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An Investigation on Waste Plastic Materials for Hydro Carbon Fuel Production Using Alternative Energy and Design and analysis of carbon fiber mono leaf spring

Capstone Project-II Report submitted in

Partial fulfillment for the award of the Degree of

BACHELOR OF TECHNOLOGY

Submitted by

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IN

MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

Under the Supervision of

GALGOTIAS UNIVERSITY

(Established under Galgotias University Uttar Pradesh Act No. 14 of 2011)

PROF. LAVPREET SINGH

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GALGOTIAS UNIVERSITY

SCHOOL OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

Certified that this project report **"An Investigation on Waste Plastic Materials For Hydro Carbon Fuel Production Using Alternative Energy and Design and analysis of carbon fiber mono leaf spring"** is the bonafide work of "**SHREYANSH KUMAR GUPTA (18021011941), RAHUL KATIYAR (18021011978)"** who carried out the project work under my supervision.

SIGNATURE OF DEAN

SIGNATURE OF SUPERVISOR

APPROVAL SHEET

This thesis/dissertation/project report entitled titled **An Investigation on Waste Plastic Materials For Hydro Carbon Fuel Production Using Alternative Energy and Design and analysis of carbon fiber mono leaf spring** by **"SHREYANSH KUMAR GUPTA (18021011941), RAHUL KATIYAR (18021011978)"** is approved for the degree of bachelor of technology in mechanical engineering.

Examiners

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Date: ___________

Place: __________

Statement of Project Report Preparation

1. Project report title: **"An Investigation on Waste Plastic Materials for Hydro Carbon Fuel Production Using Alternative Energy and Design and analysis of carbon fiber mono leaf spring".**
2. Degree for which the report is submitted: BACHELOR DEGREE OF TECHNOLOGY.
3. Project Supervisor was referred to for preparing the report.
4. Specifications regarding thesis format have been closely followed.
5. The contents of the thesis have been organized based on the guidelines.
6. The report has been prepared without resorting to plagiarism.
7. All sources used have been cited appropriately.
8. The report has not been submitted elsewhere for a degree.

(Signature of the student)

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ABSTRACT

Plastic is the most often used material in everyday life due to its light weight, durability, and flexibility. There is a deposit of polymer that has incorporated strongly in plastic, causing recycling problems. Plastic degradation has a significant influence on the environment and plants. Plastic pyrolysis is the most effective method for converting wasted solid plastics into hydrocarbon fuels. The materials from spilled plastic and commercial methods for fuel generation were discussed in the present work. The use of alternative energy systems such as solar thermal collectors are able to provide the temperature for solid plastic boiling while reducing the need of high-grade energy in the form of electricity. The solar integrated fuel system helps to reduce hazardous emissions and map the path to a de-carbonized economy.

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An Investigation on Waste Plastic Materials for Hydro Carbon Fuel Production Using Alternative Energy Sources

1. INTRODUCTION

Nowadays plastic is very essential in day-to-day life and its use in the industrial field is steadily increasing. The production and consumption of plastic are increasing at alarming rates as the human population grows, the economy expands, cities continue to grow, and lifestyles change. On the Global basis, plastic production is approximate to be around 300 million tonnes/ year, and it is steadily increasing. The vast majority of unused plastic has ended up in landfills; Because of its Plastic waste has caused major environmental concerns due to its vast volumes and disposal issues. In the presence of a catalyst, reprocessed unused plastics are expected to be the most effective method of recovering and using. Significant research have been found by the Ioannis Kalargaris and Guohong Tian.,Shikui Wu, Kaixiong Xu done experiment using from (PEVA)Plastic, where they input as (LDPE) and (EVA) for locating oil during which ensures that the engine runs smoothly [1].It is observe that trash plastic fuel has properties comparable to fossil fuel like diesel, petrol, natural gas . [2,3] experimented with the technique of cracking mixtures of different hydrocarbon feedstock in a steam pyrolysis furnace, the application of trash plastics and petro-oils, is 402°C with a pressure of about 2.0 MPa(max.), and it was discovered that trash plastic and petro-oil cracking has a better efficiency in I.C engines than petroleum. [4]

2. LITERATURE REVIEW

2.1 PLASTIC WASTE IS A SERIOUS ISSUE: EGYPT

As per supply chain mapping and evaluation of plastic, "Egypt engenders around twenty million loads of garbage and waste annually, with plastic waste postulated to represent 6 June 1944 out of the entire, distributed over Cairo (60%), Alexandria (16%), the river Delta (19%), and different regions together with Upper Egypt, Suez Canal, and Sinai (5%). Out of the 970 kilotons of plastic waste engendered annually, solely a variety of half-hour is recycled, whereas five-hitter is reused, thirty third is land filled, and thirty second is left to be burned". Overall amplitude of waste of the plastic accounts for 100% of all trash in EGYPT. One-fifth of the total amount of plastic is not mobilized or land filled. This amounts to 1.3 million tonnes in Egypt each year, with Cairo contributing only 0.78 million tonnes. When plastic garbage is burned, it emits hazardous dioxins (very poisonous compounds) that could possibly be ingested by Homo-sapiens, collected in soil and on plants, and collected in surface dihydrogen oxide. Remaining/uncollected plastics endanger animals and ocean life [5]. In the Middle East, there are various effective waste management strategies in use. This investigation focuses on the utilization of plastic trash for generation of fuel. The current approach reduces the amount of solid trash for landfills and the amount of carbonic acid gas emissions caused by plastic garbage in Egypt by roughly 8 May 1945 for the primary year, and by half an hour for the primary 5 years. Furthermore, it may reduce the high demand. Surprisingly, the carbon discharges by this plastic waste based fuel are 93% lower than those generated by fossil fuel like petrol and diesel. The catalyst of the plastic waste is available by using transformation method, some of the catalyst mixture of minerals like mineral, clay, alumina, and silicates in various proportions [6, 7].The three forms of transformation reactions are slow, timesaving and flash shift. The time interval and temperature of the biomass are distinguishing factors. [8].The primary byproducts of this method are char and gas. Temperature and heating rate pressure, and duration all influence the proportion of the byproduct. [9]

The feasibility of using trash to create a successful fuel processing system by combination of several synthetic polymer matrix composites with various functions from (HDPE), (PET),(PS), and (PP) is calculated in this study. This work successfully disposes of the trash of these undesirable materials which are not easily degradable synthetic polymers and have negative impact on environment & health by converting them to fuel via pyrolysis. This process would be extremely beneficial to the fuel industry because It would make the process more long-lasting. In this context, fuel and bio refinery study will be crucial in future.5.01 percent, resulting in smaller particle size and a faster reaction rate. [11] The ratio of plastic to catalyst is 20:2. The inclusion of the catalyst reduces both the process time and the pyrolysis temperatures, resulting in higher conversion rates across a wide range of products. The pyrolysis of low- & high-density polyethylene attempt under thermal pyrolysis environment this process minimizes the process time and improves fuel quality and possibility of wide range of plastic fuel.

