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Fem Simulation of Connecting Rod for Minimal Distortion using Aluminum Alloy

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Abstract:- The prime objective of the proposed work is to investigate the effects of different materials of connecting rod over the performance. Hence the current research approached a simulation-based design using Solid works and Ansys workbench 20. The automotive sectors are concentrating on weight reduction strategies, which can be achieved by incorporating new designs, cost-effective production processes, or employing alternative materials. Researchers have been attempting to optimize engine parts including the piston, crankshaft, and connecting rod for a number of years. An essential component of an external combustion engine, the connecting rod is subjected to extreme pressures from forces coming from the piston. It has been noted that the engine's efficiency actually increases as its weight is reduced. The main goal of this research is to introduce new and superior replacement materials for the connecting rod's existing material in order to mass-reduce opportunities for general-purpose connecting rods. The connecting rod in the proposed study was created utilizing silicon carbide, titanium alloy, and aluminium alloy components. The connecting rods made of the new materials were created using the FEM method.

Keywords:- *FEM, Connecting Road, Automobile Engineering, Distortion, Optimum Condition.*

I. INTRTODUCTION

For production engines in modern automobiles with internal combustion, the connecting rods are almost always made of steel. However, for high performance engines, they can be made of aluminum (for its lightness and its ability to absorb high impact at the expense of its durability) or titanium (for its combination of strength and lightness at the expense of its affordability). Due to the fact that they are not held in place firmly at either end, the angle that exists between the connecting rod and the piston shifts as the rod goes up and down and revolves around the crankshaft. The process of forging is used during the production of connecting rods. Because it is one of the components that is essential to the overall design of an engine, the connecting rod has to be able to endure enormous loads and convey an incredible amount of power. In an internal combustion engine that uses reciprocating pistons, the piston is connected to the crank or crankshaft by a connecting rod. They come together to create a straightforward mechanism, which, together with the crank, allows reciprocating motion to be converted into rotational motion. Because the connecting rod is stiff, it is able to transmit either a push or a pull, and as a result, it is able to spin the crank through both half of a revolution, also known as the pushing of the piston and the pulling of the piston. The larger end connects to the bearing journal on the crank, while the smaller end is attached to the pin that holds the piston in place. To lubricate the trip of the pistons and piston rings, there is often a pinhole punched between the bearing and the large end of the connecting rod. This allows pressurized lubricating motor oil to spray out onto the thrust side of the cylinder wall.

When constructing a high-performance engine, the connecting rods are given a great deal of attention. This includes the elimination of stress risers through the use of techniques such as grinding the edges of the rod to a smooth radius, shot peening to induce compressive surface stresses (to prevent crack initiation), balancing all connecting rod/piston assemblies to the same weight, and Magnaflux to reveal otherwise invisible small cracks that would cause the rod to fail under stress. Magnaflux. In addition, the con rod bolts are torqued to the precise amount stated, which requires a great deal of caution; often, these bolts cannot be reused and must be replaced instead.

For the purpose of achieving a precise fit around the large end bearing shell, the big end of the rod is produced as a unit before being cut or broken in half. Powder metallurgy allows for more precise control of size and weight with less machining and less excess mass to be machined off for balancing in more recent engines, such as the Ford 4.6 liter engine and the Chrysler 2.0 liter engine. These engines have connecting rods made using powder metallurgy, which allows for more precise control of size and weight. A fracturing procedure is then used to detach the cap from the rod. This method results in an uneven mating surface owing to the grain of the powdered metal. This assures that the cap will be correctly positioned with regard to the rod following reassembly, as opposed to the slight misalignments that may occur if the mating surfaces are both flat. These can be avoided by ensuring that the mating surfaces are not both flat.

A. Connecting Rod

It is necessary for the connecting rod to have high strength, a low inertial mass, and mass homogeneity with the other connecting rods that are joined to the crankshaft. The connecting rod is what provides the mechanical coupling between the piston and the crankshaft. The coupling to the crankshaft is accomplished by inserting solid journal bearing half shells on both sides of the split big end of the journal bearing. A gudgeon pin made of hardened steel is often used to couple to the piston. This pin is inserted into the body of the piston. In recent years, good connecting rod fittings at the split large end have been produced by controlled fracture of the connecting rod large end. This has allowed for the rods to be used in more applications. During construction, the big ends of the connecting rods are often threaded directly so that the split section may be joined. This allows the connecting rods to function as one unit. Materials that have been used for connecting rods in the past include powder metallurgy steels and medium carbon steels. Powder metallurgy steels are formed into an initial shape and then forged to near final dimension. Medium carbon steels develop superior strength either through separate heat-treating processes or by controlled cooling following the forging step.

A palm end is located at the lower end of the center connecting rod, and it is to this palm end that the bottom end-bearing keeps are attached. On the other hand, the higher end of the rod has an integrated continuous lower half keep, and it is to this keep that the upper half-bearing keeps are bolted. The side connecting rod is created with palm ends at both ends of the rod, and these palm ends serve as the attachment points for the top and bottom end bearings. Two bearing keepers are placed over the ends of the crosshead pins to create the upper half of the center connecting rod top end bearings. The lower (laden) halves of the center connecting rod top end bearings consist of continuous white metal–lined shells. Lubricating oil is sent from the main bearings to the side top end bearings via holes that run the length of the connecting rods. The side connecting rod bottom end bearings are coated with white metal, and they get their supply of oil from the main bearings. The top end bearings of the center connecting rods provide oil to the cast steel white metal–lined bottom end bearings of the center connecting rods, which are supplied with oil via holes in the rods themselves. White metal–lined thin-shell bearings are installed in the side and center top end bearings of the assembly.

The nitriding procedure is used to harden the nitriding steel that is used to make the center crosshead pins. Pins are fastened to the palm end of the piston rods at the top, with the crosshead brackets sandwiched in between. In addition, two long studs travel horizontally through the crosshead pins, securing the pins to the brackets at the rear of the assembly.

B. DESIGN OF CONNECTING ROD

A part of a machine that is put to a combination of direct tensile and compressive forces at alternate intervals is called a connecting rod. Because the compression forces are so much more than the tensile forces, the connecting rod's cross-section has been built as a strut, and the Rankine formula has been used in order to calculate the required strength. It is possible for a connecting rod that is being loaded axially W to buckle in such a way that the x-axis becomes the neutral axis in the plane of motion of the connecting rod, or the y-axis becomes the neutral axis. It is possible to think of the connecting rod as having both of its ends hinged so that it may buckle about the x-axis and both of its ends fixed so that it can buckle about the y-axis. It is important for a connecting rod to have the same amount of buckling strength in either direction.

