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DESIGN AND ANALYSIS OF CONNECTING ROD USING ANSYS

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Abstract - Connecting Rod is an important component of an internal combustion engine. It serves as an intermediate link between the piston and the crankshaft. It converts the reciprocating motion ofpiston into rotary motion of crankshaft. It is responsible for transferring power from piston to crankshaft and from there on to the transmission.The most commonly used materials in the production of Connecting Rod are Steel (for production of engines), Aluminium (ability to absorb high impact at the expense of durability, light in weight), or Titanium (combination of strength and lightness at the expense of affordability).The Objective of this project is to Design and Analyse Connecting Rod using different materials. A parametric model of Connecting Rod is modelled using CATIA V5 Software and Analysis is carried out using ANSYS 14.0 Software. Different materials taken into consideration are $42CrMo_4$, Al7075-T651, Al6061-1.5%SiC-1.5%B_4C, Al7068.Performance parameters like Von-misses stress, Deformation and Factor of safety are analysed using ANSYS. From our work, it was observed that Al7068 has more Stiffness, less Stress and less Weight.

Keywords: Al7075-T651,Al6061-1.5%SiC-1.5%B_4C, Al7068, Aluminium, Connecting Rod

1. INTRODUCTION

In a reciprocating piston engine the connecting rod connects the piston to the crank or the crank shaft. Together with the crank, they form a simple mechanism that converts linear motion into rotating motion. Connecting rods may also convert rotating motion into linear motion. Historically, before the development of engines, they were first used in this way driving machinery from water wheels. As a connecting rod is rigid, it may transmit either a push or a pull and so the rod may rotate the crank through both halves of a revolution, i.e. piston pushing and piston pulling. Earlier mechanisms, such as chains, could only pull. In a few two-stroke engines, the connecting rod is only required to push.Today, connecting rods are best known through their use in internal combustion piston engines, such as car engines. These are of a distinctly different design from earlier forms of connecting rods, used in steam engines .

Fig: Failure of a connecting rod is one of the most common causes of catastrophic engine

In modern automotive internal combustion engines the connecting rods are most usually made of steel for production engines, but can be made of T6-2024 and T651-7075 Aluminium alloys (for lightness and the ability to absorb high impact at the expense of durability) or titanium (for a combination of lightness with strength, at higher cost) for high performance engines, or of cast iron for applications such as motor scooters. They are not rigidly fixed at either end, so that the angle between the connecting rod and the piston can change as the rod moves up and down and rotates around the crankshaft Connecting rods, especially in racing engines, may be called "billet" rods, if they are machined out of a solid billet of metal (this being forge into the rough shape), rather than being cast, The forged steel having better internal grain structure for strength.

The small end attaches to the piston pin, gudgeon pin or wrist pin, which is currently most often press fit into the connecting rod but can swivel in the piston, a "floating wrist pin" design. The big end connects to the bearing journal on the crank throw, in most engines running on replaceable bearing shells accessible via the connecting rod bolts which hold the bearing "cap" onto the big end. Typically there is a pinhole bored through the bearing and the big end of the connecting rod so that pressurized lubricating motor oil squirts out onto the thrust side of the cylinder wall to lubricate the travel of the pistons and piston rings. Most small two-stroke engines and some single cylinder four-stroke engines avoid the need for a pumped lubrication system by using a rolling-element bearing instead, however this requires the crankshaft to be pressed apart and then back together in order to replace a connecting rod. The connecting rod is under tremendous stress from the reciprocating load represented by the piston, actually stretching and being compressed with every rotation, and the load increases to the square of the engine speed increase. Failure of a connecting rod, usually called "throwing a rod" is one of the most common causes of catastrophic engine failure in cars, frequently putting the broken rod through the side of the crankcase and thereby rendering the engine irreparable; it can result from fatigue near a physical defect in the rod, lubrication failure in a bearing due to faulty maintenance, or from failure of the rod bolts from a defect, improper tightening. Re-use ofrod bolts is a common practice as long as the bolts meet manufacturer specifications. Despite their frequent occurrence on televised competitive automobile events, such failures are quite rare on production cars during normal daily driving. This is because production auto parts have a much larger factor of safety, and often more systematic quality control.

A major source of engine wear is the sideways force exerted .on the piston through the connecting rod by the crankshaft, which typically wears the cylinder into an oval cross-section rather than circular, making it impossible for piston rings to correctly seal against the cylinder walls. Geometrically, it can be seen that longer connecting rods will reduce the amount of this sideways force, and therefore lead to longer engine life. However, for a given engine block, the sum of the length ofthe connecting rod plus the piston stroke is a fixed number, determined by thefixed distance between the crankshaft axis and the top of the cylinder block where the cylinder head fastens; thus, for a given cylinder block longer stroke, giving greater engine displacement and power, requires a shorter connecting rod (or a piston with smaller compression height), resulting in accelerated cylinder wear.