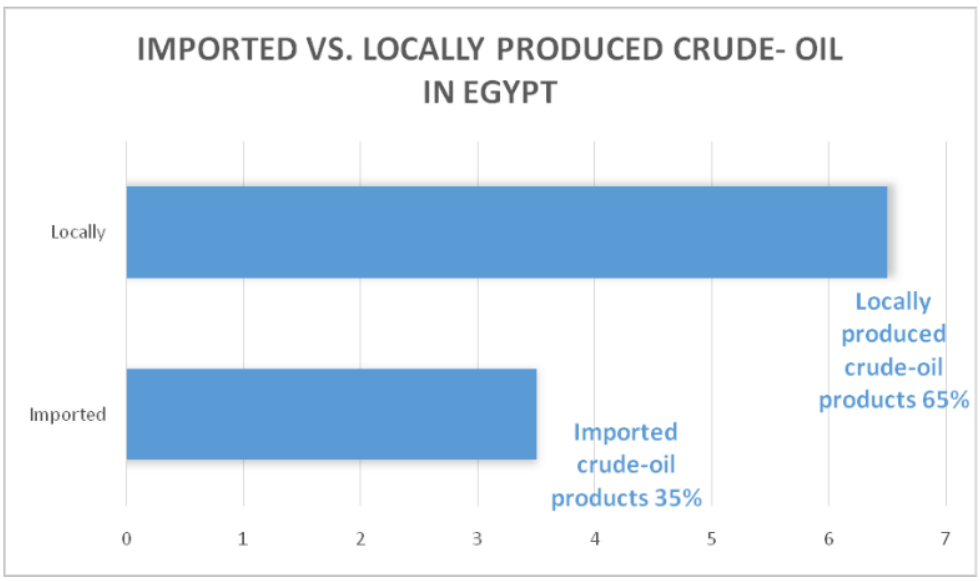


Fig. 1.Crude oil states (fuel production and import) in Egypt.

2.2 INDUSTRIAL PYROLYSIS PROCESS:

At first, the plastic trash goes through process like cleaning, drying, and reducing in size; rapid pyrolysis process is available for fuel extraction from unused plastic plastics like HDPE, LDPE, and PET. Food and mouthwash containers include polyethylene terephthalate. Polypropylene can be found in plastic containers like food storage, yogurt, parts of automotive, thermal vests, and diapers disposals etc. Polystyrene can be found in food containers, utensils, and straws etc. To limit the amount of plastic in the reactor, the waste is shredded and crushed into little pieces (1x3 cm2). To remove any potentially dangerous materials, the plastic parts are washed. The required catalyst is Zeolite Socony Mobil-5 (ZSM-5), a high-silica zeolite that is commonly used in the petroleum industry as a heterogeneous catalyst for hydrocarbon isomerization reactions. The employment of a catalyst is required. However, before breaking, it should be dried in an oven to reduce the moisture content to less than 5.01 percent, resulting in smaller particle size and a faster reaction rate. [11] The ratio of plastic to catalyst is 20:2. The inclusion of the catalyst reduces both the process time and the pyrolysis temperatures, resulting in higher conversion rates across a wide range of products. The pyrolysis of low- & high-density polyethylene attempt under thermal pyrolysis environment this process minimizes the process time and improves fuel quality and possibility of wide range of plastic fuel.

2.3 LIQUID FUEL SYNTHESIS:

Before being fed into the pyrolysis reactor, the feedstock is shredded and precisely blended with the catalyst in specific condition which is available in Table 1. The reactor is made of stainless steel and has a fixed bed. The heat is supply at rate of 15°C/minutes to 550°C/minutes. During the pyrolysis process, vapor are created first, which are collected in the form of gas in collection chamber, it gets converted into oil after pyrolysis process [12]. Condensation of these compounds yields in the form of fuel, kerosene and propane gas etc. At refineries, the previously described catalyst is utilized to convert biofuel oil to gasoline and diesel. Ships are supplied with heavy oil. One of the most essential factors in assessing a fuel's efficiency is its heat value. The characteristic difference between diesel, kerosene, bio diesel as shown in Fig.2.The heat value of the fuel engendered from plastic trash was calculable consistent with the IP 12/58 methodology. Its heat value was 9830 kcal/kg as shown in Fig 2. that is proximate to the calorific value of diesel [11–13].

An Raw material Process Type	Raw material Quantity(g)	Catalyst Quantity(g)	Raw Material Ratio	Reaction Temp. (C)	Heating Rate (C/min)	Efficiency
HDPE	5000	500	100%	550°	15	94%
PET	5000	500	100%	550°	15	70%
PS	5000	500	100%	550°	15	80%
Polypropylene	5000	500	100%	550°	15	60%
PP/PET	5000	500	50-50%	550°	15	67%
PS/PP	5000	500	50-50%	550°	15	75%
Mixed	5000	500	25% each	550°	15	85.6-89.5%

TABLE 1 Conditions of Catalyst

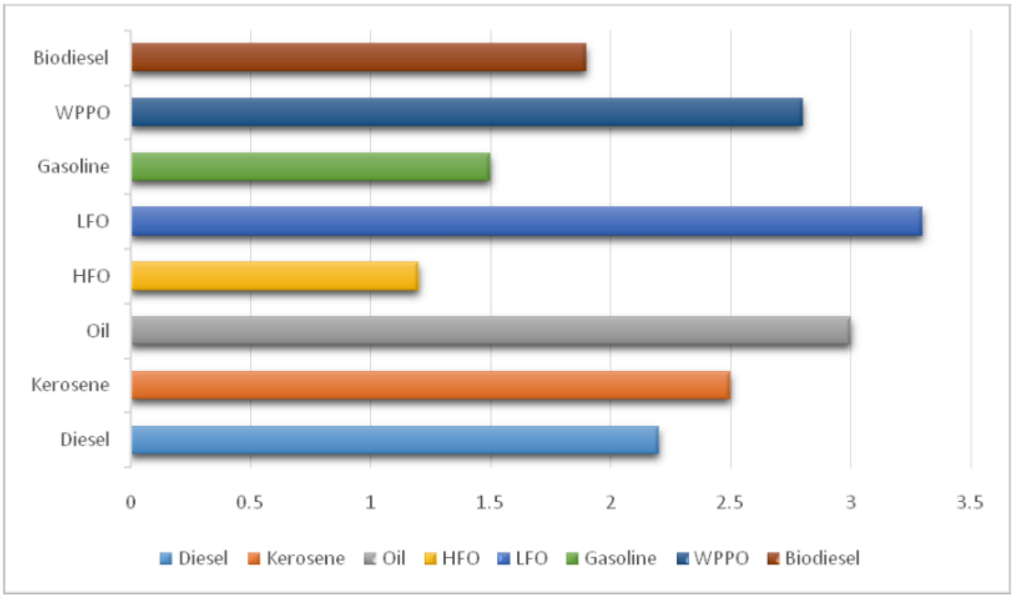


Fig 2. Characteristic difference of waste plastic fuel and other fuel [13]

2.4 Disposing of plastic waste is a major issue:

Toxic fugitive emissions are eliminated during the polymerization process.