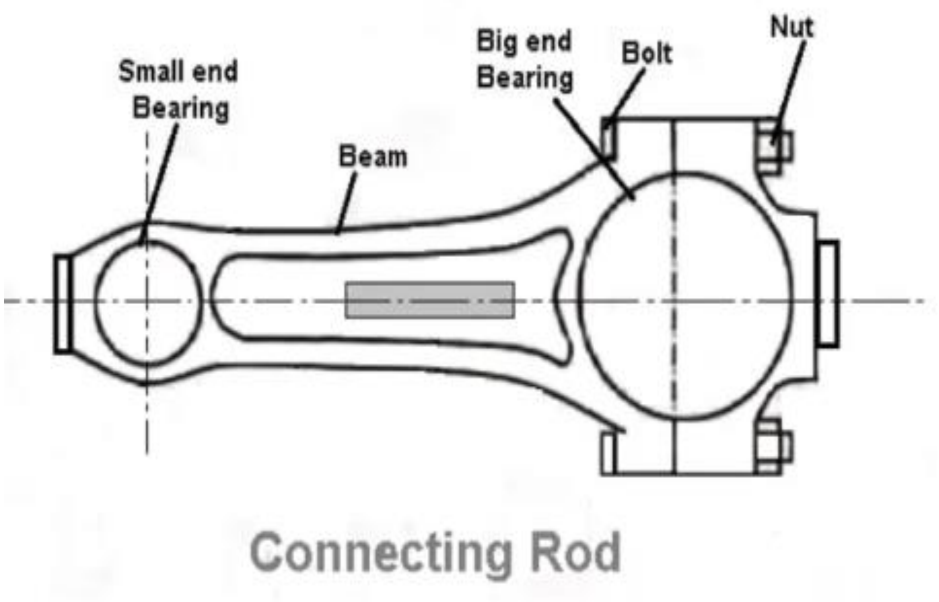

Fig. 1: Design of Connecting Rod

The shell bearing has an adjustment for wear, which not only provides control over running and side clearance, but also ensures that the bearing cap is a good fit. When using spur bearings, it is very uncommon for shins, which are relatively thin pieces of metal, to be used. These may have less material packed into them in order to make up for the wear that the bearing has experienced and also to ensure that there is enough bearing clearance between the connecting rod and the crankshaft. The smaller end is often a solid eye that has a phosphor bronze bush and a screw to seal the eye around the pin. The larger end is typically a pin. It is essential that an engine's connecting rods all have the same weight; otherwise, the engine might exhibit discernible vibration. During the assembling process, the connecting rods and caps are carefully matched to one another on an individual basis. It is customarily marked with identification numbers to prevent the parts from being confused in the event that the engine has to be taken apart for maintenance.

C. APPLICATION

- It is a part of a piston engine that connects the piston to the crankshaft.
- The connecting rod converts the reciprocating motion of the piston to the rotation of the crankshaft. Conrods are applied in various engines of automobiles.
- The connecting rod is used in all types of vehicles such as cars, trucks, and bikes. In addition, it is also used in construction vehicles like bulldozers, road rollers (earthmovers).
- A connecting rod is an important component of any internal combustion engine, including those used in automobiles, trucks, and motorcycles.
- Automobile engines are the most common use for this component.
- A connecting rod is the most common usage for this component. Connecting rods are a component of every type of industrial vehicle, even those that are propelled by the kinds of engines described before.
- Even the earthmoving machinery used in construction, such as bulldozers and road rollers, are powered by internal combustion engines.
- Pistons, connecting rods, and crankshafts are three components that are required for the operation of almost every form of machine in the contemporary period. These parts are essential to the internal combustion engine's smooth operation and must be present at all times. There are a variety of applications for connecting rods, sometimes known as con rods.

D. MATERIALS USED FOR CONNECTING ROD

Connecting rods may be crafted out of a broad variety of materials, including carbon steel, iron base sintered metal, micro-alloyed steel, and graphite cast iron, to name just a few examples. Steel is the material that is most often used in the manufacture of connecting rods in mass-produced engines for automobiles. Instead of being cast or forged, connecting rods for high-performance applications often make use of billet components, which are machined from a single piece of metal rather than being cast or forged. Other possible materials include aluminum alloy, which may be used due to its low weight as well as its capacity to absorb high levels of impact, but at the sacrifice of its durability. Cast iron, on the other hand, is found to be less costly but is used for applications that need extremely low performance such as scooters. Titanium, another choice, is fairly expensive and is found to reduce weight. Titanium, however, is also an option. Titanium is an option. Other options include:

In the construction of connecting rods, there are often just a few materials that are used on a regular basis. Like steel alloy, aluminum and titanium. Commonly used as steel alloy, aluminum and titanium steel alloys like **42CrMo4, 43CrMo4, 44csr4, C-70,EN-8D, SAE1141**, etc. In order to enhance the steel's mechanical qualities, it is often alloyed with a number of other elements in total quantities ranging from 1% to 50% of the weight of the steel. Alloy steels are broken down randomly While Smith and Hashemi place the difference at 4.0%, Degarmo and both of them place it at 8.0%. Most of the time, when people talk about "alloy steel," they are really referring to low-alloy steels. Although technically speaking, every kind of steel is an alloy, not all types of steel are referred to as "alloy steels." The most basic types of steel consist of iron (Fe) that has been alloyed with a little amount of carbon (C) (anything from 0.1% to 1%, depending on the kind). However, the term "alloy steel" is the standard term referring to steels with other alloying elements added deliberately in addition to the carbon. Common alloyants include manganese (the most common one), nickel, chromium, molybdenum, vanadium, silicon, and boron. Less common alloyants include aluminum, cobalt, copper, cerium, niobium, titanium, tungsten, tin, zinc, lead, and zirconium. Aluminum alloys like **T6-2024 and T651-7075** also light and has the ability to absorb high impact.

