT'S LAW:

Fuels are carefully coordinated to firearm strength, chamber volume and barrel length, and to projectile material, weight and dimensions. The time of gas generation is relative to the surface territory of consuming force grains as per Piobert's Law. Movement of consuming from the surface into the grains is ascribed to heat transfer from the outside of energy important to start the response.

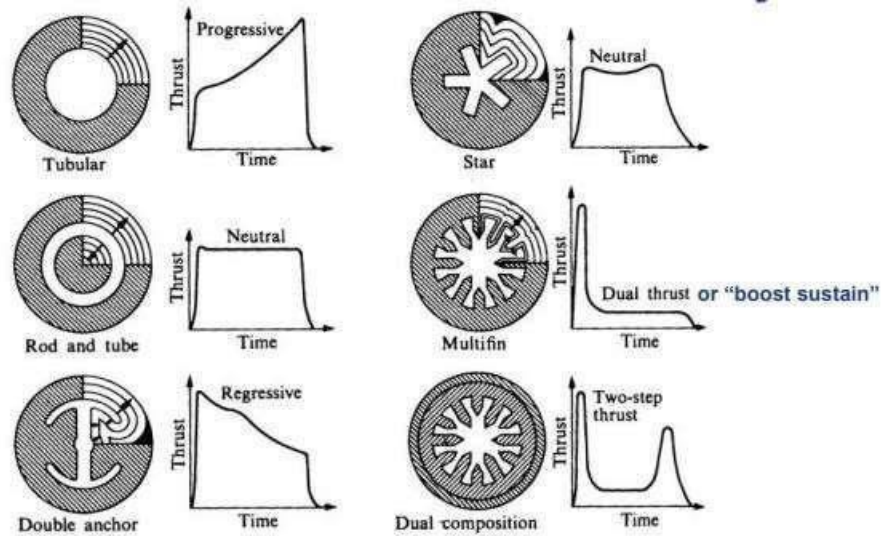


Fig 1.3.1.3.1 Piobert's Law

Smokeless fuel responses happen in a progression of zones or stages as the response continues from the surface into the solid. The most profound segment of the solid encountering heat transfer melts and starts stage change from solid to gas in a foam zone. The vaporous charge decays into less complex particles in an encompassing fizz zone.

Endothermic changes in the foam zone and fizz zone require energy at first given by the groundwork and in this manner delivered in a glowing external fire zone where the less complex gas particles respond to shape ordinary burning items like steam and carbon monoxide

1.3.1.4 PARAMETERS OF THE ROCKET:

1.3.1.4.1 COMBUSTION:

It is an exothermic response including fast oxidizing responses. The ignition wonder of solid fuels are substantially more mind boggling than those of gas in light of the stage changes engaged with going from a solid to a liquid to a gas.

1.3.1.4.2 PROPELLANT:

It is characterized as the material which creates countless vaporous atoms at high temperature during burning which can self-support without the presence

of surrounding oxidiser ignition. At the end of the day fuel is a material which consumes quickly yet doesn't detonate and is self-supporting during consuming.

Significant applications of propellants are in rockets and weapons the two of which use gas at high pressure and temperature to create propulsive powers. Rockets comprises of propellant and combustion chamber inside their projectile, though firearm projectile typically don't. The solid rockets work at working pressure factors somewhere in the range of 10 and 300 atm. A rocket engine is an average illustration of an energy transfer framework which can be straightforwardly clarified by thermodynamics and Newton's third law - A compressed high temperature gas created in the framework is extended adiabatically and the reasonable energy of the gas is changed over to active energy. Consequently, the framework delivers a response power. In this manner, the thermodynamic prerequisite for rocket engine is to get a high pressure factor and high temperature gas in the engine, and to change over the reasonable energy adequately into the motor energy through physicochemical cycles. Subsequently, temperature in the chamber, atomic load of combustion gases and proportion of explicit heats are the presentation boundaries. Be that as it may, these boundaries can't be estimated. Henceforth these boundaries are changed over to the accompanying parameters.

1.3.1.4.3 CHARACTERISTIC VELOCITY:

In the figure of value of the charge, It relies on the burning fire temperature and sub-atomic weight of burning gases. It addresses the burning effectiveness of fuel.

1.3.1.4.4 THRUST COEFFICIENT:

It depends upon the expansion ratio of the nozzle.

1.3.1.4.5 SPECIFIC IMPULSE:

Thrust per unit weight flow time of propellant.

1.3.1.4.6 GRAVITY:

The local gravity can be determined from the equation

$$g_o = g_e \left[\frac{R_e}{R_e - h} \right]^2 \quad g_o = \text{Local gravity (m}^2/\text{s)} \quad g_e$$

= Gravity of the Earth

R_e = Radius of the Earth (km)

H = Altitude from the mean sea level (km)

1.3.1.4.7 BURNING RATE:

It is a distance, normal to the burning surface of the propellant, travelled by a flame front per unit time. It is a key factor in determining the performance of solid propellant. Since the gas generation in the chamber is a function of the propellant burning and mass discharge through the nozzle. Under steady state condition, RHS of equation vanishes. However, this term plays a dominant role in ignition transients, burning, and combustion termination.

The time of mass discharge is given by which is purely a fluid dynamical relation. The time of gas generation in the combustion chamber is equal to the mass burning time of the propellant. The combustion index n can never exceed one and it is desirable to have low or even a negative value. If n is smaller than one, after a small increase in pressure the mass flow through the nozzle becomes greater than the mass burning time and the pressure returns towards equilibrium. The smaller the value of n , the quicker the return. On the other hand, if n is greater than unity, the mass burning time exceeds the discharge time and pressure increases until an explosion occurs. Inversely following a negative differential, the pressure continues to drop until combustion stops. Therefore, stable burning can only be achieved if the combustion index n is smaller than one.

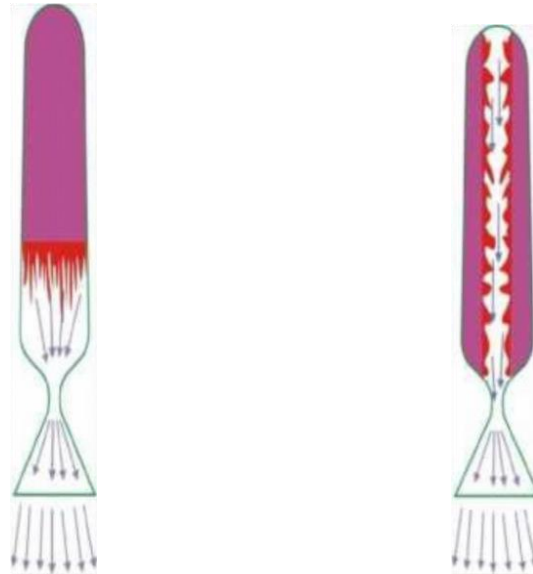


Fig 1.3.1.4.7 Burning Time

1.3.1.5 PROPELLANT (FUEL) FAMILIES:

1.3.1.5.1 BLACK POWDER PROPELLANTS:

Black powder (explosive) is made out of charcoal as fuel, potassium nitrate as oxidizer, and sulphur (fuel and impulse). It is one of the most established pyrotechnic arrangements with application to rocketry. In current occasions, black powder discovers use in low-power model rockets, (for example, Estes and Quest rockets), as it is modest and genuinely simple to create. The fuel grain is ordinarily a combination of squeezed fine powder (into a solid, hard slug), with a burn time that is profoundly reliant upon precise piece and working conditions. The exhibition or Specific Impulse of black powder is lower approximately around 80 sec. The grain is touchy to break and, accordingly, disastrous disappointment. Black powder doesn't commonly discover use in engines over 40N.

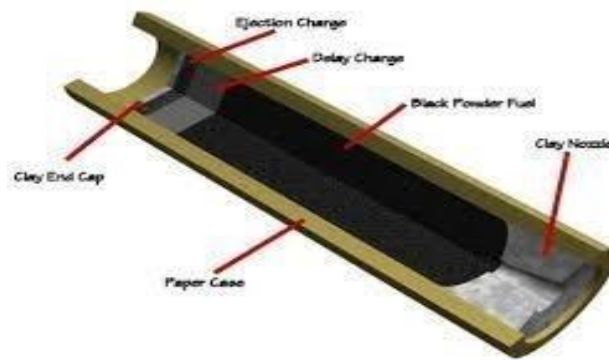


Fig 1.3.1.5.1 Black Powder (gunpowder) fuel

1.3.1.5.2 ZINC–SULPHUR (ZS) PROPELLANTS :

Made out of powdered zinc metal and powdered sulphur as oxidizer, Zinc-Sulphur or "micro grain" is another squeezed fuel that doesn't locate any common application outside particular amateur rocketry circles because of its lackluster and quick straight burn times on the request for 2 m/s. Zinc-Sulphur is frequently utilized as a curiosity force as the rocket quickens amazingly rapidly giving up a breath-taking enormous orange fireball it.

1.3.1.5.3 CANDY PROPELLANTS:

All in all, rocket candy propellants are an oxidizer is potassium nitrate and a sugar fuel that are projected into shape by delicately dissolving the propellant constituents together and pouring or pressing the amorphous colloid into a form. Candy forces produce a low to medium specific impulse around 130s and, consequently, are utilized fundamentally by test rockets.



Fig 1.3.1.5.3 Candy propellants

1.3.1.5.4 DOUBLE-BASE PROPELLANTS:

Double-Base propellant are two monopropellant fuel segments in which one commonly goes about as a high-energy monopropellant and different goes about as a lower-energy stabilizing monopropellant. In regular conditions, dynamite broken into a nitrocellulose gel and hardened added substances. Double-Base fuels are actualized in applications insignificant smoke is required at this point medium-high performance is required. The expansion of metal energy (like aluminium) can expand the exhibition (around 250s), however metal oxide nucleation in the exhaust can turn the smoke opaque.