Compound Rods

Many-cylinder multi-bank engines such as a V12layout have little space available for many connecting rod journals on a limited length of crankshaft. This is difficult compromise to solve and its consequence has often led to engines being regarded as failures (Sunbeam Arab, Rolls-Royce Vulture).The simplest solution, almost universal in road car engines, is to use simple rods where cylinders from both banks share a journal. This requires the rod bearings to be narrower, increasing bearing load and the risk of failure in a higher performance engine. This also means the (i) opposing cylinders are not exactly in line with each other.

Articulated Connecting Rods

In certain engine types, master/slave rods are used (ii) rather than the simple type shown in the picture above. The master rod carries one or more ring pins to which are bolted the much smaller big ends of slave rods on other cylinders. Certain designs of V engines use a master/slave rod for each pair of opposite cylinders. A drawback of this is that the stroke of the subsidiary rod is slightly shorter than the master, which increases vibration in an engine, catastrophically so for the Sunbeam Arab. Radial engines typically have a master rod for one cylinder and multiple slaverods for all the other cylinders in the same bank.

Materials Used

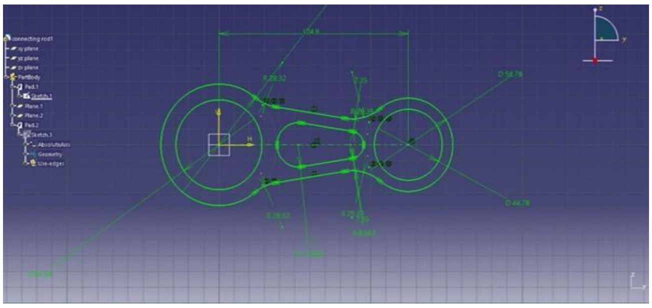
42CrMo$_4$: Steel grade 42CrMo$_4$ is an alloy steel for quenching and tempering. Grade 42CrMo$_4$ products are mainly used for the manufacture of machine parts. Steel is made in accordance with the requirements of the DIN EN ISO 683-2 standard (formerly EN 10083-3). It is a heat-treated alloy steel. Steel grade 42CrMo$_4$ has low weldability due to high crack sensitivity.

Chemical composition of 42CrMo$_4$,%

C	Si	Mn	P	S	Cr
0,43	0,26	0,65	0,015	0,021	1,07
Ni	Mo	Cu	Al	Sn	
0,19	0,16	0,16	0,021	0,006	

Al7075: Itis an aluminium alloy with zinc as the primary alloying element. It has excellent mechanical properties and exhibits good ductility, high strength, toughness, and good resistance to fatigue. It is more susceptible to embrittlement than many other aluminium alloys because of micro segregation, but has significantly better corrosion resistance than the alloys from the 2000 series. It is one of the most commonly used aluminium alloys forhighly stressed structural applications and has been extensively used in aircraft structural parts.7075 aluminium alloy's composition roughly includes 5.6–6.1% zinc, 2.1– 2.5% magnesium, 1.2–1.6% copper, and less than a half percent of silicon, iron, manganese, titanium, chromium, and other metals. It is produced in many tempers, some of which are 7075-0, 7075-T6, 7075-T651.

Al6061-1.5%Sic-1.5%B$_4$C: It is a metal alloy with low density and high thermal conductivity, but it has poor wear resistance. To overcome this drawback, Al6061 alloy is reinforced with ceramic materials so that its hardness, young‟s modulus and wear resistance are increased. It has a very good corrosion resistance and very weld ability. Al6061 has an excellent heat and elasticity conductor and in relation to its weight is almost twice as good conductor as copper.Ceramic materials generally used to reinforce Al alloys are SiC, TiC, ZrB_2, AlN, SiN_4, Al_2O_3, TiB_2 and SiO_2.Al6061 alloy is lightweight materials with P = 2.7g/cc and is het treatable alloy with strengthhigher than 6005A.



Reinforcements used:

SiC: It is a chemical compound of Carbon and Silicon; it is produced by high temperature electro chemical reaction of sand and carbon. SiC has low density, high strength and high hardness and good elastic modulus.

B$_4$C: It is an extremely hard material it is used in refractory applications because to its high melting point and thermal stability. It is also used as abrasive powder and coatingdue to its extreme abrasion resistance it has high hardness and low density and it is commonly used in nuclear applications a newton radiation absorbent.

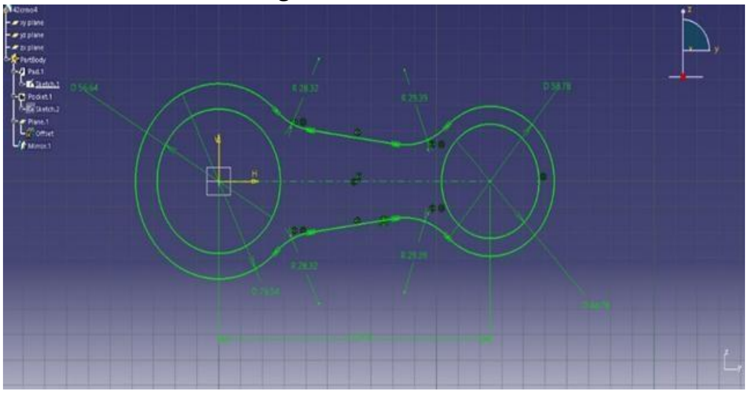
Al7068: It is a new high-performance aluminium alloy. The typical yield strength reaches 700MPa, which is 15% to 20% higher than 7075 alloy. The high temperature performance is better than 7075.Due to its excellent properties, 7078 aluminium sheet has been adopted by the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA). Haomei Aluminium has both 7075 and 7068 aluminium. Welcome to leave messagebelow to inquire what you need.