- Burning of plastic garbage in the open is a common occurrence in cities and towns, resulting in toxic emissions such as CO, Cl, HCL, C8H8, C6H6, C4H6, CCL, and C2H4O etc. are polluting the environment.
- Unrecyclable plastic trash, such as metalized pouches and multi-layered sachets, as well as thermoset polymers like SMC/FRP, provides a number of disposal issues.
- Garbage mixed with discarded plastic which clogs 3 recycling and solid waste processing equipment and causes problems in recycling operations.

- According to the Centre, over 34 lakh tonnes of plastic garbage were generated in 2019-20, compared to 30.59 lakh tonnes in 2018-19.
- In the last five years, India's plastic trash creation has more than doubled, with an average yearly rise of 21.8%.

2.5 DEMAND OF FUEL:

The current rate of economic expansion is unsustainable unless fossil fuel is conserved. Costas A. Velis et al. [14] and John N. Hahladakis et al. Reviewed an overview of chemical composition of plastics, its release in environment effect on food chain and environmental impact and its mitigation during use recycling and disposal and found that disposal methods are more preferable by converting into another form of energy.

2.6Technical Details:

In the plastic pyrolysis process the major factor influencing the molecular distribution are Chemical compositions of plastic operating pressure rate of heating temp. of cracking types of catalyst used and type of reactor use in this process. Plastic liquid hydrocarbons at normal temperature and pressure are referred to as liquid fuel. PP, PS, and PE are being prepared as feedstock for the production of liquid hydrocarbons. Plastics are converted to liquid fuel through pyrolysis and condensation of the resultant hydrocarbon. The temperature required for transformation of plastic trash into fuel is 450C°-550C° for liquid fuel production process.The fuel result (a mixture of liquid hydrocarbons) is continuously refined once when the reaction temperature is attained, the plastics trash inside the reactor has tainted adequately to evaporate. A catalyst is used to further crack the evaporated oil; the reactor's hydrocarbons are distilled. Some high-boiling-point hydrocarbons, such as A condenser is a device that condenses kerosene, diesel, and gasoline in water. The liquid collected in the collecting chamber contains, wax, grease, and other impurities; which must be removed using filtration process therefore, the impurities must be removed. In the filtration process, colloidal substances can be removed using filter paper; the filter paper will allow molecules smaller than its pores to pass through, resulting in cleaner fuel. The purified fuel is tested to determine its chemical composition which interprets the quality and properties of the fuel. Ravishankar R [15] Roopa et al. performed the various experiment on in PP and LLDPE conversion to fuel using clay catalyst with mixing of Bentonite catalyst with polypropylene (PP) and linear low density polyethylene (LLDPE) in a batch reactor in a feed ratio of 2:8 for getting fuel oil on temperature 440–455 C° for time three hours & conclude that physical properties using Penske Martin Apparatus of oil samples such as specific gravity, density, fire point,& flash point(Redwood et al. [16] numerous concerns and challenges linked with bio waste management were explored.

2.7 SOLAR THERMAL ENERGY CONVERSION SYSTEMS-COLLECTORS MATERIAL, APPLICATION AND RESEARCH CHALLENGES:

Energy from the sun is used by the solar thermal system to increase the temperature of the heat carrying fluid which in turn is transferred to another medium of the system or process. Fossil fuels can be replaced by this type of renewable energy solutions and this can prove to be commercially economic alternative for energy generation in presence of competitive market [17, 34]. However, economic feasibility for the development of new projects is still low as the irregular solar energy necessitates an auxiliary thermal storage system which needs abundant investments to be made possible [18]. Latent heat and sensible heat are forms in which the thermal energy is stored but the phase change materials (PCM) that use latent heat mechanism, the energy density is greater than that in heat sensible materials which results in relatively smaller volume for storage [19].

Solar Thermal Collectors are the devices used for changing solar energy into thermal energy by the application of various operating principles that differ by the collector type taken in use [20]. Availability of space, degree of maturity of the analyzed technology, energy requirement and target temperature are the crucial aspects that are considered for installing a solar thermal system in industrial applications [21, 33]. Here, various low and medium temperature collectors are mentioned which are classified on the basis of use in industry and temperature ranges. Existing method is available which integrated high grade energy source with more than 5 Kw power supply. The present research tittle describe solar thermal energy based waste fuel generation system, so solar energy waste system is available.