1.3.1.5.5 COMPOSITE PROPELLANTS:

Oxidizer and metal fuel in powdered form are personally blended and immobilized with a rubbery binder. Composite propellant is regularly either ammonium perchlorate-based or ammonium Nitrate-based. Ammonium Nitrate composite propellant frequently utilizes Magnesium(Mg) as well as aluminium as fuel and conveys medium performance though ammonium perchlorate composite propellant regularly utilizes aluminium fuel and delivers high performance. Aluminium is utilized as fuel since it has a sensible explicit energy thickness, a high volumetric energy thickness, and is hard to touch off coincidentally. Composite propellants are projected, and hold their shape after the elastic cover, for example, Hydroxyl-ended polybutadiene, crossjoins with the guide of a corrective added substance. Due to its superior, moderate simplicity of assembling, and moderate expense, APCP finds broad use in space rockets, military rockets, side interest and beginner rockets, while less expensive and less proficient ANCP discovers use in amateur rocketry and gas generators. Ammonium dinitramide, $\text{NH}_4\text{N}(\text{NO}_2)_2$, is being considered as a 1-to-1 without chlorine substitute for ammonium perchlorate in composite propellants. Not at all like ammonium nitrate, ADN can be fill in for AP without a misfortune in engine execution.



Ingredients	Percentage by weight	
	Mix1	Mix2
Al (22 μm)	23.0	19.0
RDX (5 μm)	10.0	33.0
AP (200 μm)	36.4	23.1
AP (20 μm)	15.6	9.90
HP4000D	5.69	5.75
BuNENA	8.00	8.00
HX 878	0.20	0.20
2-NDPA	0.25	0.25
N100	0.86	0.80

Fig 1.3.1.5.5 Composite propellants

1.3.1.5.6 HIGH-ENERGY COMPOSITE PROPELLANTS:

Average HEC propellants start with a standard composite fuel combination and include a high-energy which can act as an explosive along with everything else. This additional segment in which the small quantity of RDX or HMX, the two of which have higher energy than ammonium perchlorate (AP). Regardless of an unassuming expansion in specific impulse, usage is restricted because of the expanded dangers of the high explosives added substances.



Fig 1.3.1.5.6 High-energy composite (HEC) propellants

1.3.1.5.7 COMPOSITE MODIFIED DOUBLE BASE PROPELLANT:

Composite changed double-base propellants start with a dynamite/nitrocellulose double-base propellant as a binder and add solids regularly utilized in composite fuels. The ammonium perchlorate covers up the

requirement of oxygen presented by utilizing nitrocellulose, improving the general specific impulse. The aluminium improves specific impulse just as burning stability. High performing propellants, for example, Trident II D-5 uses NEPE-75 as a fuel, SLBM supplant the greater part of the AP and polyethylene glycol-bound HMX, further expanding specific impulse. The blending of composite and double base force fixings has gotten so basic as to obscure the utilitarian meaning of double base fuels.

1.3.1.5.8 MINIMUM-SIGNATURE (SMOKELESS) PROPELLANTS:

Quite possibly the most dynamic regions of solid fuel research is the advancement of higher-energy, least mark fuel utilizing $C_6H_6N_6(NO_2)_6$ CL-20 nitroamine, which has 20% higher energy per density and 14% higher energy mass than HMX. The new propellant has been effectively evolved and tried in strategic rocket engines. The fuel is non- contaminating: corrosive free, solid particulates free, and lead free. It is likewise smokeless which has just a weak stun precious stone example that is obvious in the usually straightforward exhaust. Without the bright fire and dense smoke trail created by the burning of aluminized fuels, these smokeless charges everything except take out the danger of parting with the situations from which the rockets are terminated. The new CL-20 fuel is stun unfeeling (peril class 1.3) rather than current HMX smokeless charges which are exceptionally detonable (danger class 1.1). CL-20 is viewed as a significant discovery in strong rocket charge innovation however presently can't seem to see boundless use since costs stay high.

1.3.1.5.9 ELECTRIC SOLID PROPELLANTS:

Electric solid propellants are a group of plastisol solid propellants which can be lighted and choked by the utilization of electric flow.

Dissimilar to regular rocket engine forces that are hard to control and douse, ESPs can be touched off dependably at exact spans and terms. It does have any moving parts and the propellant is insensitive toward electrical sparks.

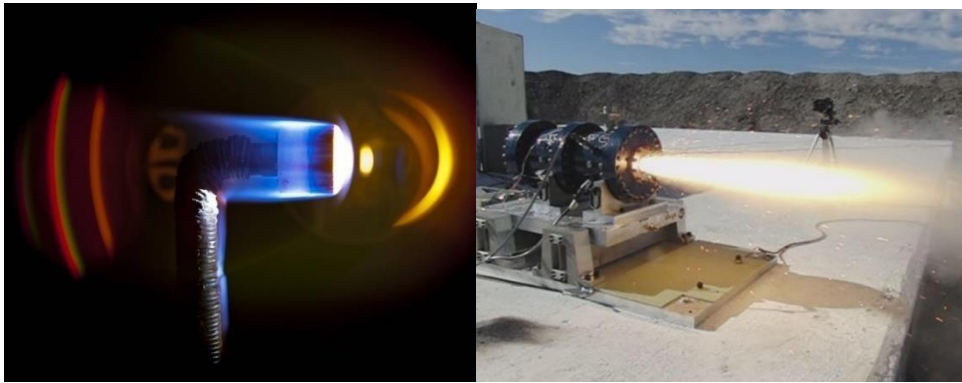


Fig 1.3.1.5.9 Electric solid propellants

1.3.2 LIQUID PROPELLANT:

While the solid rocket is in everyday use for most sorts of strategic and vital military rocket, the liquid fuel rocket has numerous benefits. The most significant of these are the capacity to stop, restart and choke the rocket, higher energy levels, and the capacity to cool the spout basically and without any problem. Therefore, the liquid propellant rocket is overall use as a space drive engine, and it is alluring for some military applications, giving that the capacity and dealing with issues of the liquid propellant can be survived.

Liquid Propellants. The constituents of liquid propellants are like strong fuels in that they contain a fuel and an oxidizer. Furthermore, they may likewise contain an impetus to help substance response, and a dormant added substance, like water, for cooling purposes. They normally vary from solid fuels in that these constituents are generally conveyed in isolated tanks and are just united in the combustion chamber for the consuming measure. There are in any case, a few sorts of charge accessible:

1.3.2.1 MONOPROPELLANT:

A monopropellant is a charge containing oxidant and fuel in a solitary substance. It very well might be a combination of a few mixtures, for example, hydrogen peroxide and alcohol, or a homogeneous charge, for example, nitromethane.

1.3.2.2 BIPROPELLANT:

A bipropellant is a propellant where an oxidant and fuel are conveyed independently from each other, and just blended in the combustion chamber. Since more tanks are included, this is a more convoluted framework than the monopropellant, however most of liquid propelled rockets use bipropellant systems of the fact that they are more lively.

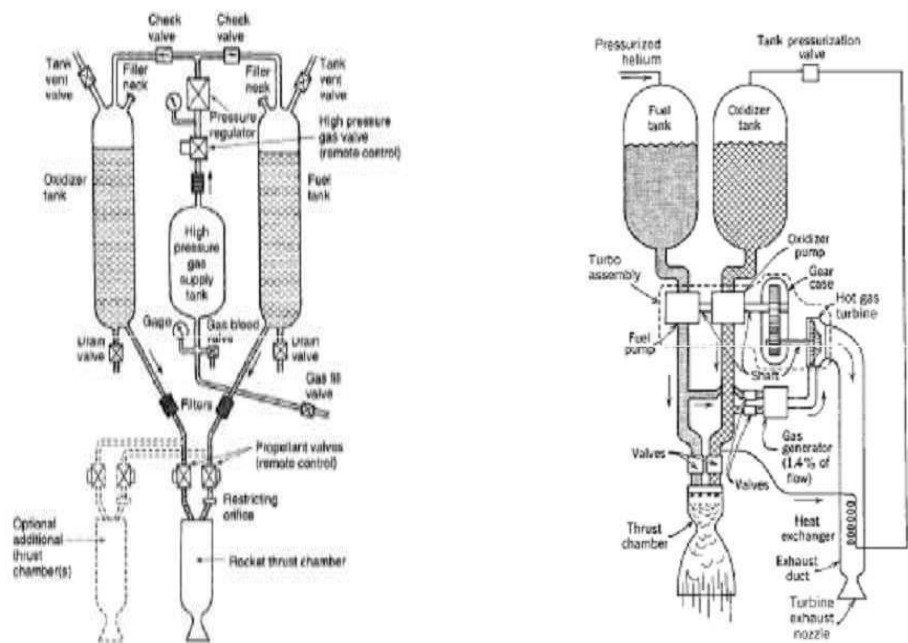


Fig 1.3.2 Liquid Propellant

1.3.3 HYBRID PROPELLANTS:

Hybrid propellant motors address an intermediate among solid and liquid propellant motors. One of the substances utilized is solid, generally the fuel, while the other, typically the oxidizer, is liquid, despite the fact that switch hybrid, for example, liquid hydrogen igniting with solid oxygen have been considered. Such motors have a execution like that of solid propellants, yet the burning can be directed, halted, or even restarted. It has a preferable specific impulse over solid rocket motors.