It refers to several alloys in which aluminum (Al) predominates over other metals. Copper, magnesium, manganese, silicon, tin, and zinc are some of the common elements that are used in alloying. There are two primary categories, namely casting alloys and wrought alloys. Both of these categories may be further classified into the categories heat treatable and non-heat treatable alloys. Casting alloys and wrought alloys are the fundamental categories. Roughly 85 percent of all aluminum is processed into some kind of wrought product, such as rolled plate, foils, or extrusions. Cast aluminum alloys often have lower tensile strengths than wrought aluminum alloys, despite the fact that the low melting point of cast aluminum alloys allows them to produce items at a cheaper cost. The Al–Si system is the most essential one for cast aluminum alloys. This is because it contains high amounts of silicon (4.0–13%), which help to providing outstanding casting qualities. Aluminum alloys have widespread use in the engineering industry, particularly in the construction of lightweight buildings and components that must also be resistant to corrosion. Titanium is a common component in high-performance engine components. Although it is light and sturdy, the price is much greater. Ti is an element in the periodic table that has the chemical symbol Ti and the atomic number 22.

It is a transition metal that is glossy and silver in color, has a low density, and has excellent strength. Titanium does not corrode easily in harsh environments such as sea water, aqua regia, or chlorine. Cast iron may be used for applications on a smaller scale, such as two-wheelers. The term "cast iron" refers to a set of iron-carbon alloys that have a carbon content that is more than 2%. The comparatively low melting point of the material contributes to its practicality.

Cast iron's primary alloying elements are carbon (C), which may account for between 1.8 and 4 weight percent, and silicon (Si), which can account for between 1 and 3 weight percent. Steel is the common name given to iron alloys that have a carbon content of 0.8% or less. Even though this makes the Fe–C–Si system a ternary system from a mathematical perspective, the idea of cast iron solidification may be understood from the more straightforward binary iron–carbon phase diagram. The melting temperatures of most cast irons range from 1,150 to

1,200 degrees Celsius (2,100 to 2,190 degrees Fahrenheit). This is about 300 degrees Celsius (540 degrees Fahrenheit) lower than the melting point of pure iron, which is 1,535 degrees Celsius (2,795 degrees Fahrenheit). The melting point of pure iron is 1,535 degrees Celsius (2,795 degrees Fahrenheit).

- Galling, the process whereby cold-welding of material causes seizure, does not affect steel.
- Steel is no need to worry when inserting a bush, or when re-bushing con rods.
- The stiffness of steel is much higher than that of titanium.
- Its density of 7.85 g/cc, it is almost 80% more dense than a typical titanium.

II. LITERATURE REVIEW

Saswat Satpathya et.al proposed a research paper on the topic entitled “Static and Fatigue Damage Analysis of a Connecting Rod”. Here, the structural analysis, vibration analysis, and fatigue analysis of a connecting rod are all included in this thesis work. SOLIDWORKS is used to create a parametric model of a connecting rod, and then that model is sent to ANSYS so that it may be analyzed. When doing an analysis of connecting rods using finite elements, forged steel is taken into consideration. Steel that has been forged has a higher factor of safety, lower weight, increased stiffness, and lower levels of both normal and equivalent stresses.

After doing a fatigue study to determine the lifetime of the connecting rod as well as the amount of time it would take for the rod to sustain damage, the researchers discovered that forged steel had the longest possible lifespan. In these tests, the connecting rod, which is manufactured out of forged steel, is subjected to study of stress, vibration, and fatigue. The model is examined using FEM while doing a stress analysis. For the purpose of the vibration analysis, three different types of material—aluminum alloy, cast iron, and forged steel—are compared and contrasted in order to determine which kind of material produces the lowest frequency. The lifespan and the amount of deformation of the connecting rod may both be calculated as a result of the fatigue study. According to the results of a stress test performed on connecting rods made from a variety of materials, it was determined that forged steel has lower levels of stress and experiences less deformation than aluminum alloy and cast iron. When subjected to an unrestrained free vibration examination, forged steel is found to have a lower frequency than the other two materials.

The fatigue research performed on the connecting rod led to the determination that its life lifetime is 106. R.Sangeethkumar et.al. proposed a research paper on the topic entitled “Design and Analysis Of Connecting Rod Using Aluminum Alloy” In this study, the connecting rod was manufactured by employing the stir casting method to get reduced weight. This was accomplished by combining aluminum and fly ash in a ratio of 5:1 to form the metal matrix composite. The program known as solid Working was used to create a model of the construction of the connecting rod. The draught angle that is offered on the connecting rod surface is another factor that is taken into consideration in order to preserve the capacity to forge. The cost is often a confidential business problem that is difficult to get.

The production costs of steel forged connecting rods and powder forged connecting rods were evaluated in research that was published by Clark et al. [15] in the year 1989. It was shown that the cost of machining accounts for 62% of the entire cost of a standard forged steel (FS) connecting rod, while the cost of machining accounts for 42% of the total cost of a powder metal (PM) connecting rod. The standard FS connecting rod had a total cost that was 6% more than that of the more modern PM connecting rod. It can be deduced from this that the employment of the fracture splitting technique, which is utilized for PM connecting rods, results in a decrease in the cost of machining that contributes to a 23% reduction in the overall cost of the FS connecting rod. This research looked at the potential for weight and cost reductions offered by steel connecting rods that have been forged.

The connecting rod that was selected for this project came from an original equipment manufacturer (OEM) and was part of a mid-size vehicle. The use of optimization techniques makes it simple to cut down on both material and expense.

Pankaj Kumar Gupta et.al. proposed a research paper on the topic entitled “Design, Structural and Thermal Analysis of Piston” by Using Finite Element Analysis “Using the solid modelling program CATIA V5, the project's goal is to produce a model of a piston. Using the ANSYS program, the geometry will be meshed, and then it will be examined. For the purpose of the investigation of piston input conditions and the analysis method, a comprehensive search of the relevant literature was carried out. The high pressures of the combustion gas act as mechanical stresses, creating significant strains in the region of the piston that is important to its operation.

A comprehensive static structural analysis is performed for a variety of loading scenarios, such as the one with the highest possible gas pressure load. A comparison analysis is performed so that the appropriate material may be selected. When it comes to content, comparative analysis is never really dominant. A cylinder is a kind of mechanical component that may be found in a wide variety of cycles, such as pneumatic chambers. gas blowers, responding syphons, and responding motors are all included. The upward growth inside of a chamber that is stored in an airtight cylinder is what this term refers to. In the field of automobile manufacturing, it has been discovered that the cylinder is the most important component of the motor, despite the fact that it is subjected to significant mechanical and hot stresses.