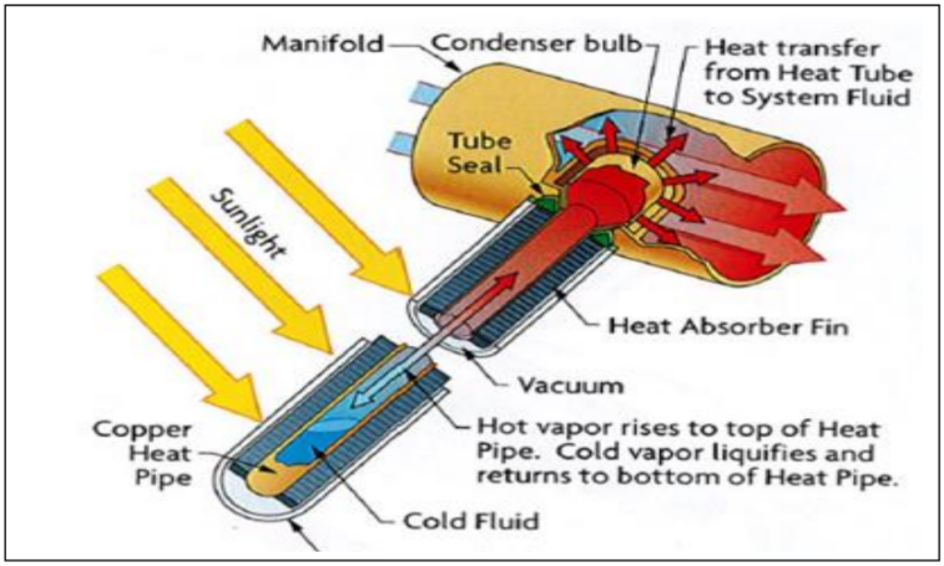
A. Low Temperature Collectors

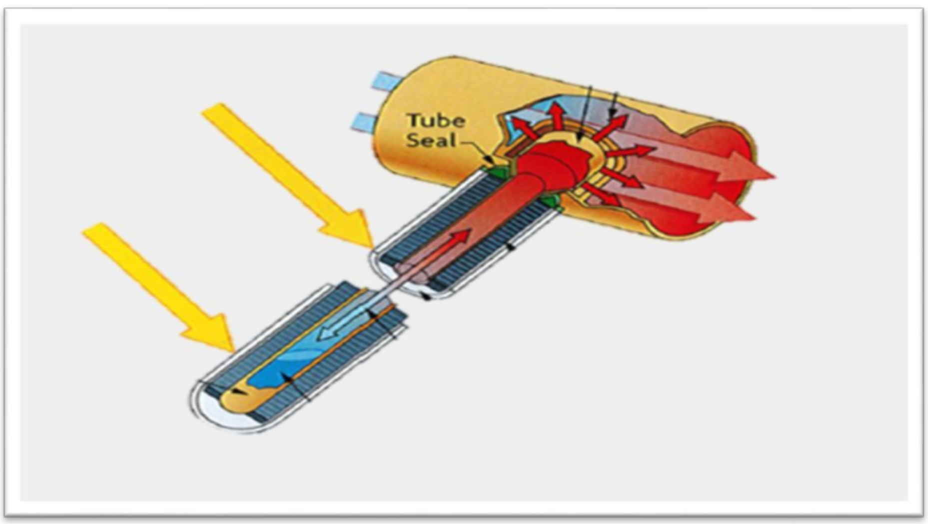
- **Flat Plate Collector (FPC):** The thermal energy is intercepted by the plate following which the heat carrying fluid circulates via tubes and reaches the storage system if it is not used directly [22].

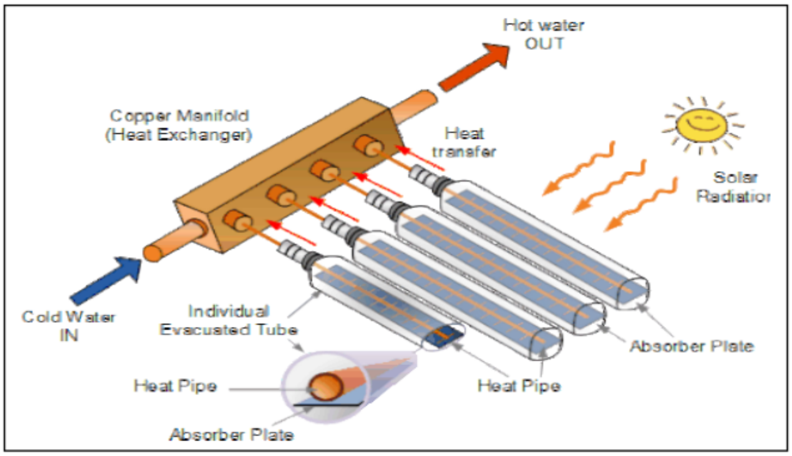
The flat plate collector (FPC) is also one of the more familiar in the language of SECSs. A solar hot water panel that is constructed as a large box is also a flat plate collector for optocaloric utility. We will clearly define a flat, non-concentrating photovoltaic panel as an optoelectronic flat plate collector (with some additional undesirable optocaloric properties). From the roots in engineering, we typically refer to flat plate collectors for photovoltaic modules or solar hot water panels. But going beyond the simple box model, what else could be viewed in the pattern of the flat plate collector? A wall or a roof top could be a flat plate collector, but so could a parking lot or the canopy on a picnic table. Flat plate collectors are also ancient strategies for maintaining microclimate in urban centers, as seen in stone plazas.

- **Vacuum Tube Collector or evacuated tube collector (ETC):**

In Vacuum tube or the Evacuated type a number of rows of transparent glass tubes are connected parallel to a header pipe and where the heat transfer fluid (commonly 50% Glycol Propylene) circulate and absorbs the tube heat that is being generated. The shape of these glass tubes is cylindrical. This makes the angle of the sunlight always perpendicular to the heat absorbing tubes which enables these collectors to perform well even when sunlight is low such as when it is early in the morning or late in the afternoon, or when shaded by clouds.

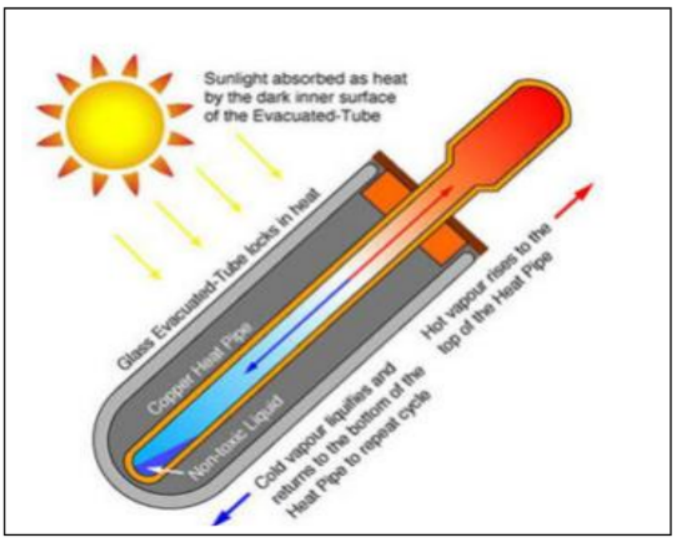

Manifold
Condenser bulb
Heat transfer from Heat Tube to System Fluid
Tube Seal
Sunlight
Heat Absorber Fin
Vacuum
Copper Heat Pipe
Hot vapor rises to top of Heat Pipe. Cold vapor liquifies and returns to bottom of Heat Pipe.
Cold Fluid


Tube Seal



- **Compound Parabolic Collector (CPC):**

Transform the sun's rays into free heat for your premises to reduce your energy costs and impact on the environment. To increase the solar collector efficiency, concentrating collectors such as CPC solar collector can be used.CPC solar collector. Compound parabolic concentrator solar collectors are non-imaging concentrators with a low concentration ratio. The CPC solar collector uses a compound parabolic reflecting surface to reflect and concentrate the solar radiation to the focal line.