The liquid oxidizer is infused into the solid, whose fuel case additionally fills in as the combustion chamber. An igniter begins the burning cycle, which creates heat to disintegrate the surface layer of solid fuel. The growing hot fuel gas extends

away from the solid surface and meets the splash of liquid oxidizer; the ignition measure proceeds in a self-supporting way. The hot fuel gas layer and the burning layer fill downstream in a limit layer design until they converge at the centreline at almost five distances across from the underlying station. Eventually, on the request for a several breadths the downstream way, the oxidizer supply has been completely utilized and no further ignition can be kept up. This represents the combustion measure in a hybrid engine. Ordinarily, the fuel is a polymeric hydrocarbon solid like HTPB and the oxidizer can be any of the oxidizers utilized with liquid bipropellant motors (hydrogen peroxide). HTPB has gradually burning times, in this manner various openings, or ports, uncovering more surface region of the fuel for consuming are added. Lamentably, such countless openings make the solid fuel fundamentally frail also, subject to hazardous separation as the combustion chamber develops pressing factor and gas stream. Examination on new fills has been conveyed out. It is hard to utilize this idea for enormous pushes, thus hybrid propellant rockets are applied to missions requiring choking, restart, or long-haul fuel capacity.

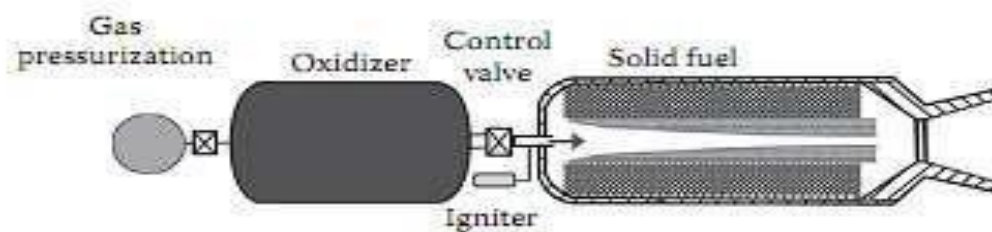


Fig 1.3.3 Hybrid Propellants

CHAPTER-2

LITERATURE SURVEY

- Braedyn D. Hutchison performed this project and figured out which sugar among Sucrose, Glucose, and Fructose settles on the most ideal decision of sugar fuel for sugar-based solid propellant engines. Gain insight with materials, gear, strategies, and security insurances essential for proceeding with research with higher-energy composite and electric solid fuels that are important for present day launch, orbital, and space tasks.
- Robert Eliason, Eric J. Lee et al. studied that the sucrose and potassium chlorate show has been altered to give a more secure start strategy and to expand its astounding nature. A splendid rocketlike fire can be created via completing the response in a short piece of covered pipes pipe. We discovered that response blends relating to stoichiometric molar measures of the reactants produce the least debris. Brilliantly hued blazes likewise can be created by blending the fitting colorizing salts and powdered polyvinyl chloride with the response combination. Plans for response combinations and for colorizing salt blends are introduced. To evaluate the level of openness to colorizing salts by a crowd of people, the percent of metal salt that is disintegrated was examined.
- Garima GUPTA, Lalita JAWALE, MEHILAL, Bikash BHATTACHARYA carried out this project determine burning rate of fuels assumes an indispensable part along the boundaries that controls the activity of solid rocket engines, in this way, this is significant to accurately measure the burn time in the effective plan of a solid rocket engine.
- Atwood, T. L. Boggs et al. carried out to study burn time information are given regard to starting temperature and pressing factor for 3 compounds that are right now utilized in propellant and dangerous definitions. The reliance of burning time on starting temperature furthermore, pressure is introduced for ammonium perchlorate, HMX, and RDX. Information for fixings being thought for cutting edge forces, for example, CL-20, ammonium dinitramide (ADN), and hydrazinium

nitroformate are likewise introduced and contrasted with the more traditional compounds. These fixings are for the most part equipped for self-deflagration, and their behaviour most of the time controls the behaviour of the propellants in which they are the main ingredients.

- Antônio Carlos Foltran, Diego Fernando Moro et al, performed “Burning Time Measurement of KNSu Propellant Obtained by Mechanical Press”.
- The potassium Nitrate (KNO_3)/sucrose ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) propellant, known as KNSu, is generally utilized in rocket concentrates by novice gatherings. Execution trial of KNSu, whose synthesis is 65 wt% KNO_3 and 35 wt% $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, cold-produced by mechanical press, are introduced. The investigation decides the conduct of density (ρ) and burning time (r) as function of pressure (P_c) for the fuel grain producing. 44 examples were arranged and tried, for seven distinct estimations of P_c . It was seen that ρ and r rely upon P_c , as indicated by quadratic polynomial capacities, and the mass motion per unit region is a consistent.
- S. Krishnan, R. Jeenu “Combustion Characteristics of AP/HTPB Propellants with Burning Time Modifiers”. Fe_2O_3 , copper chromite impetus (CC), LiF, and CaCO_3 are the four burning time changing added substances considered in this examination. A wide assortment of sub atmospheric flares are noticed for the propellants with added substances. Under sub atmospheric pressures a dark zone is available; this zone gets thicker at lower pressure and with better ammonium perchlorate (AP) particles. A seething surface without a gas-stage fire is noted for the added substance Fe_2O_3 . From the smoke stores, acquired from the sub atmospheric consuming of forces with burning time enhancers, it is shown that the breakdown of substantial fuel atoms is better with better AP particles. The low-pressure deflagration limit is diminished by the expansion of Fe_2O_3 or CC and expanded by the expansion of LiF or on the other hand CaCO_3 . Within the sight of LiF or CaCO_3 , over certain added substance focus levels, decrease in AP molecule size is found to push down the consuming time further. LiF, underneath certain fixation levels, goes about as a burning time enhancer up to a specific pressing factor and as a depressant from there on. The kind of added

substance impacts the pressing factor at which the state of burning AP surface changes from arched to sunken and furthermore the pressing factor at which the AP surface breaks comparative with the mean surface.

- Tamir Hasan, Jay Phillips performed “Potassium Nitrate Based Rocket Propulsion”. Tried rocket motors, fluctuating the proportions of two principle
- parts of the fuel – the fuel and the oxidizer. The examinations were conveyed out by means of tests in which the rocket motor was mounted spout end-up in a test stand, so when the motor was ignited it pushed down against a power plate, used to create a diagram of push versus time. Simultaneously, strain measures and temperature sensors were put along the rocket packaging body to gauge chamber pressure, case pressure, and case temperature.
- Magnus Mar Gudnason performed “Characterization of Potassium Nitrate-Sugar Alcohol Based Solid Rocket Propellants”. Standard KN-Sorbitol, KNErythritol and KN-Mannitol charges with 65/35 oxidizer/fuel proportion were casted into 8x8x100 mm measured strands for strand burner tests at pressing factors of 0 to 10 MPa. The utilization of a pressing factor alleviation valve for arrival of burning gases was contemplated. Consume time coefficient a what's more, pressure type n for KN-Sorbitol, KNErythritol and KN-Mannitol solid fuels were resolved as 5.132 mm/s/MPa and 0.222, 2.903 mm/s/MPa and 0.395, and 5.126 mm/s/MPa and 0.224, separately. The essential goal of these examinations is to give data on the burning time of sugar liquid fuels.

CHAPTER-3

AIM AND SCOPE

3.1 AIM:

To investigate and study the burning time on solid propellant with different propellant and catalyst.

3.2 SCOPE:

3.2.1 OBJECTIVE:

A solid propellant motor test was conducted in order to determine the favourable oxidizer/fuel (O/F) ratio, measured burning time at various temperatures and oxidizer and fuel ratios. A series of 6 test were conducted use potassium nitrate as common oxidizer with various fuel ingredients like Fructose, Glucose and Lactose, using catalysts like Copper and Aluminium powder. The burning time of catalysts copper were compared with burning time of aluminium catalyst. Finally, it resulted that the longest burning time of Fructose with Copper Powder and Potassium Nitrate and highest temperature resulted in Lactose with Copper Powder and Potassium Nitrate.

CHAPTER- 4 MATERIALS AND METHODS

4.1 MATERIALS:

4.1.1 PROPELLANT:

A fuel or propellant is a synthetic substance utilized in the creation of energy or compressed gas that is consequently used to make development of a liquid or to produce drive of a rocket, projectile, or other object.

4.1.2 FUEL:

Fructose, Glucose and Lactose are considered as a fuel in this experiment. Minuscule fructose, glucose and lactose particles catch fire in a flash due to their high proportion of surface area to volume.

4.1.3 OXIDIZER:

Potassium Nitrate is considered as an oxidizer in this experiment. Potassium nitrate replaces the requirement for oxygen and occupies considerably less space, which leaves the blast alone more stronger and quicker. It is a fundamental element of explosive. Potassium Nitrate is additionally utilized in rocket fuel for a similar explanation as in explosives, then again, actually the objective is to allow the fuel to burn longer, not quicker.

4.1.4 CATALYST:

Copper and Aluminium Powder were used as catalyst because they are metals and have tendency to increase the burning time.

4.1.5 THERMOCOUPLE SENSOR:

K type thermocouple (MAX6675) is a sensor which has capacity to temperature up to 1020 degree Celsius.

This might be a immersion sensor, a surface sensor, wire or another style of sensor or cable.

4.2 FABRICATION:

4.2.1 FABRICATION OF CYLINDER:

A cylinder of outer diameter 35mm, inner diameter 25mm and of length 90mm was made of stainless steel.