Even when subjected to severe circumstances, an aluminum piston maintains a high level of strength. When compared to grey cast iron, aluminum exhibits much less deformation, significantly reduced stress, and improved temperature distribution. A cast iron piston’s restriction is somewhat alleviated by the use of an aluminum piston. As a result of this study, we have a far better grasp of the Al material and the qualities it has. Emarti Kumari et.al proposed a research paper on the topic entitled “Design and Shape Optimization of Connecting Rod End Bearing through ANSYS”. Within this, they do a comprehensive load study on connecting rod ends that come in a variety of shapes. In the course of this study, the initial step was to generate accurate models of connecting rods including a variety of cross sections. We manufacture connecting rods with I sections, H sections, and rectangular sections respectively. After that, we analyze the various loads that are placed on the static structure, as well as the buckling loads that are placed on the various kinds of connecting rods.

This analysis is performed using the finite element technique using ANSYS software for the FE study. You have a choice between three distinct cross-sections: I section, H section, and rectangular section. The goal of this project is to structurally analyze a connecting rod consisting of three different alloy kinds. Connecting rods are widely used in all types of automotive engines, serving as an essential juncture between the piston and, therefore, the crankshaft. By translating the piston's reciprocating motion to the crankshaft's rotation, it is responsible for transmitting the piston's up and down movement to the engine. The design and weight of a rod affect how well it works in an engine. Analysis and optimization are thus required for the construction of a durable, cost-effective, and lightweight rod. Aluminum alloy, magnesium alloy, and titanium alloy are used as substitutes for "structural steel" as the material for rod.

For static analysis, the rod model was created in CATIA v5 and loaded into the ANSYS 2021 R1 workbench. Following analysis, a comparison between an existing steel rod and the three composite rods is established in terms of Von Misses stress, equivalent strain, and total deformation. All of these parameters are also determined analytically, and the results of finite element analysis are compared. The values of these materials are discovered in comparison to steel since all of those findings are inside the range. There are three stages to the whole project. Concept and an assessment of prior literature come first. Second, we perform static structural analysis and modelling.

The third comparison involves the highest Von Misses stress value, total deformation, and elastic strain in alloy connecting rods. In this project, we are comparing the static structural analysis of the connecting rod with 4 different materials while applying a specified load to the various materials used in the connecting rod. Furthermore, it was discovered that connecting rods with an I-section had a greater safety factor. The initial buckling stress is relatively significant for H-sections but considerably lower for rectangular sections, according to the findings of the buckling investigation. Wilarso et.al proposed the research paper on the topic entitled “Investigation and failure analysis of a diesel generator connecting rod “A collapse study of a diesel generator set connecting rod type 3516 B that has been in operation for 79,678 hours is presented in this article. According to what can be seen, the connecting rod cylinder number 10 has acquired a new color in the region of the shank.

Because this event could be representative of a large number of instances of generator failure, a thorough investigation into the fundamental reasons for the malfunction is required for publication in scholarly journals. In this particular instance, tests of the chemical composition, the microstructure, the SEM-EDX, and the electron microscope were carried out in order to acquire more thorough findings. Through the use of fault tree analysis, we were able to determine that compression leakage brought on by wear on the cylinder liner was the root cause of the connecting rod damage. An examination using scanning electron microscopy (SEM) reveals that the piston rod material has become a darker color as a consequence of heat, namely the production of iron oxide. Nishanth R et.al proposed the research paper on the topic entitled “Generative Design Optimization and Analysis of Connecting Rod for Weight Reduction and Performance Enhancement”. An examination using scanning electron microscopy (SEM) reveals that the substance of the connecting rod has become a darker color as a result of heat, which results in the development of iron oxide. It was calculated that the connecting rod had been subjected to heat of 200 degrees Celsius. According to the findings of the fault tree analysis, the predominant cause of the color change on the connecting rod was radiation from the cylinder wall, which was caused by exhaust gas leaking into the crankcase.

The findings of our study revealed that the piston ring on cylinder #10 had been damaged, which causes the piston ring to stack and renders it unable to expand. This, in turn, results in a loss of compression pressure. The analysis is broken up into two distinct stages. The first portion of it is using generative design to do an analysis of the loads, including compressive and tensile loads, that are operating on the connecting rod as a function of time in order to optimize its weight and manufacturing cost. The generative design methodology is an iterative design approach that generates a predetermined number of outputs according to the power, stress, and further limitations were imposed.

For the connecting rod design that we come up with, the most important factors to take into account are its weight, the material it is made of, and the cost. This design, in turn, offers an adequate level of strength, stiffness, and fatigue resistance. The second component is an analysis of finite elements, which was carried out at a variety of crank angles. The goal of this step was to determine whether or not the designs that were created can sustain loads ranging from the compressive load, corresponding to the peak gas pressure as the other extreme load at the maximum engine speed tensile load, corresponding to 3600 crank angle as one of the extreme loads at the maximum engine speed

The examination concluded that both Ti-6Al4V and 17-4Ph stainless steel possessed the required level of properties; however, 17-4Ph stainless steel exhibited superior strength and also proved to be a cheaper alternative. The results of the examination concluded that both of these materials possessed the required level of properties. Shubham Saxena, and R. K. Ambikesh, they both had proposed the research paper on the topic entitled “Design and finite element analysis of connecting rod of different materials”. In this particular piece of research, the primary focus is on the mass reduction opportunities of the two-wheel connecting rod by introducing two alternative materials other than the existing material of the connecting rod. These materials are considered to be more lightweight than the existing material of the connecting rod. By consulting the literature study, the connecting rods that use carbon steel, aluminum 7475, and titanium 6-al-4-v as their primary materials were conceptualized and constructed. The normal empirical method was used in the design process for the connecting rods made of the new materials.

After that, the ANSYS software is used to do a finite element analysis in accordance with the estimated loading conditions in order to analyze the data such as total deformation, maximum shear stress, etc., and then the optimal results are compared to one another. rod. The carbon alloy had the smallest amount of elastic strain, while the titanium alloy con rod had the largest amount. According to the findings of the study, aluminum alloy is the best material out of the three options since it has the lowest total mass and the highest strength to weight ratio. Wenjie Qin et.al have proposed the research paper on the topic entitled “Interference and thickness design of bushing of connecting rod small end for Anti-loosening” in this study, the finite element technique was used to evaluate the impact of bushing thickness and interference on the pressing force of the bushing of the connecting rod small end in a V-type diesel engine.