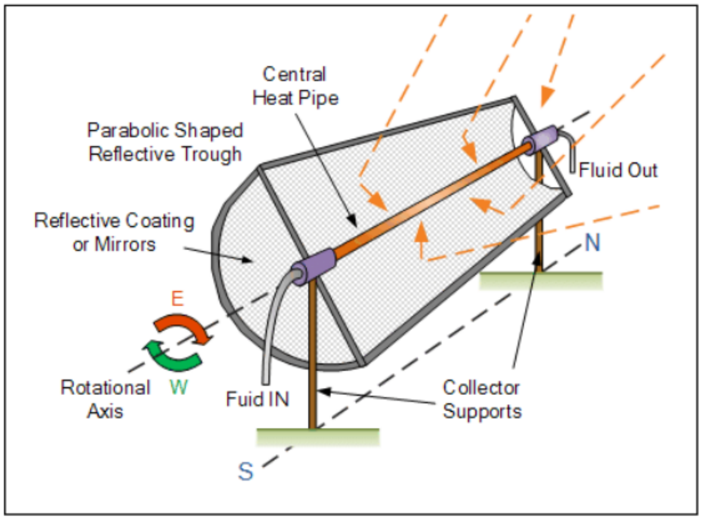
B. Medium Temperature Collectors:

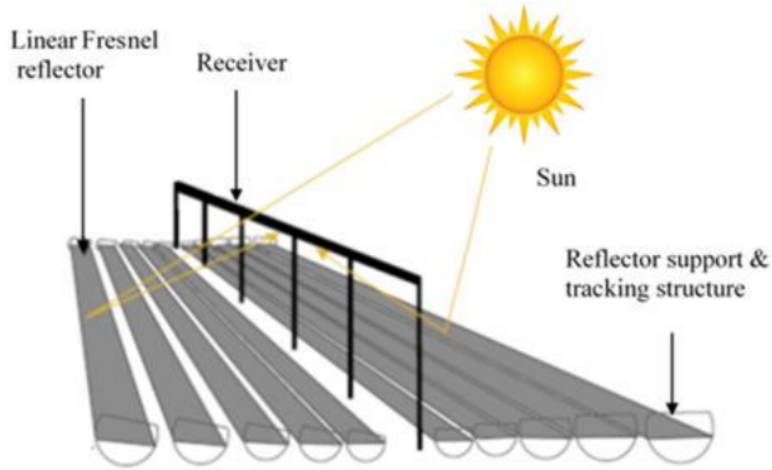
Low temperature thermal solar energy is used in applications that require temperatures between 100ºC and 250ºC. From 80 degrees Celsius flat collectors have practically no performance anymore and other collection systems have to be used.

Low temperature thermal energy systems are mainly used for applications that demand thermal energy, that is, heat between 125ºC and 400ºC. To reach higher temperatures, it is necessary to concentrate solar radiation.

Two types of solar collectors are used for this type of solar thermal energy:

- Evacuated flat plate collectors (EFPC)
- Parabolic Cylindrical/Trough Collector (PTC)
- Linear Fresnel Collector (LFC)





C. **Concentrated Collectors.**

TABLE 2 :**Simulation of solar collectors with ETC and FPC technologies for industrial purposes and technical, environmental and economic aspects of the application**

City/Country Located In	Industries Using Solar Collectors	Temperature (°C)	Area Captured by the Collector (m^2)	Solar Percentage (%)	Total Fuel Saving	Reference
South Africa	Fish Flour Preheating Production	70	384-Flat Plate Collector	81	32061 Liters of fuel oil	[23]
Macedonia	Saline Solutions Preparation, Molasses and Ethanol Water Heating Production	95	n/a-Evacuated Tube Collector	n/a	approx. 57 % of fuel oil	[24]

Reunion Island	Direct Integration of solar collector in the boiler tank for Yogurt-vapor generation	160-170	555-Evacuated Tube Collector	n/a	24% of Fuel	[25]
Morocco	Cleaning and drying of fruits, Milk-water heating, cooling and pasteurization	60-90	400-Evacuated Tube Collector	41	77.23 tCO_2e/year	[26]
Ethiopia	Heating and Dying of Clothes-Water	50-90	472-Evacuated Tube Collector	56.3	252.2 tCO_2e/year	[27]

2.8 SOLAR THERMAL TECHNIQUE FOR PLASTIC WASTE IN A FUEL PRODUCTION DOMESTIC USE

The most known application of solar technology is (PV- photovoltaic) panels, but solar thermal technology is another, often ignored, use of solar energy in low-temperature applications. Solar thermal is most commonly utilized for direct solar water heating and disinfection of water sources stored in dark or translucent containers to be heated in its most basic form. (Solar Cookers International, n. d.), Solar cooking appliances have been used since the late 1700s, because to the rising usage of glass (Solar Cookers International, n. d.). Horace de Saussure, the original conceptualizer came with the most interested design of solar cooker known as 'hot boxes' (Solar Cookers International, n. d.). Insulated boxes with clear glass coverings and dark metal interiors were used to make these solar-heated containers. Enthused by Saussure Sir John Herschel, In the 1800s, hot boxes were enhanced built one during a South African expedition, but using sand loaded up against the sides of the box. He is reported to have exhibited the capacity to cook an egg in a way similar to today's solar ovens that hold heat and can store heat by relying on the surrounding insulation of bricks and sand. All of these basic solar cookers were able to achieve temperatures over the boiling point, flagging the door for future solar cooker advancements. In poor areas, solar cookers are beneficial, where organizations like CEDESOL in Bolivia and Solar Cookers International are active (Solar Cookers International).To enhance the amount of sunlight that reaches the surface and the temperature of the air within the solar cooker, reflector or focusing lens can be used (such as Fresnel lenses) can be added to the solar cooker, for higher temperature ranges parabolic dish\trough type can be use and for food drying. Low-temperature solar cookers can also be used, water distillation, or purification systems that use direct solar energy without the use of reflection or insulation. Solar water disinfection is as simple as exposing a clear water bottle to direct sunlight for 6 hours, but more effective water treatment requires boiling or distillation, which entails heating water to steam and then re-condensing pollutants that precipitate upon re-condensation. Various tests will be performed to assess the properties of plastic oil, including, viscosity, color, calorific value, cloud point, flash point, gas chromatography and pour point. Several systems have been developed to transform plastic garbage into gasoline. Using modern plastic pyrolysis technology, the problem such as increase landfill size increased agricultural land infertility, issues in domestic waste management operations and processing which caused due to plastic waste can be solved sustainably.

TABLE 3 Various Solar Capturing Technologies and their Costs.