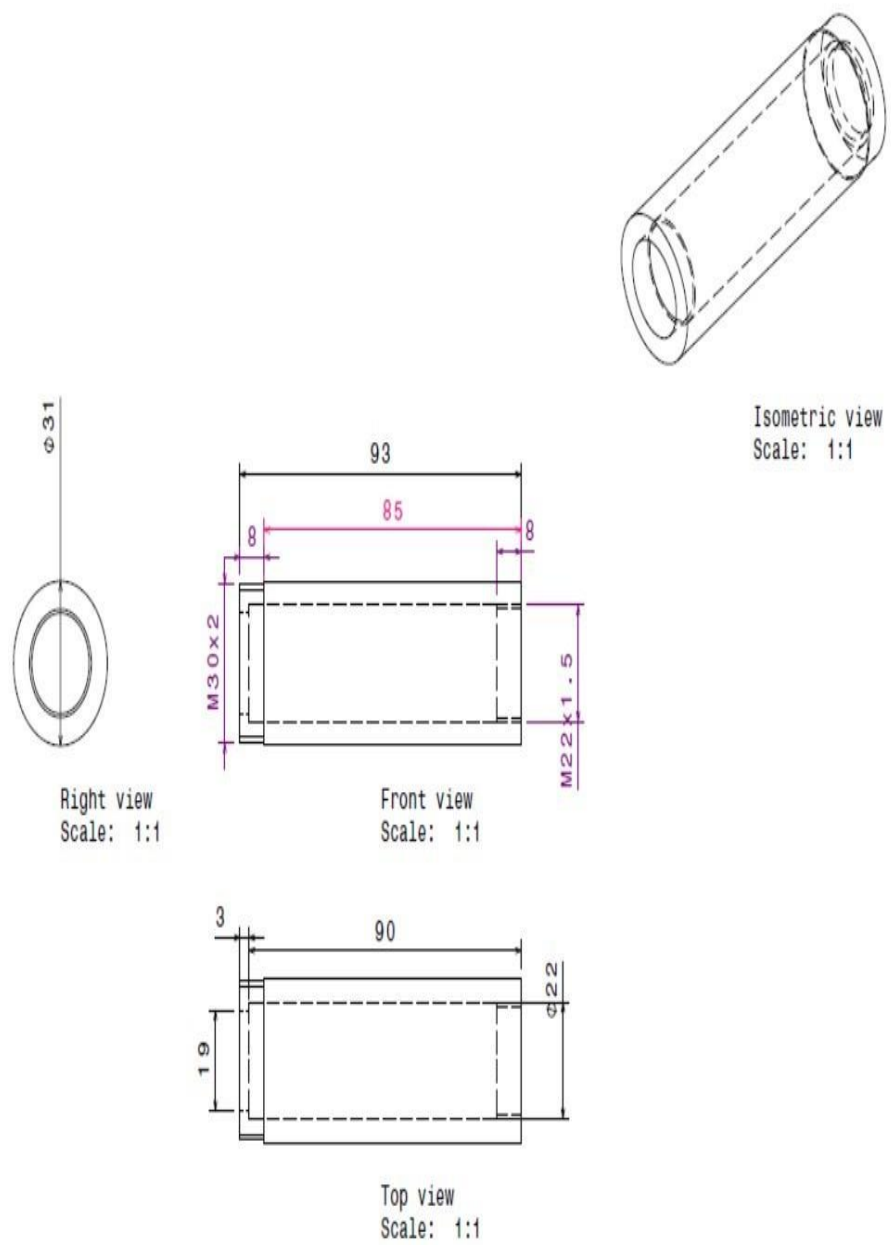


Fig 4.2.1 Cylinder Fabrication

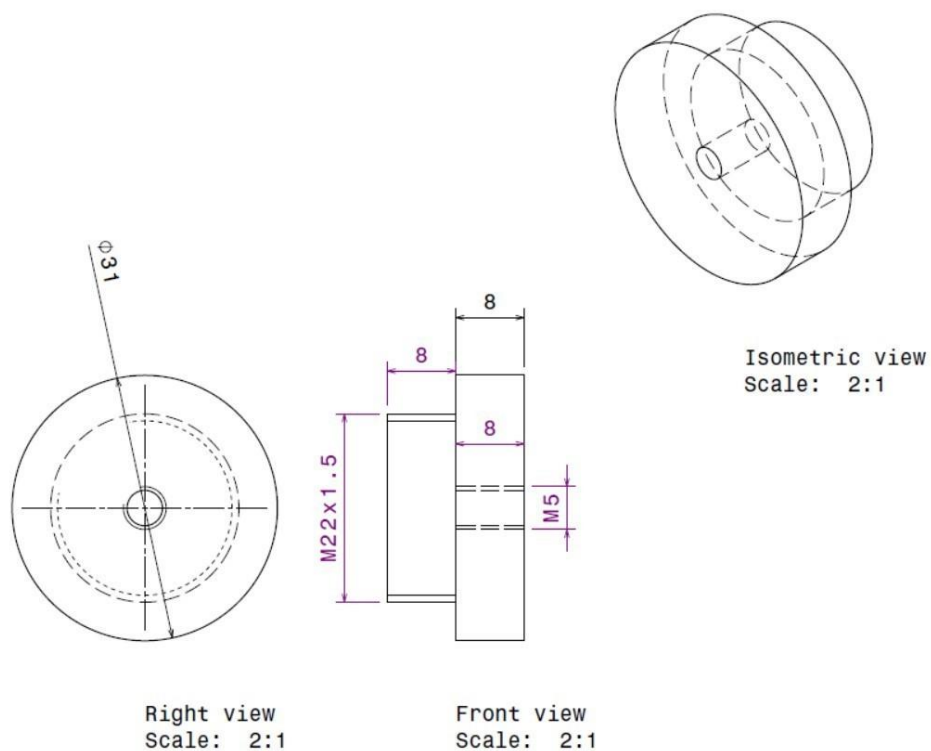


Fig 4.2.1 Cylinder Fabrication

4.2.2 FABRICATION OF PROPELLANT:

- Total mass of the propellant mixture was 35g out of which 22.75g was of oxidizer that is Potassium Nitrate (KNO_3), 11.25g was of Fuel that is Fructose/Glucose/Lactose (based on test) and 1g of catalyst was used that is copper/aluminium in powdered form (based on test).
- There were 6 samples:

Sample 1 - Fructose(fuel), Copper(catalyst) and Potassium Nitrate(oxidizer)

Sample 2 - Glucose(fuel), Copper(catalyst) and Potassium Nitrate(oxidizer)

Sample 3 - Lactose(fuel), Copper(catalyst) and Potassium Nitrate(oxidizer)

Sample 4 - Fructose(fuel), Aluminium(catalyst) and Potassium Nitrate (oxidizer)

Sample 5- Glucose(fuel), Aluminium (catalyst) and Potassium Nitrate (oxidizer)

Sample 6- Lactose(fuel), Aluminium (catalyst) and Potassium Nitrate (oxidizer)

4.3 METHODOLOGY:

- An ignitor was connected to the mixture of propellant nozzle.
- At the end of nozzle k type thermocouple sensor was attached.
- Thermocouple sensor was attached to UNO Arduino which used to calibrated the input.
- This UNO Arduino was connected to laptop where the reading were noted down.

SCHEMATIC SET UP:

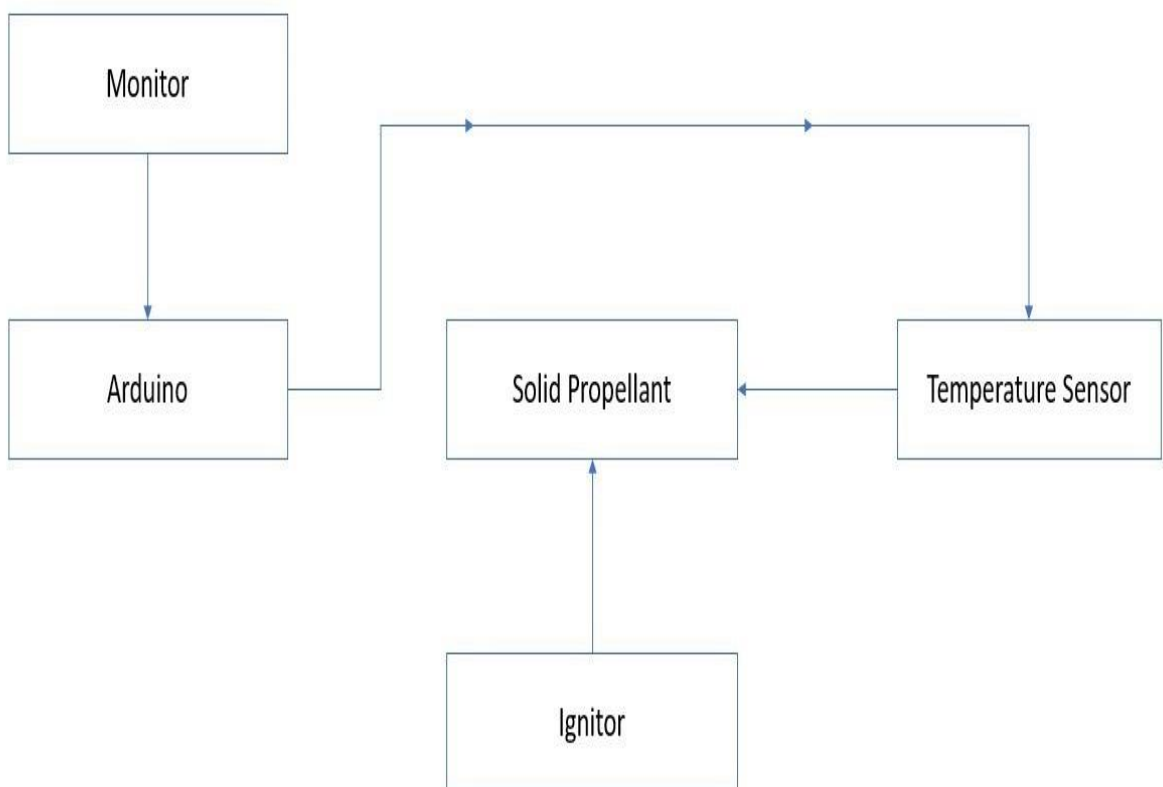


Fig 4.3 Schematic Set Up

CHAPTER-5 RESULT AND DISCUSSION

5.1 RESULT:

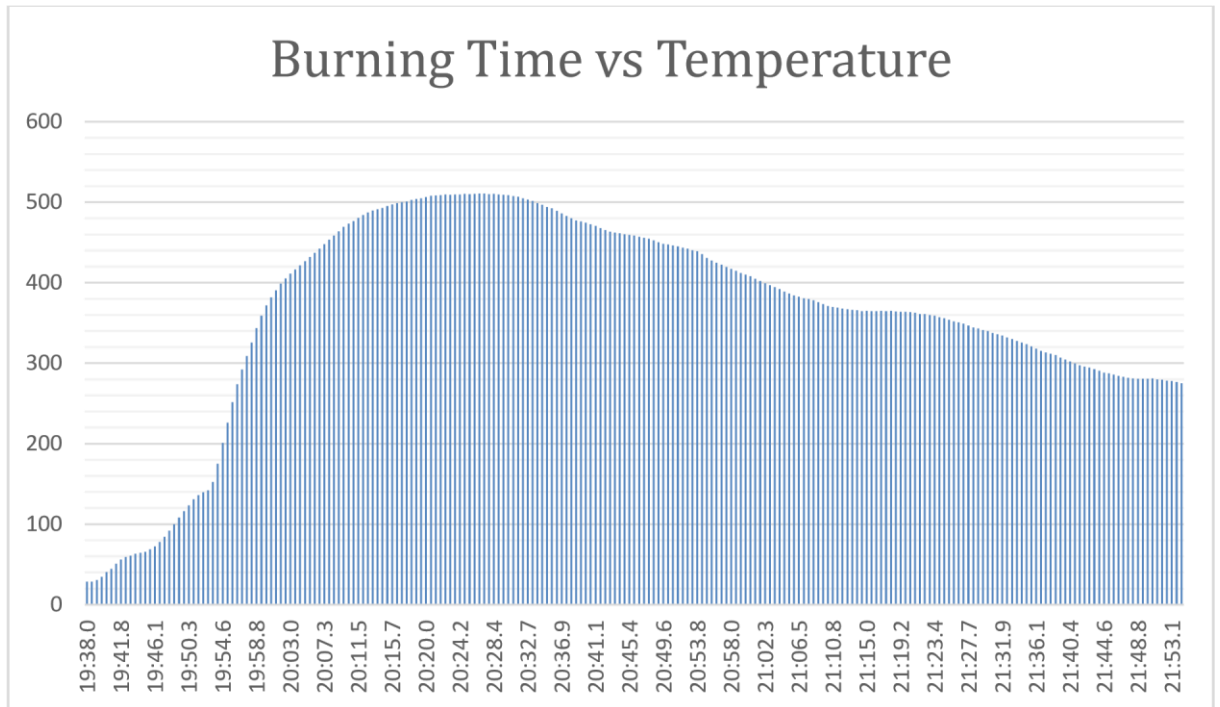
There were 6 different samples tested to calibrate temperature and burning time.



Fig 5.1 Mixture of propellant filled in cavity

5.1.1 SAMPLE 1:

In sample 1, the cavity was filled with the mixture of Fructose as a fuel, Potassium Nitrate as an oxidizer and Copper powder as a catalyst was used to increase the speed of burning time of propellant.

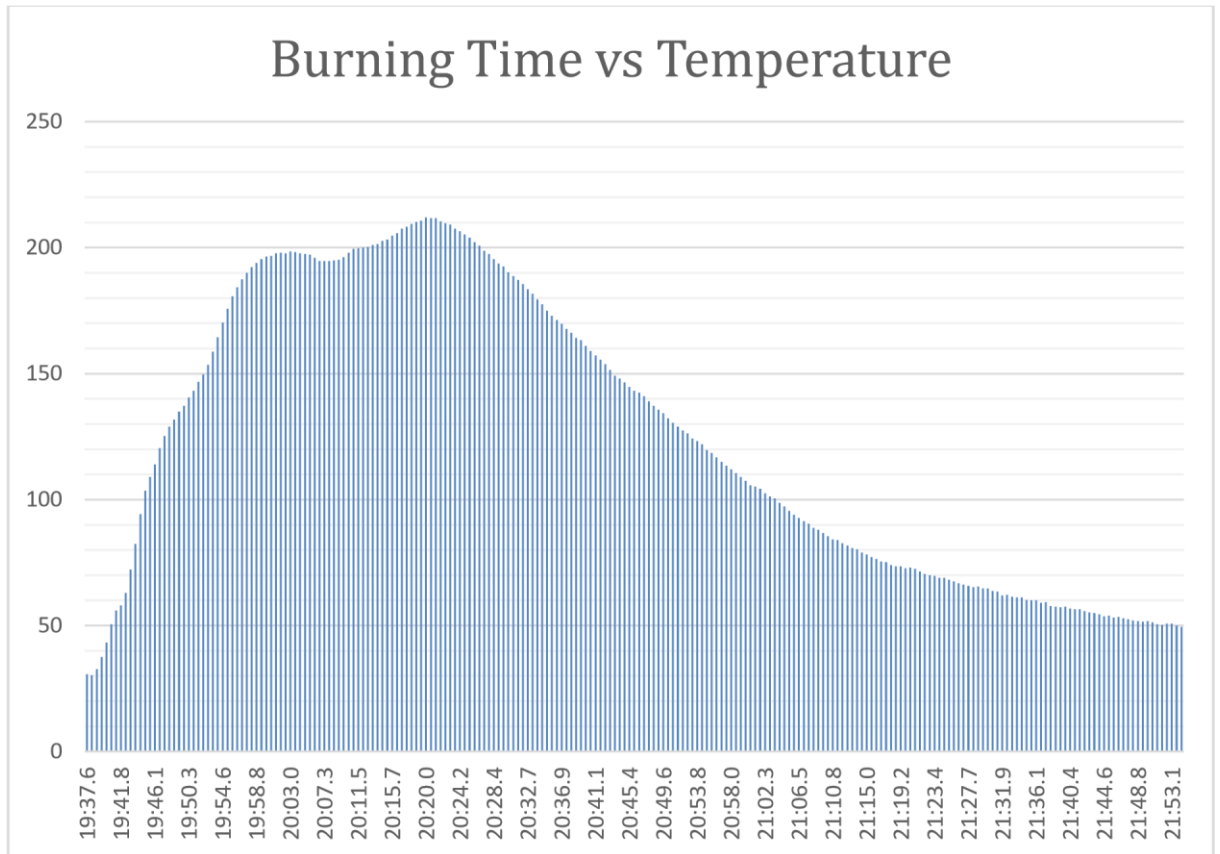


Graph 5.1.1 Sample 1

In sample 1 the maximum temperature calibrated was 510.75 degree C and the Burning Time calibrated was 137sec.

5.1.2 SAMPLE 2:

In sample 2, the cavity was filled with the mixture of Glucose as a fuel, Potassium Nitrate as an oxidizer and Copper powder as a catalyst was used to increase the speed of burning time of propellant.

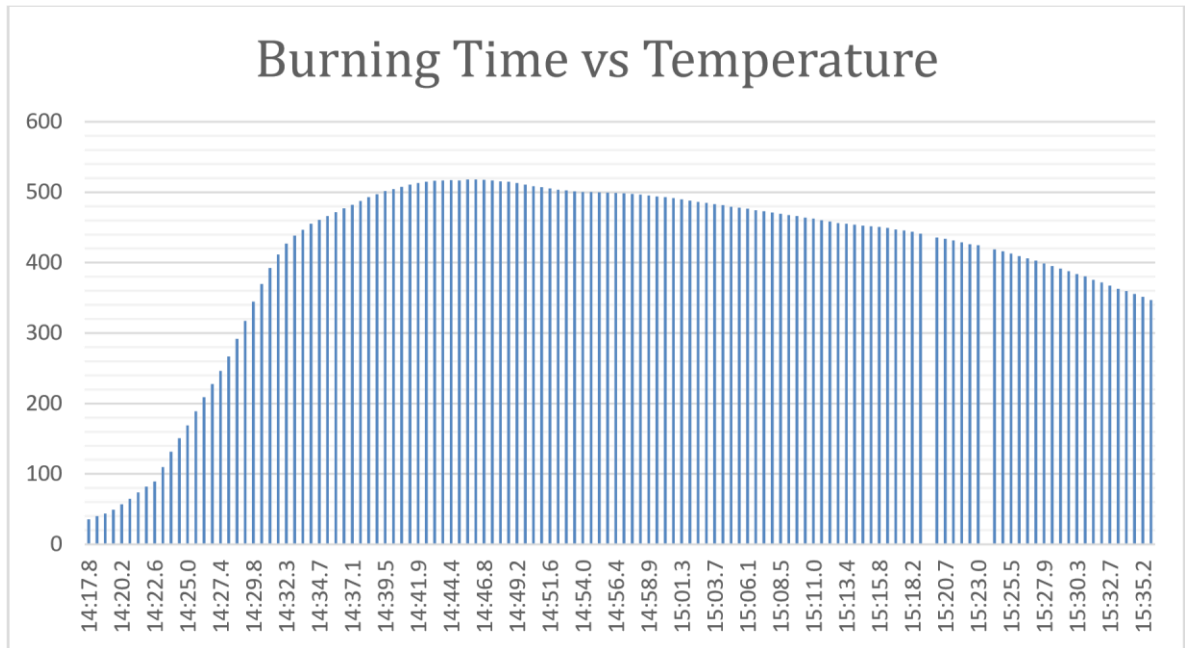


Graph 5.1.2 Sample 2

In sample 1 the maximum temperature calibrated was 211.75 degree C and the Burning Time calibrated was 136sec.

5.1.3 SAMPLE 3:

In sample 3, the cavity was filled with the mixture of Lactose as a fuel, Potassium Nitrate as an oxidizer and Copper powder as a catalyst was used to increase the speed of burning time of propellant.