When designing this connecting rod small end, it was necessary to take into account the strength of the bushing as well as the stiffness of the connecting rod small end. As a result, the appropriate bushing thickness as well as the interference were determined and then confirmed in practice. FE analysis was used to compute the bushing pressing forces for a variety of bushing thicknesses and interference levels. The impacts of bushing thickness and interference on the pressing force were also explored. The optimal bushing thickness and interference were determined to be 2 millimeters and 0.1 millimeters respectively in order to make the connection between the bushing and the small end as tight as possible. This was done by taking into consideration the rigidity of the con-rod small end in order to prevent severe deformation and the strength of the bushing in order to prevent yielding. This concept has been put into action, and positive results have been achieved as a consequence. Tanya Buddi and R.S.Rana they both have proposed the research paper on the topic entitled “Fabrication and finite element analysis of two wheeler connecting rod using reinforced aluminum matrix composites Al7068 and Si3N4” Developing the model of the connecting rod is accomplished by incorporating ceramics Si3N4 into the Al7068 alloy.

The hardness of the segment was observed to rise from 61.2 to 92.4 when the weight percentage of the Si3N4 particles in the Al-Si3N4 composites went from 0 to 5 weight percent (BHN). It may be deduced from this that the addition of 5 weight percent of Si3N4 to an aluminum alloy would result in a hardness that is 49.8 percent higher.

When slick aluminum was combined with Al-Si3N4 composites containing 5 weight percent, the elasticity increased from 98 MPa to 140.5 MPa. It has been shown that including Si3N4 into an aluminum composite results in improved material characteristics. This is because of the high degree of similarity between the Si3N4 and the aluminum framework, as well as the strong interfacial grip between the two. It has been observed that even the hard and fragile Si3N4 particles in a delicate and malleable Al amalgam lattice reduce the pliability substance of the created AMCs. This is because there is a small amount of malleable substance of framework metal in the composite, which significantly improves the hardness of the manufactured AMCs. Based on this research, this may be extended to experimental evaluation of connecting rod for various materials.

This may enable us to further reduce the weight of the connecting rod, which is the primary consideration while designing connecting rods. Additionally, dynamic stress and fatigue stress analysis may also be performed in order to make it so that it has a longer life for both large and small engines. D. Vishwa et.al have proposed the research paper on the topic entitled “Design, analysis and topology optimization of connecting rod” In this work, the design, analysis, and topological optimization of the connecting rod are the main topics of discussion. Each internal combustion (IC) engine needs a certain number of connecting rods, and the exact number of rods needed is determined by the number of cylinders in the engine. After the 3D model of the connecting rod has been developed using the Creo Parametric program, it is exported and loaded into the ANSYS software, where the design is meshed, the Finite Element Method (FEM) is used to analyze it, and the results are edited.

Using the data that were acquired from ANSYS by doing a static stress analysis, the topology optimization of the connecting rod has been carried out by using the software that is provided by Autodesk Fusion 360. The technique of topology optimization is a productive mathematical method that is used to optimize the layout of the design for the given loads and boundary conditions within the given design space. The purpose of the method is to raise the desired performance characteristics of the given design. Topology optimization is an efficient mathematical technique. When compared to the initial design, the optimized design exhibits lower values for the maximum principal stress, equivalent stress, maximum principal strain, and total deformation.

Additionally, the optimized design results in a weight reduction of approximately 3.5% for the material of steel that is subjected to a force of 39473.16 N. On the basis of the existing connecting rod analysis results, the topology optimization was performed on the shank region, which connects the small end and the big end. The optimization was performed by including holes in the shank region where the stress is minimal. This was done in order to achieve the best possible results. This design may be put to use in the production of connecting rods that are both lighter in weight than the version that is now in use and able to withstand the same amount of load. Shubham Joshi and Suman Sharma they both have proposed the research paper on the topic entitled “Simulation and Modelling of Connecting rod of IC by Using Aluminum Alloy” Utilizing the finite element technique (FEM), the purpose of this study effort is to ascertain which are the optimal design parameters for the connecting rod in order to lower the critical buckling stress for the material that is currently in use, which is AA2618. Determine the optimal value of the stress that should be applied to the connecting rod.

The connecting rod is responsible for transferring the thrust force that is generated in the cylinder as a result of the combustion of the fuel during the power cycle to the crankshaft so that the vehicle can be driven in a rotating motion. This thrust force is developed as a direct result of the power cycle. It fulfils the function of a connecting link between the crankshaft and the piston, so transforming the reciprocating action of the piston into the rotating motion of the crankshaft. In the study being presented here, deformation, stress analysis, and strain testing are carried out using an aluminum alloy serving as the connecting rod. When conducting the initial deformation and stress analysis for the connecting rod of the internal combustion, structural steel is used as the material of choice.

The connecting rod that was engine utilized for this investigation was obtained from a previous research article. Catia V5 is the designing program that was used to create the model of the connecting rod that was used for analysis. After that, numerical and FEM analyses are carried out to estimate the deformation, and then Von Mises stress and elastic strain are computed by applying an external force with a load value of 1040 N. Following the completion of the study, the data that were produced from the analysis are used in order to forecast the structural behavior of the connecting rod under the specified load. Suraj Kumar , he have proposed the research paper on the topic entitled “Design and Simulation of Connecting Rod using Finite Element Analysis” In comparison to an aluminum alloy 7075, which has a maximum stress of 0.0330MPa, the connecting rod made of alloy steel 4340 has a maximum stress of 0.0332MPa. This value is somewhat higher.

When compared to a connecting rod made of alloy steel 4340, which has a maximum distortion of 0.000824 millimeters, the maximum deformation of a connecting rod made of aluminum alloy 7075 is 0.00229 millimeters. In addition, the connecting rod that is constructed of aluminum alloy 7075 has a maximum strain that is 4.61 times greater than an alloy steel 4340, which has a maximum strain of 1.66 times higher. In addition, if one disregards the fact that there is a slight stress difference between alloy steel 4340 and aluminum alloy 7075 and instead assumes that the stress in alloy steel 4340 is almost identical to the stress in aluminum alloy 7075, then an overall comparison reveals that alloy steel 4340 is the superior material for connecting rods. Suman Sharma, she have proposed the research paper on the topic entitled “Simulation and Modelling of Connecting rod of IC by Using Material C70S6”. The connecting rod is responsible for transferring the thrust force that is generated in the cylinder as a result of the combustion of the fuel during the power cycle to the crankshaft so that the vehicle can be driven in a rotating motion.