Collector Type	Country of Origin	Cost of Collector (USD/m^2)	Reference
Compound Parabolic Collector	Italy	131	[28]
	Spain	268-387	[29]
Flat Plate Collector	Zimbabwe	220-347	[30]
	Mexico	287	[31]
	Chile	330-687	[32]
Linear	Italy	199	[28]

Fresnel Collector	Spain	309-506	[29]
Evacuated Tube Collector	Zimbabwe	157-433	[30]
	Mexico	472	[31]
	Chile	460-817	[32]
Parabolic Trough Collector	Chile	379-1263	[32]
	Spain	393-666	[29]
	Italy	262	[33]
	Mexico	402	[31]

2.9 PARABOLIC CONCENTRATOR:

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More modern types of solar cookers use curved mirrors to reflect sunlight to a focal point, where a parabolic shape reflects incoming UV radiation to the focus. The most common and mature solar thermal technology is the parabolic trough concentrator, which can also be found in industrial scale solar thermal facilities for high temperature applications. Reflective metal sheets with mirror-like properties are used in parabolic solar thermal collectors to precisely concentrate sunlight to the designed focal points where a receiver unit sits. The entire solar radiation spectrum, including infrared and ultraviolet wavelengths, is present in reflected sunlight. A glass collector tube chosen for its UV penetration properties serves as the focal point of a parabolic solar collector. This collector sleeve houses an absorber tube made of a heat-conductive metal that is dark in color. To reduce heat loss from convective air flow, industrial applications are evacuated between the collector and absorber. To raise temperatures even higher, additional insulation and a heat transfer fluid may be added to the absorber. This fluid is extracted from the collectors and used to generate steam or heat via other conductive processes.

3. Conclusion:

Using modern pyrolysis technology plastics which are non-degradable can be easily converted into high calorific value alternative fuel, which reduces the environment pollution which is produced by burning of plastic, burning of conventional fuel in I.C engines as well as environmental effects such as overheating and green house emission. The pyrolysis process is regarded as an efficient, clean, and highly effective method of dealing with plastic solid waste, as well as a low-cost energy source. Converting plastic waste into fuel in the Indian market would not only solve the country's plastic waste crisis, but would also reduce plastic pollution by avoiding incineration and landfilling, as well as reduce the amount of imported oil barrels. For the burning of the plastic in the conversion chamber the solar energy, the Fresnel lens can be used.

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Design and analysis of PLA and carbon fiber mono leaf spring for small commercial vehicles

ABSTRACT

Finite Element Analysis (FEA) has been used to study and analyze a single leaf of the steel spring used in the Tata Ace as its rear suspension. To compare the result, a single leaf composite spring has been designed by 3D modeling and optimized. Main consideration was to optimize the spring geometry to obtain spring that has maximum stress and is able to withstand the external static forces without failure. Deformation and stresses are the design constraints whereas width at the points and area of the cross section are the variables of the design. The comparison between PLA (Polylactic Acid), Carbon Fiber (390 GPa) and High Carbon Steel will be the primary objective of this paper in order to analyze max. and the min. stress on the mono leaf spring using different category of Materials.

CHAPTER 1

INTRODUCTION

People nowadays can't imagine moving without automobiles. One of the issues that come to mind in this case is comfort, which is dependent on the suspension system. The most likely matter that follows the word "suspension system" is the use of springs. The most common spring is the 'Leaf Spring,' which is made of numerous metal strips, fixed in a sequence of increasing length one on top of the other, also slightly curved upwards in shape. When the weight, stress, natural frequency, and corrosion of metal springs are compared to springs made of different composites, an engineer should choose the composite made ones. Because composite materials outperform all other metals in terms of weight, stress due to a given load, and corrosive behavior. The use of animated composites in the manufacturing industries is increasing with each passing day because of the properties that they exhibit like minimum density, high strength, and elevated stiffness. Mechanical structures have improved torsional rigidity hence making them ideal for shell structures. When compared to metallic springs, Flexural strength at lower mass and increased damping is the primary characteristics of composite leaf springs. Approximately 60% of the weight can be reduced by the use of composite leaf springs in place of metallic springs [1]. Composite leaf springs have shown 180% maximum proof strength of that of steel while the stress level was 22% lower [2]. Various materials have been used to manufacture composite leaf springs out of which carbon fiber reinforced polymer (CFRP) showed stress of about 43.2% [3]. The use of E-glass fiber composites showed a weight redirection of 72% while E-glass showed a 62% weight reduction as compared to steel [4]. The reinforced hybrid composites of 30 percent glass fiber and 30 percent carbon fiber showed better results than other composites [5]. The tests conducted on Glass Fiber Reinforced Polymer (GFRP) provided more flexibility to it and significantly improved noise and harshness in the test drive [6]. 55% fiber volumetric fraction and higher frequency of the composite springs provide optimum results as well [7]. Preference of carbon fibers over glass fibers is not surprising as the material for composite leaf spring development despite its good insulating properties, high strength, and better chemical resistance [8, 9]. The tensile limit of the fiber composites is also increased by the addition of minimal quantities of aluminum in carbon fiber composite along with boron carbide [10]. The most basic and cheaper manufacturing technique is hand layup [11]. Improved damping properties were shown by CFRP bodies in the first three resonance frequencies. Higher resonance frequencies are achieved by the low masses of the composites [12]. A higher frequency than steel is achieved [13]. CFRP is proven to be better than GFRP In its shock-absorbing properties; still, it cannot replace steel yet [14]. Therefore the layering of the CFRP on top of GFRP has provided better results after exposing it to compressive loads in comparison with metallic or steel springs and can be used to replace it, hence proving the additional benefits of hybridization [15]. The aramid composite was tested and investigated because of its mechanical properties and it provided with desirable results when compared to the otherwise common metallic material for spring [16].

Several articles focused on using composites as materials for various parts in automobiles. Composite structure is being used in automobiles [17]. These materials' potential for use in vehicle structures has been determined. Furthermore, in terms of fabrication advancements, composites possess various properties that make them ideal for types of structural uses. Despite the fact that no specific design or model is introduced [18].In addition, composite leaf springs are used in big trucks. Because of the higher load acting in these sorts of vehicles, the utilization of composite materials should be thoroughly researched [19]. The primary distinction is the usage of a single leaf. The composite leaf spring provided with extraordinary results when compared to metallic leaf [20].

Material properties like energy absorption, modulus of the material and flexural strength can be altered extensively by incorporating hybridization in the design. The addition of two basalt fiber layers to the surface of the carbon fibers provided the highest flexural strength of the structure [21]. The mechanical properties can also be tailored by shuffling the stacking sequence of the hybrid composites [22]. The amount of water absorption can be significantly reduced by using carbon in the hybridization process. Alternatively stacking carbon fiber piles between basalt layers will significantly increase the impact resistance when tested under the same force conditions. The benefits of both reinforcements in a hybrid can be observed by setting carbon fiber on the second layer of the stacking arrangement as it increases the energy absorption of the laminate [23].