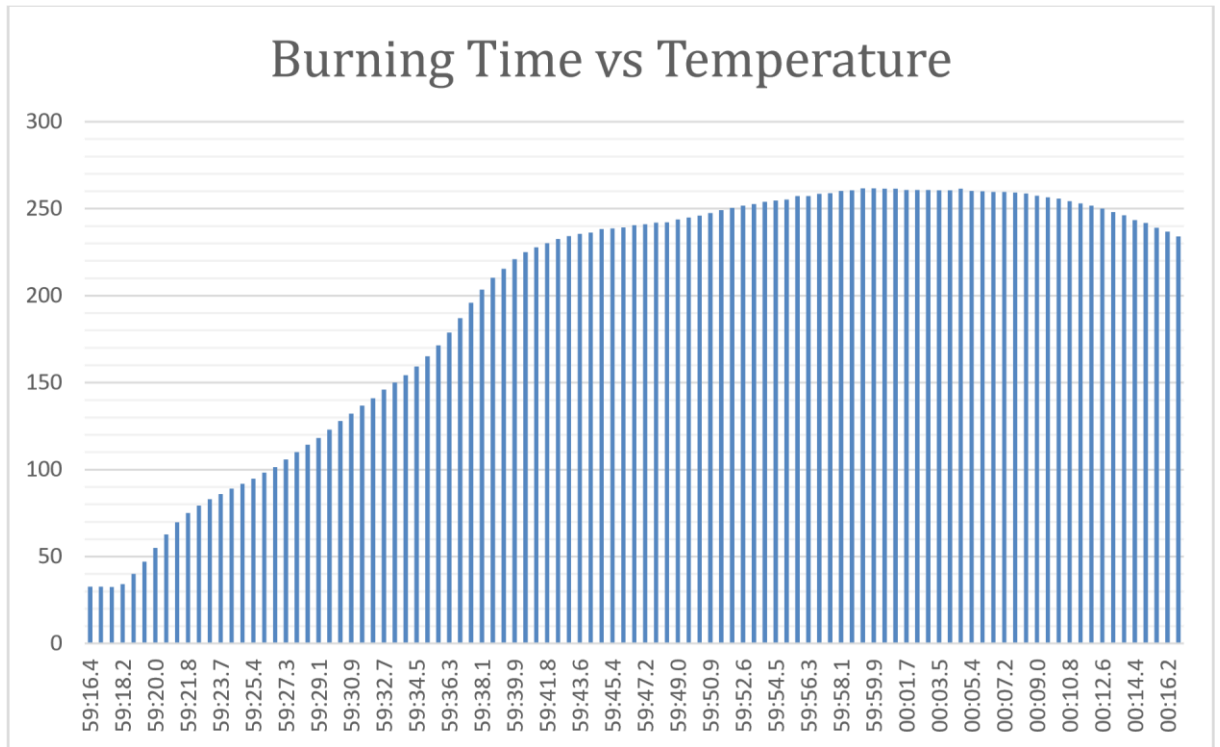


Graph 5.1.3 Sample 3

In sample 1 the maximum temperature calibrated was 518 degree C and the Burning Time calibrated was 68sec.

5.1.4 SAMPLE 4:

In sample 4, the cavity was filled with the mixture of Fructose as a fuel, Potassium Nitrate as an oxidizer and Aluminium powder as a catalyst was used to increase the speed of burning time of propellant.

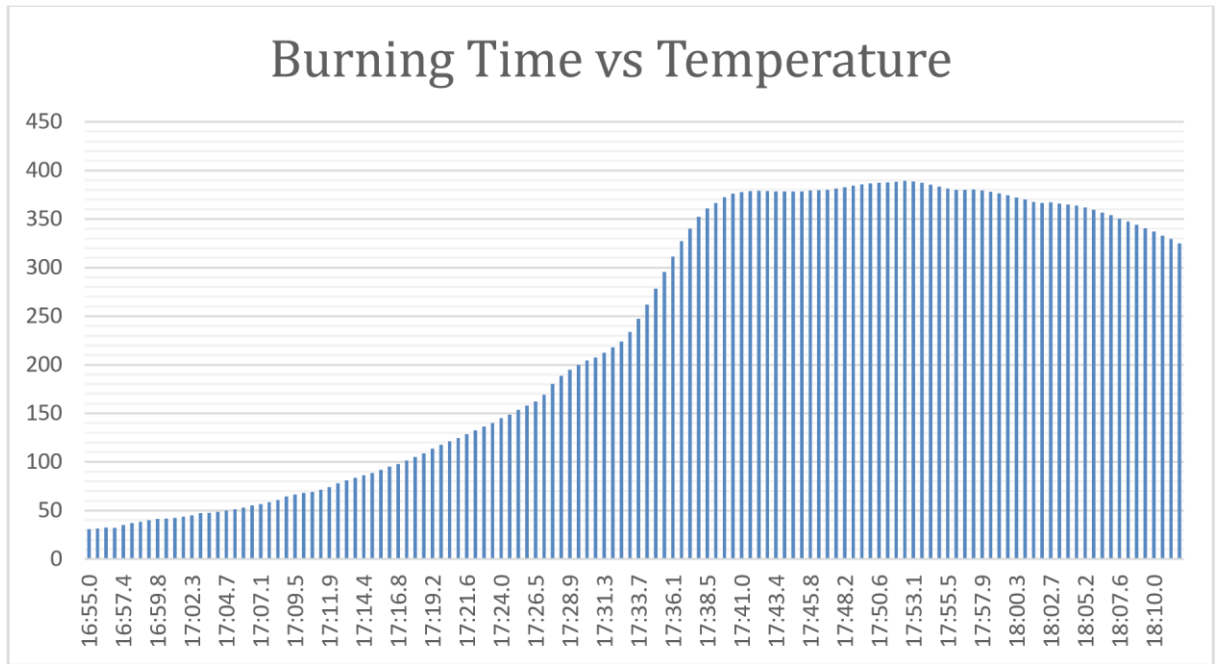


Graph 5.1.4 Sample 4

In sample 1 the maximum temperature calibrated was 261 degree C and the Burning Time calibrated was 60sec.

5.1.5 SAMPLE 5:

In sample 5, the cavity was filled with the mixture of Glucose as a fuel, Potassium Nitrate as an oxidizer and Aluminium powder as a catalyst was used to increase the speed of burning time of propellant.

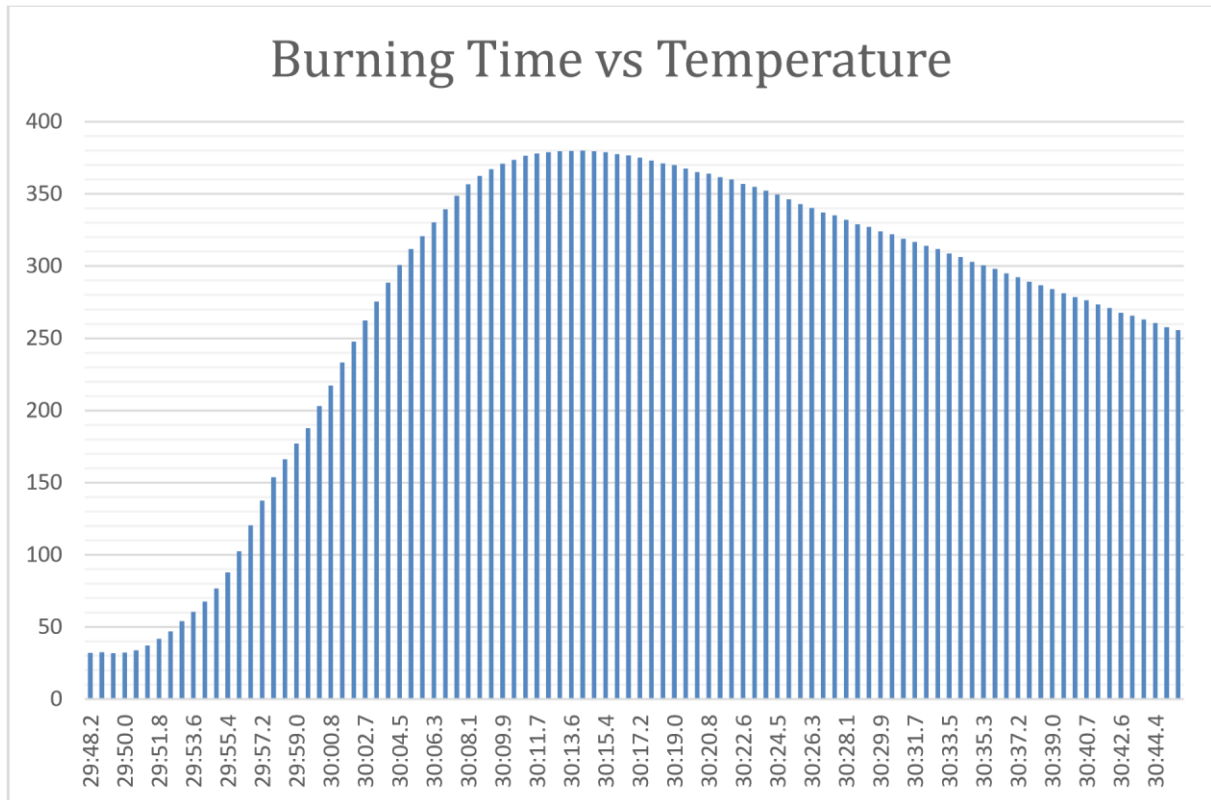


Graph 5.1.5 Sample 5

In sample 1 the maximum temperature calibrated was 388.75 degree C and the Burning Time calibrated was 76sec.

5.1.6 SAMPLE 6:

In sample 6, the cavity was filled with the mixture of Lactose as a fuel, Potassium Nitrate as an oxidizer and Aluminium powder as a catalyst was used to increase the speed of burning time of propellant.