This thrust force is developed as a direct result of the power cycle. It fulfils the function of a connecting link between the crankshaft and the piston, so transforming the reciprocating action of the piston into the rotating motion of the crankshaft. The purpose of this body of study is to figure out which design parameters of the connecting rod will result in the least amount of critical buckling stress for the material C70S6 that is already in use. Today, a broad variety of car industries make use of this material in a variety of applications. In order to determine the stress level on the connecting rod, it is essential to do a stress and deformation study on the connecting rod. In the section under "Results and Discussion," a FE analysis for stress and deformation was done on various parameters of connecting rods using structural steel and aluminum alloy-based materials.

This study looked at stress and deformation in the material. For this particular piece of work, the connecting rod is made out of structural steel, and deformation, stress analysis, and strain are all done on it. When conducting the initial deformation and stress analysis for the connecting rod of the internal combustion engine, structural steel is used as the material of choice. The connecting rod that was utilized for this investigation was obtained from a previous research article.

Changing the material allows for subsequent analyses of stress and strain to be carried out after the deformation has been carried out. Catia V5 is the designing program that was used to create the model of the connecting rod that was used for analysis. After that, numerical and FEM analyses are carried out to estimate the deformation, and then Von Mises stress and elastic strain are computed by applying an external force with a load value of 1040 N. Following the completion of the study, the data that were collected from the analysis were used in order to make a prediction about the structural behavior of the connecting rod under the provided load. Aman Shrivastava et.al have proposed the research paper on the topic “STRUCTURAL ANALYSIS OF CONNECTING ROD”. The purpose of this study is to carry out the structural analysis of a connecting rod that is constructed out of three distinct kinds of alloys. Connecting Rods have a significant role to play in the operation of a variety of different types of automotive engines.

By transforming the reciprocating motion into a rotating motion, it is responsible for transmitting the up and down movement of the piston to the crankshaft of the engine. The design of a rod and the amount of weight it contains both have an effect on the performance of the rod in an engine. Because of this, analysis and optimization are now required in order to complete the assembly of a rod that is durable, cost-effective, and lightweight. The "structural steel" substance of rod is being phased out in favor of aluminum alloy, magnesium alloy, and titanium alloy as the new material for rod. Catia v5 is used to create the model of the rod, which is then loaded into the workbench of ANSYS 2021 R1 for static analysis. Following the completion of the study, a comparison is made between an already existing steel rod and, as a result, the three composite rods with regard to the Von Misses stress, equivalent strain, and total deformation.

All of these parameters are discovered analytically as well, and the results of the finite element analysis are compared with them. Analysis. Because each of those findings falls inside the range, we may deduce that the values of these materials are as follows: compared to the material steel. The overall task can be broken down into three distinct stages. To begin, the idea and a review of the previously developed information.

III. REASECH METHODOLOGY

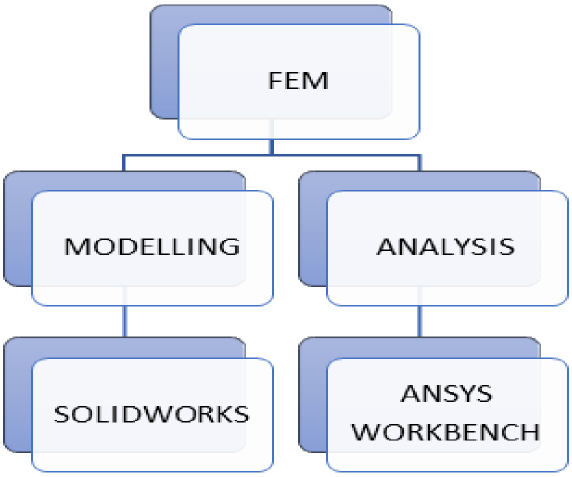

Fig. 2: An overview of methodology

A. STEPS

- *MODELLING*

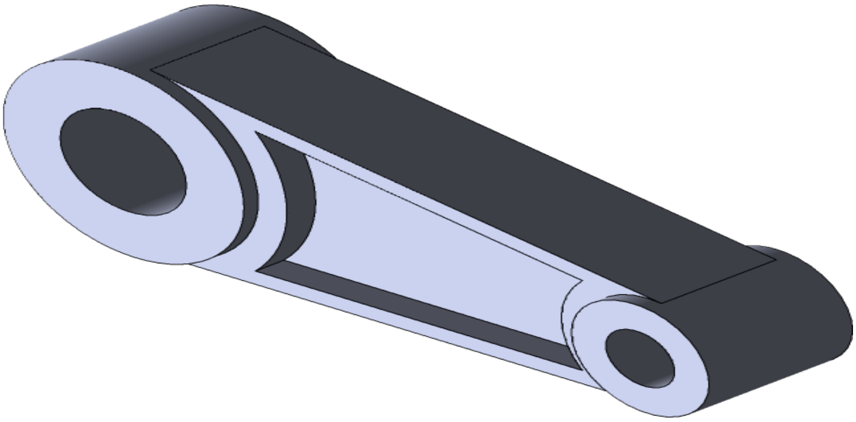

Fig. 3: Model of connecting rod

- *ANALYSIS*

The following steps were taken to execute the steady state thermal analysis using Ansys Workbench.

- Imported the geometry that built in SOLIDWORKS into Design Workbench of ANSYS static structural analysis window.
- Defined material properties for each layer of the solar panel model in the Engineering Data Such as modulus of elasticity and density.
- The geometry was opened in the Ansys modeler window to perform rest of the activities such as meshing, boundary condition.
- Meshing of the Connecting rod was done and 1mm meshing size was selected for this meshing work.
- Boundary condition was applied and here force (5000N) was applied at the small side of the connecting rod while the fixed support was considered at bigger end of the connecting rod for the analysis.
- After the boundary condition and the load were applied, it was solved using Ansys solver.
- The next step was to select the output variables so here, total deformation, directional deformation, von Mises stress, max and minimum principle stress and normal stress was tested.
- The result was demonstrated using output display unit of Ansys workbench and min-max Prob was selected to show the maximum and minimum value.