The bast of the PLA plant provides us with the lax fiber beneath its surface [24]. It is a soft, flexible, and lustrous fiber. The impact resistance of the spring can be increased by sandwiching lax between the consecutive layers [25]. The interface between basalt layers contains delamination in large amount and PLA can be demonstrated by the falling weight impact test [26]. The tensile strength, impact resistance, flexural rigidity can be altered majorly by different sequencing of the layers of the spring [27]. High damping properties are shown by PLA over pure carbon. Internal piles of carbon along with the outer layers of hybrid PLA composites show a decline in the damping coefficient. Damping can otherwise be altered by the fiber direction [28]. A comparison between the composites reinforced with PLA fibers and those reinforced with carbon fiber showed that the damping coefficient was 4 times higher in PLA fibers than in the latter; meanwhile, the elastic modulus and strength were lost [29]. Higher damping coefficients were examined in PLA laminates than those in carbon composites in finite element analysis and experimental investigation [30]. The use of PLA fibers showed an increment in bending modulus was observed from 2% to 10% [31]. Furthermore, an increment in impact resistance was seen when PLA layers were introduced in the middle of the composite [32].

Design of the composite beam and its applications for composite leaf spring have been done through a preliminary approach [33]. The amount of elastic energy that a leaf spring volume unit can store has been shown by Eq. 1[34].

$$1a^2/2E \qquad (1)$$

Here the modulus of elasticity (longitudinal direction) is represented by E while the max. allowed stress imparted into the spring is represented by a. While major load on a leaf spring is the vertical force, above equation reveals that the ideal material for the leaf spring would be the one which has minimum elasticity modulus in the longitudinal direction and maximum strength. Luckily, these properties are possessed by composites [35]. The lighter weight of the composites makes it a better option over steel. Other major features that makes composites ideal for leaf springs is lack of friction between the leafs, high strength by weight ratio, greater resistance to fatigue, "fail-safe" abilities, smoother ride, higher natural frequency, exceptional resistance to corrosion, and so on [36].

2 Mono Leaf Spring Dimension

In this paper the required load on the single mono leaf is been calculated manually, the mass of the mini truck is 890kg with the pay load of 710kg, so the approx. weight is 1600kg, the force requirement is 3922.7N on single mono leaf spring.

Table 1. Mono Spring Leaf Sizing and Parameters

Parameters	Values
EYE TO EYE Diameter	930mm
THICKNESS	8mm
WIDTH	60mm
CAMBER	82.77mm
NODE	35372
ELEMENTS	6180
MESH SIZE	5mm

1kg = 9.8N

For 4 sheet leaf spring is = 1600x9.8N = 15680N.

For single mono leaf spring:

1600x9.8/4=3922.66N (3.9227KN)

So, on the single leaf spring the force will be applied around 3922.66N.

Calculated load: The assume weight of the mini truck body is 890 kg with the payload of 710.

Table 2. Load Parameters

LOAD	VALUE(kg)
BODY	890
PAYLOAD	710
TOTAL	1600

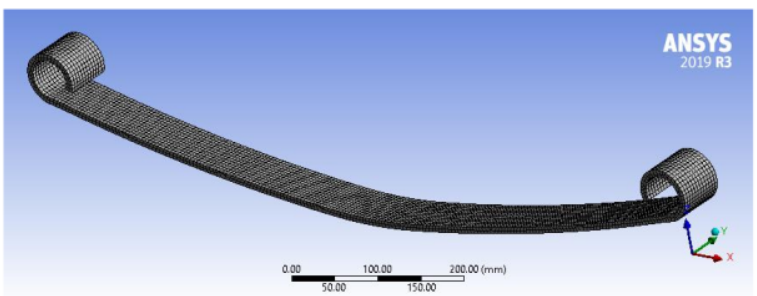

Fig 1. Meshing of single mono leaf spring

3 Materials selection

Here High Carbon steel, carbon fiber (390GPa) and PLA will be use. High carbon steel has moderate ductility while having extravagant hardness, extreme strength and wear resistance, by which we can measure the load capacity of the material while it does not break but is allowed to deform. FDM (Fused Deposition Modeling) is a method which is used for 3D printing using PLA that is a form of bioplastic. This material as well as ABS (Acrylonitrile Butadiene Styrene) is standardized for this technology. The most frequent alternatives available for consumer printers are these materials only; therefore there is a tendency to have them compared. PLA material is user friendly and has some mechanical qualities that often interest their users. Carbon fibers are fibers consisting primarily of carbon atoms and measuring 5 to 10 micrometers (0.00020–0.00039 in) in diameter. Carbon fibers provide a number of benefits that include elevated tensile strength, strong chemical resistance, and high stiffness, a high strength by weight ratio, minimal thermal expansion and increased temperature tolerance.

Table 3.Material Properties

Material Properties	High Carbon Steel	Carbon fiber 390	PLA(Polylactic acid)
Poisson's Ratio	0.29	0.2	0.39
Young's Modulus	2012e+05MPa	6000MPa	3450MPa
Bulk Modulus	1.6825e+05MPa	-----	5227.3MPa
Shear Modulus	82171MPa	8000MPa	1241MPa
Isotropic Secant Coefficient (Thermal Expansion)	1.1e-05 1/'C	-----	0.000135 1/'C
Tensile Ultimate Strength	1070MPa	-----	59.2MPa
Tensile Yield Strength	761MPa	-----	54.1MPa
Density	7.85e-06kg/mm³	1.8e-06kg/mm³	1.25e-06kg/mm³

4 Simulation

The simulation was conducted on ANSYS 2019 R3 In which a single leaf model was made of the eye to eye diameter of 930mm and thickness of 8mm. The width of the leaf was taken to be 60mm while the camber was 82.77mm. The total number of nodes was taken to be 35372 with 6180 elements and a mesh size of 5mm. A manual calculation of the required load on the single mono leaf has been conducted in this paper. The payload was taken to be 710kg whereas the mass of the truck itself was 885kg. The total approximate load was 1595kg which was then rounded off to 1600kg. This resulted in a force of 3922.7N applicable on a single mono leaf spring.