Graph 5.1.6 Sample 6

In sample 6 the maximum temperature calibrated was 379.5 degree C and the Burning Time calibrated was 57sec.

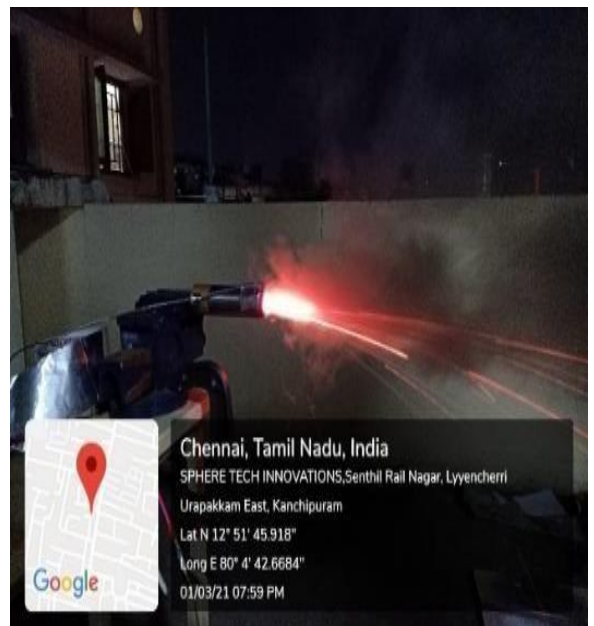


Fig 5.1 During Testing

5.2 DISCUSSION:

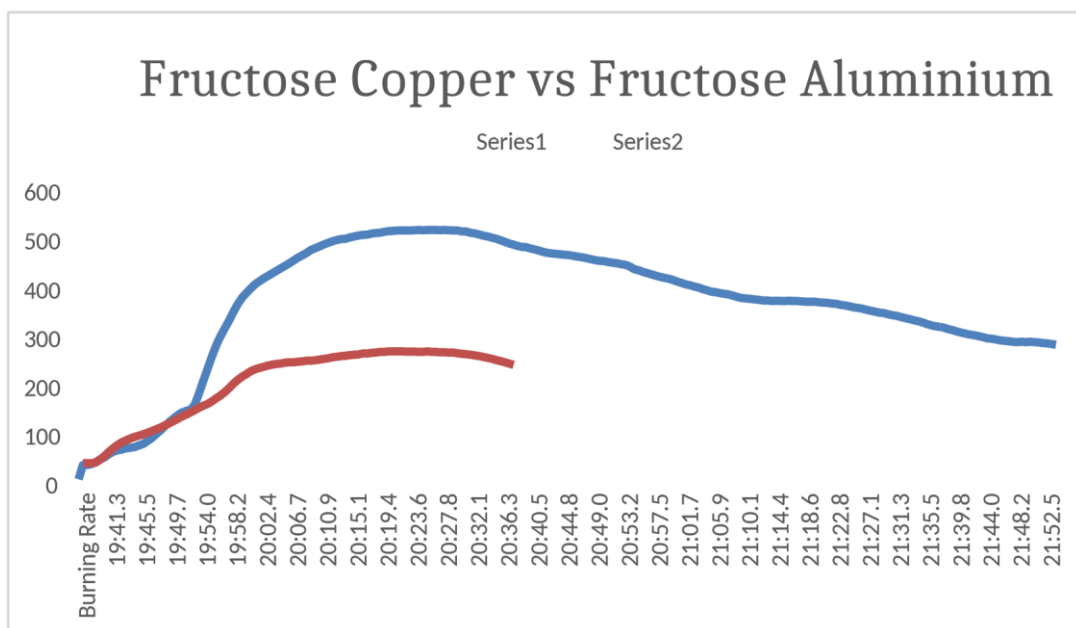
On comparing the propellants just by changing the catalyst there is vast variation on the result

5.2.1 SAMPLE 1 and SAMPLE 4:

In these 2 samples, the fuel and oxidizer is same that is Fructose and Potassium Nitrate just we have changed the catalyst i.e. Copper powder and Aluminium powder. In Sample 1 we consider Copper as catalyst and in Sample 4 we consider Aluminium as catalyst.

Table 5.2.1 Sample 1 and Sample 4

FUEL	CATALYST	OXIDIZER	TEMPERATURE (degree C) (MAX)	BURN TIME (sec)
Fructose	Copper	Potassium Nitrate	510.75	132
Fructose	Aluminium	Potassium Nitrate	261.75	60



Graph 5.2.1 Sample 1 and Sample 4

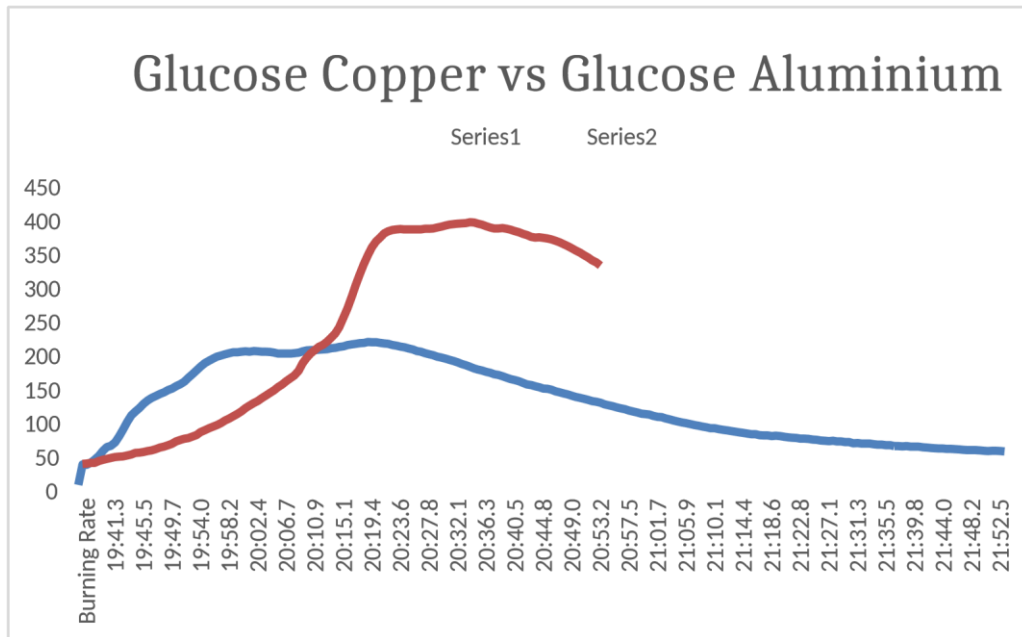
- On comparing the 2 data we can get to know that the sample which is mixed with Copper powder has higher burning time as compared to the mixture of Aluminium powder as catalyst.
- On comparing the 2 data we can get to know that the sample which is mixed with Aluminium powder has lower temperature as compared to the mixture of Copper powder as catalyst.

5.2.2 SAMPLE 2 and SAMPLE 5:

In these 2 samples, the fuel and oxidizer is same that is Fructose and Potassium Nitrate just we have changed the catalyst i.e. Copper powder and Aluminium powder. In Sample 1 we consider Copper as catalyst and in Sample 4 we consider Aluminium as catalyst.

Table 5.2.2 Sample 2 and Sample 5

FUEL	CATALYST	OXIDIZER	TEMPERATURE (degree C) (MAX)	BURN TIME (sec)
Glucose	Copper	Potassium Nitrate	211.75	136
Glucose	Aluminium	Potassium Nitrate	388.75	76



Graph 5.2.2 Sample 2 and Sample 5

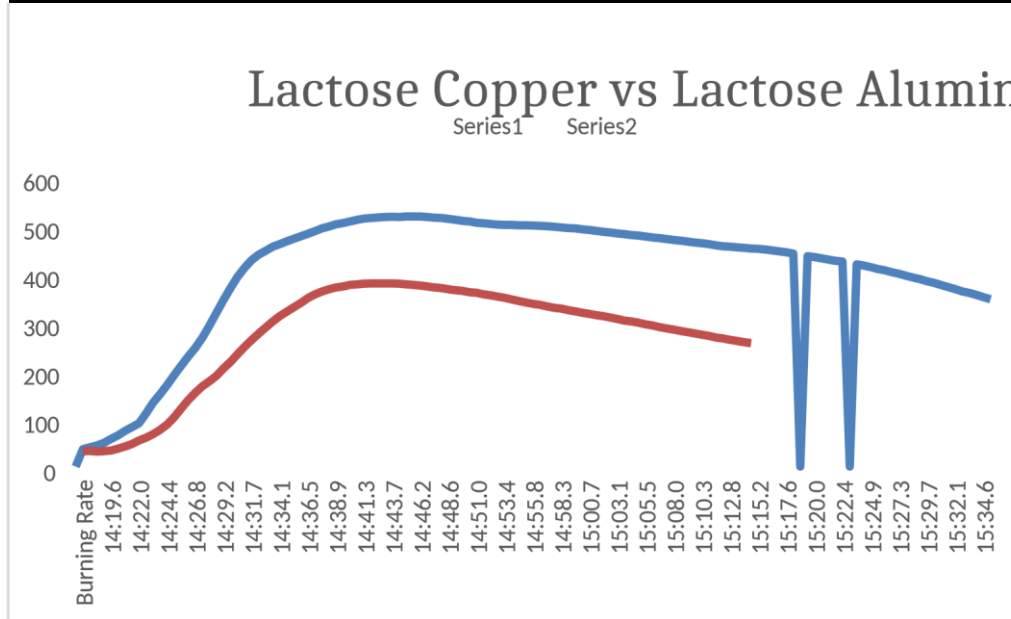
- On comparing the 2 data we can get to know that the sample which is mixed with Copper powder has higher burning time as compared to the mixture of Aluminium powder as catalyst.
- On comparing the 2 data we can get to know that the sample which is mixed with Aluminium powder has higher temperature as compared to the mixture of Copper powder as catalyst.