- *MESHING*

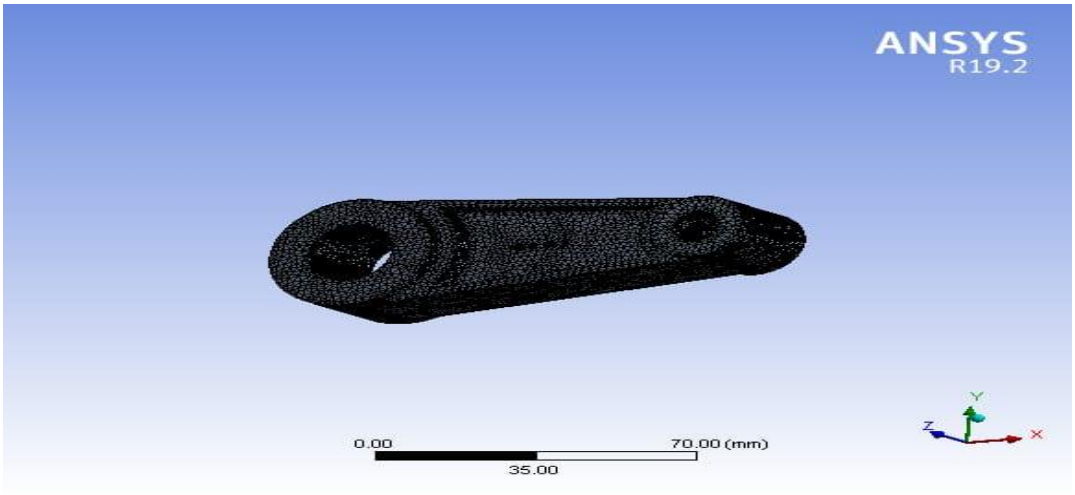

Fig. 4: Meshing

B. ANALYSIS

- MATERIAL – ALUMINIUM ALLOY

IV. BOUNDARY CONDITIONS

Fig. 5: Fixed Support

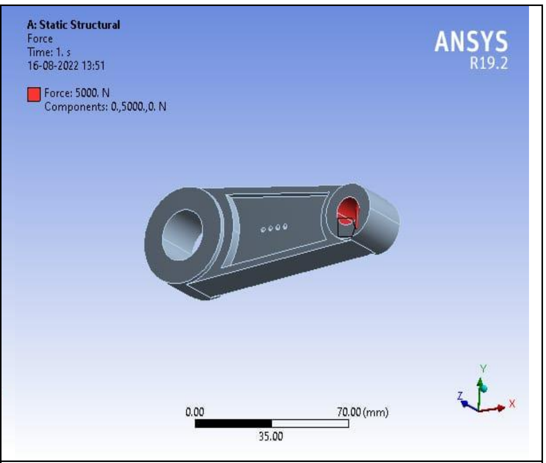

Fig. 6: Force (500N) Applied

V. RESULT AND DISCCUSSION

In this section, the results show which aluminum alloy is a good choice for the manufacture of connecting rods. For these, there are some variables such as stress (internal resisting force), deformation, and strain. With the help of these variables, a better material for connecting rods can be found because connecting rods fail these variables the most.

ALUMINIUM ALLOY (Al 6061 MG)

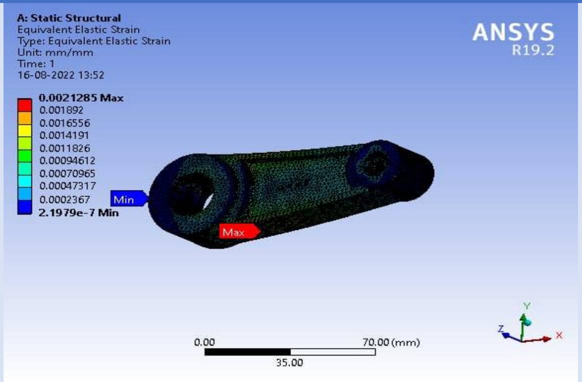

Fig. 7: Strain of Al 6061MG

ALUMINIUM ALLOY (Al 6061 TG)

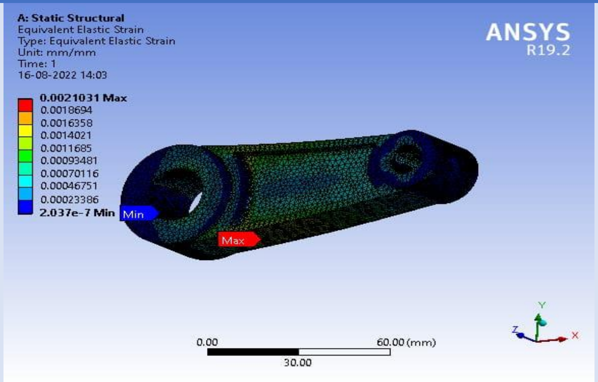

Fig. 8: Strain of Al6061 TG

ALUMINIUM ALLOY (Al 6061 MG)

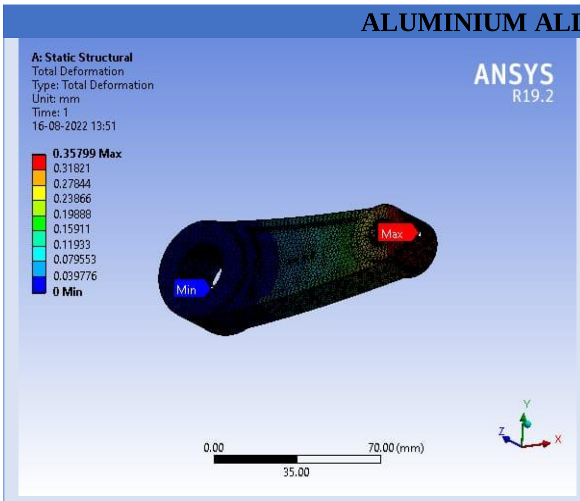

Fig. 9: Total deformation of Al6061 MG

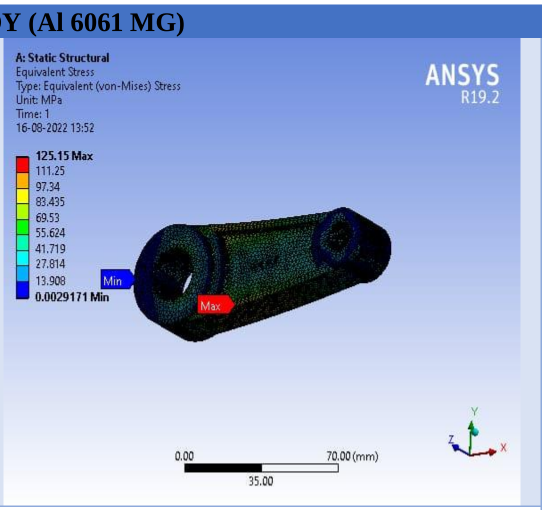

Fig. 10: Von Mises Stress of Al6061 MG

Aluminium Alloy (Al 6061 TG)