Though stresses under different loads have been discovered, the maximum stress under 3922.7 loads for both types of springs is illustrated in fig. of

(a) Carbon fiber 390GPa

(b) High Carbon Steel

(c) PLA

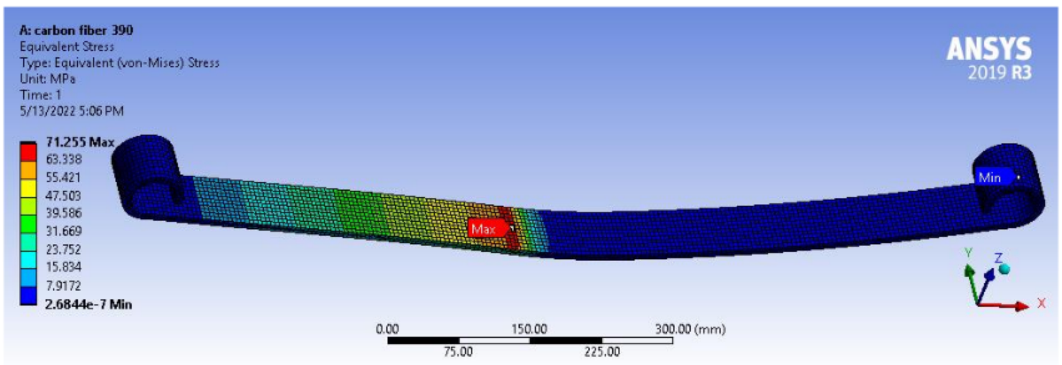

Fig 2. Carbon fiber 390GPa

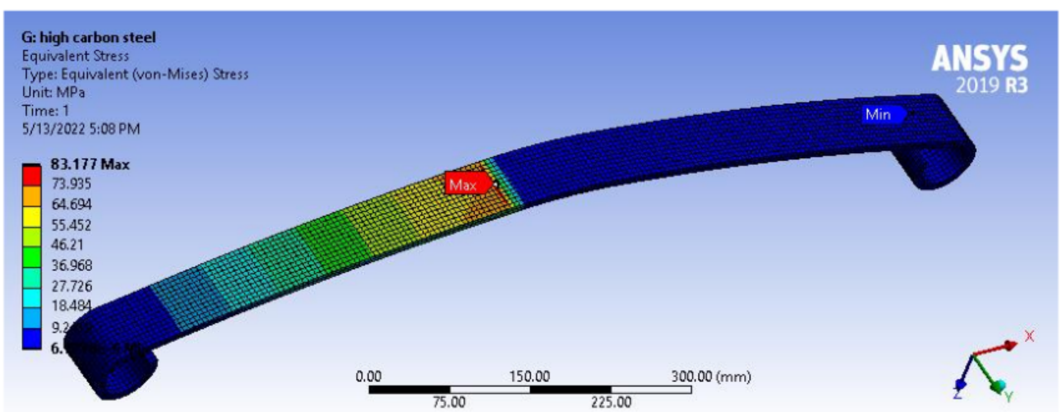

Fig 3. High Carbon Steel

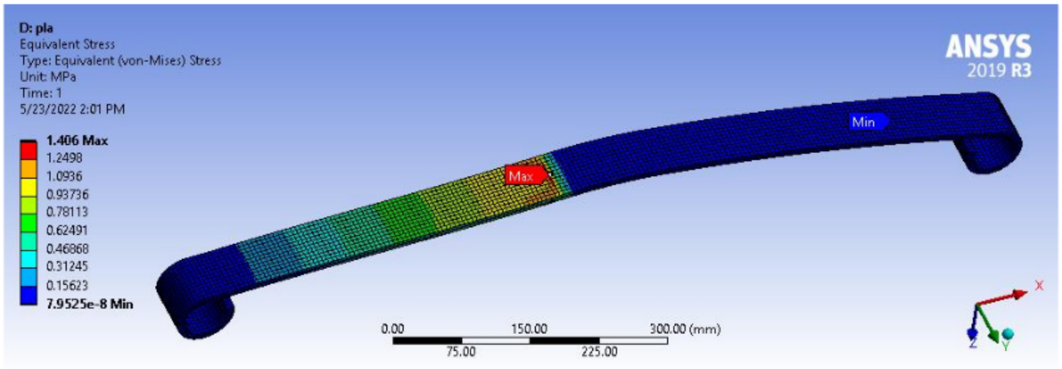

Fig 4.PLA

5 Result and Discussion

The simulation revealed the maximum stress (equivalent von-mises) and weight variation of leaf springs. The weight was calculated manually based on the density of the components.

Table 4.Weight Reduction (for single mono leaf spring)

Properties	Carbon Fiber (360Gpa)	Polylactic Acid	High Carbon Steel
Density	1.8e-06kg/mm^3	7.85e-06kg/mm^3	1.25e-06kg/mm^3
Volume	5.9888e+005 mm^3	5.9888e+005 mm^3	5.9888e+005 mm^3
Spring weight(kg)	1.078	0.7486	4.7012

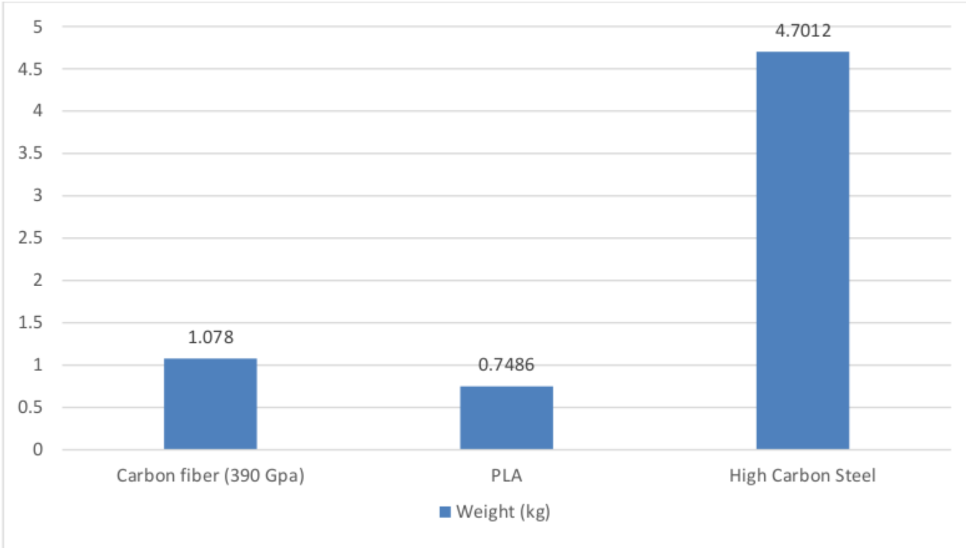

Fig 5. Weight comparison of single mono leaf spring

Table 5.Stress Comparison (On 3922.7N)

MATERIAL	FORCE(N)	MIN.[MPa]	MAX.[MPa]	AVG.[MPa]
CARBON FIBER 390(GPa)	3922.7N	2.6844e-007	71.255	7.4219
PLA	3922.7N	7.9525e-008	1.406	0.13444
HIGH CARBON STEEL	3922.7N	6.7278e-006	83.177	8.19

6 Conclusion

In this research method main compared parameters are design optimization and analyzing the different materials like composite materials and thermoplastic. After the completion of analysis and comparing the result it has been figured out that weight of the thermoplastic material (PLA) as minimum weight and low maximum stress.

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