5.2.3 SAMPLE 3 and SAMPLE 6:

In these 2 samples, the fuel and oxidizer is same that is Fructose and Potassium Nitrate just we have changed the catalyst i.e. Copper powder and Aluminium powder. In Sample 1 we consider Copper as catalyst and in Sample 4 we consider Aluminium as catalyst.

Table 5.2.3 Sample 3 and Sample 6

FUEL	CATALYST	OXIDIZER	TEMPERATURE (degree C)(MAX)	BURN TIME (sec)
Lactose	Copper	Potassium Nitrate	518	68
Lactose	Aluminium	Potassium Nitrate	379.75	57

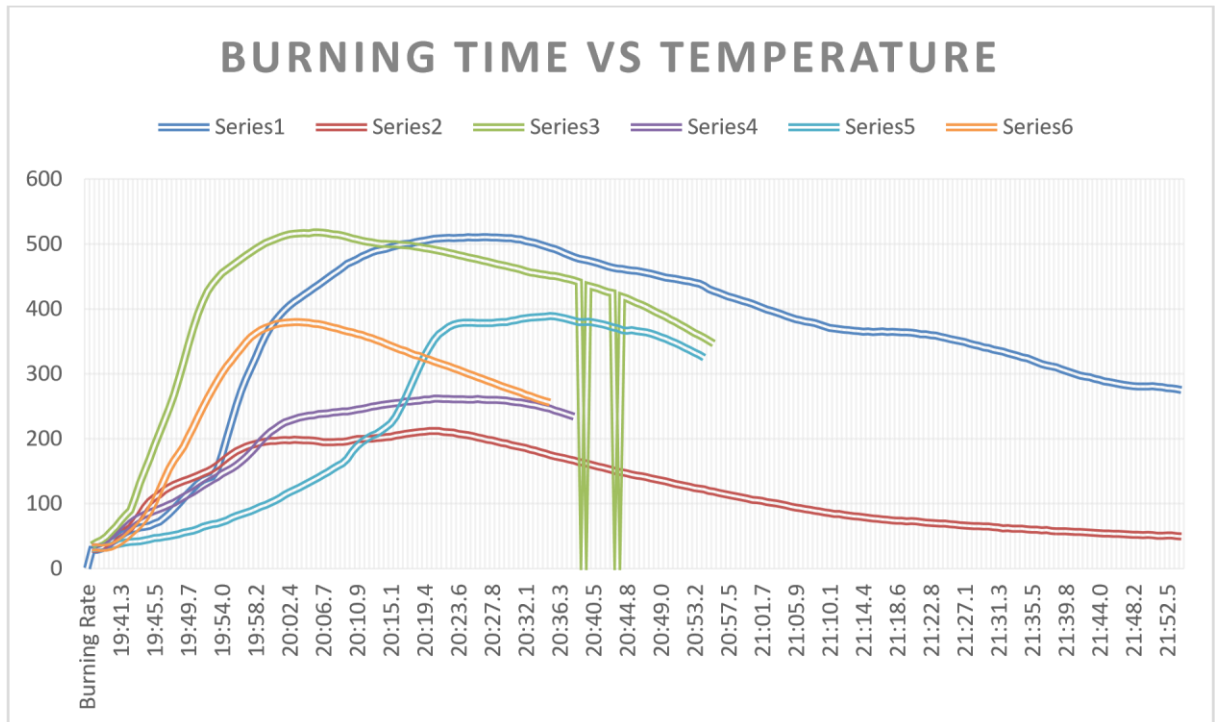


Graph 5.2.3 Sample 3 and Sample 6

- On comparing the 2 data we can get to know that the sample which is mixed with Copper powder has higher burning time as compared to the mixture of Aluminium powder as catalyst.
- On comparing the 2 data we can get to know that the sample which is mixed with Aluminium powder has lower temperature as compared to the mixture of Copper powder as catalyst.

5.2.4 COMPARISION OF ALL THE RESULT:

All the Samples burning time and temperature are calibrated and are represented in this graph.



Graph 5.2.4 Comparing all the propellants

On comparing the all the Samples we came an conclusion:

- Shortest burning time Lactose with Aluminium Powder and Potassium Nitrate i.e., 57mm/sec
- Longest burning time Fructose with Copper Powder and Potassium Nitrate i.e., 132mm/sec
- Lowest temperature Fructose with Aluminium Powder and Potassium Nitrate i.e., 261.75°C
- Highest temperature Lactose with Copper Powder and Potassium Nitrate i.e., 517.75°C



Fig 5.2 After Testing

5.3 COMPUTATIONAL ANALYSIS:

Below Figure shows the maximum temperature reaching up to 7.9090×10^2 K at the exit of the exhaust.

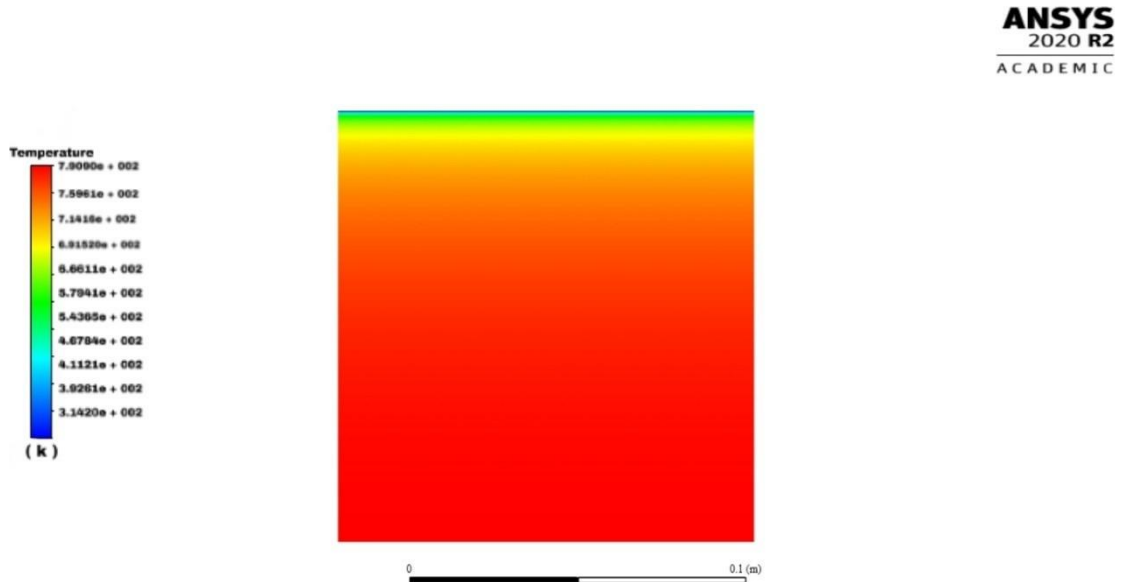


Fig 5.3 Temperature at exit of the exhaust

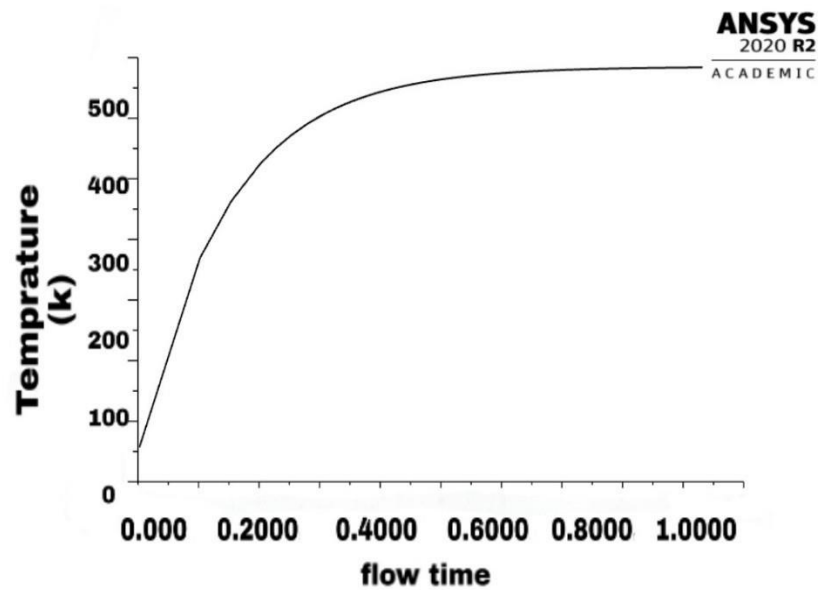


Fig 5.3 Temperature and flow time graph

CHAPTER-6

SUMMARY AND CONCLUSION

Considering safety, in this investigation of burning time with solid propellant with potassium nitrate (KNO_3) as a main oxidizer was taken as dry granules and fuel ingredients fructose, glucose, lactose and the catalyst copper and aluminium mixtures was taken in powdered form. solid propellant with KNO_3 as main oxidizer with fuel ingredients like fructose, glucose, lactose and catalysts copper and aluminium were taken in a powdered form. Investigation of burning time was observed. We found that highest burning time of fructose with copper powder and KNO_3 ran out unto 132 sec when compared to smallest burning time of lactose with aluminium powder and potassium nitrate mixture unto 57 sec. The highest temperature of lactose with copper powder and potassium nitrate went unto 517.75 degree Celsius when compared to the lowest temperature of the mixture fructose with aluminium powder and KNO_3 unto 261.75 degree Celsius. The combustion time of a solid fuel depends highly on the mode of preparation, particularly the granulometry, the degree of dryness, etc. We conclude that with the simplest way of preparation and with easily available ingredients comparatively with lesser cost, the burning time of solid propellants with different propellant, lactose with copper dominating as catalyst and kno_3 combination proved to be the best solution and hence can be used as environmental friendly even for the economically backward countries can develop solid rocket propellants.

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