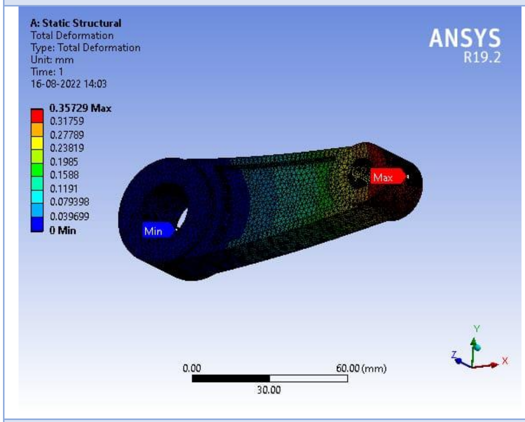

Fig. 11: Total deformation of Al6061 TG

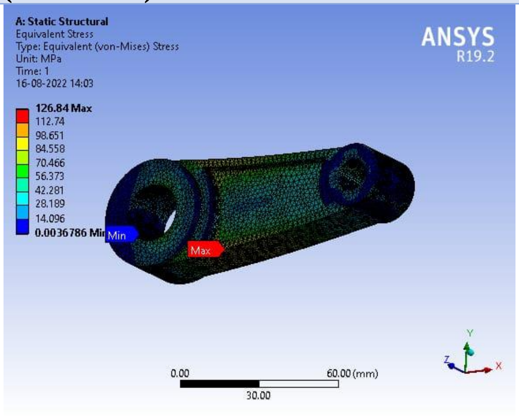

Fig. 12: Von Mises Stress of Al6061 MG

Table 1: Show the properties of Aluminum alloy

SL NO	PROPERTIES	ALUMINIUM ALLOY Al 6061 MG	ALUMINIUM ALLOY Al 6061 TG
1	TOTAL DEFORMATION (mm)	0.35799	0.35729
2	VON M ISES STRESS (MPa)	125.15	126.84
3	NORMAL STRESS	122.24	126.84
4	STRAIN	0.00211285	0.0021031

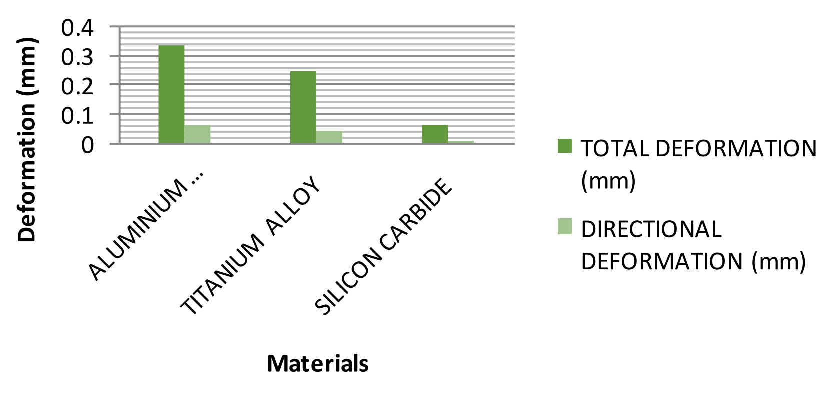

Fig. 13: Total deformation and directional deformation comparison

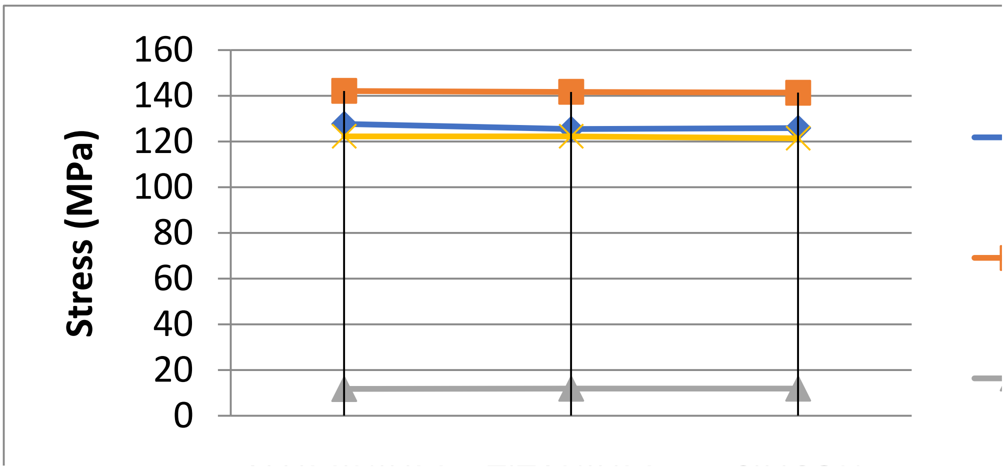

Fig. 14: Von Mises Stress, Principle Stress and Normal Stress comparison

VI. CONCLUSION

Static structural analysis was done for the connecting rod and performance was measured using Aluminium alloy materials. Materials like Aluminium alloy is suitable for connecting rod, proven in this analysis. The finding reveals the best materials for minimum deformation under a static load of 5000N was Aluminium alloy which gives 0.35 mm deformation. Al 6061 TG is less deformation than Al 6061 MG so we can say that Al 6061 TG is best material compare to the Al 6061 TG, deference is very less.

VII. FUTURE SCOPE

- Silicon carbide may one of the best alternative materials among all others as it has better performance on deformation and this can help to minimize the deformation under high load as well.
- Titanium alloy may extremely well for von-Mises stress and could minimize the stress which gives minimum stress among all three materials.

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