DESIGN PROCEDURE

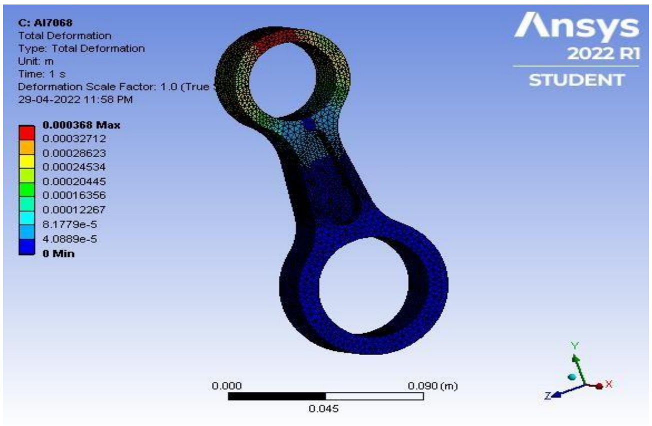
The connecting rod consists of an eye at the small end to accommodate the piston pin, a long shank and a big end opening split into two parts to accommodate the crank pin. The construction of connecting rod is illustrated The basic function of the connecting rod is to transmit the push and pull forces from the piston pin to the crank pin. The connecting rod transmits the reciprocating motion of the piston to the rotary motion of the crankshaft. It also transfers lubricating oil from the crank pin to the piston pin and provides a splash or jet of oil to the piston assembly. The connecting rod of an IC engine is made by the drop forging process and the outer surfaces are left unfinished. Most internal combustion engines have a conventional two-piece connecting rod. The whole rod is forged in one piece; the bearing cap is cut off, faced and bolted in place for final machining of the big end. The small end of the rod is generally made as a solid eye and then machined.

Design Procedure In Catia Software

Sketch-1 of Connecting Rod

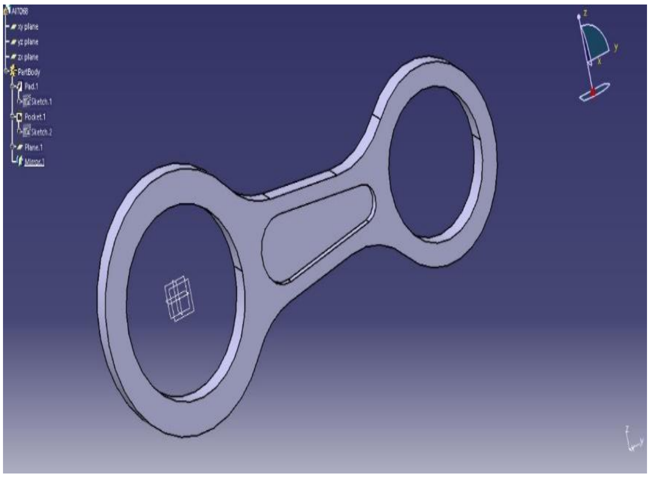


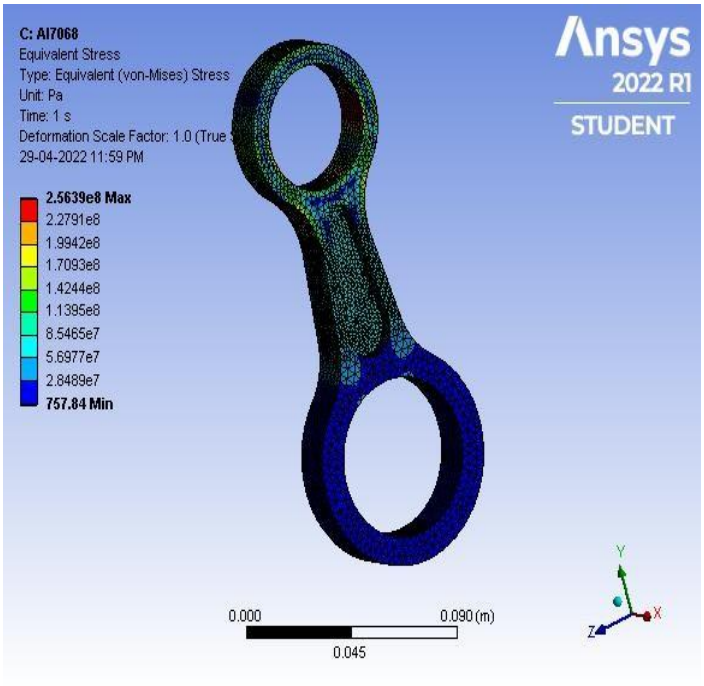
Sketch-2 of Connecting Rod



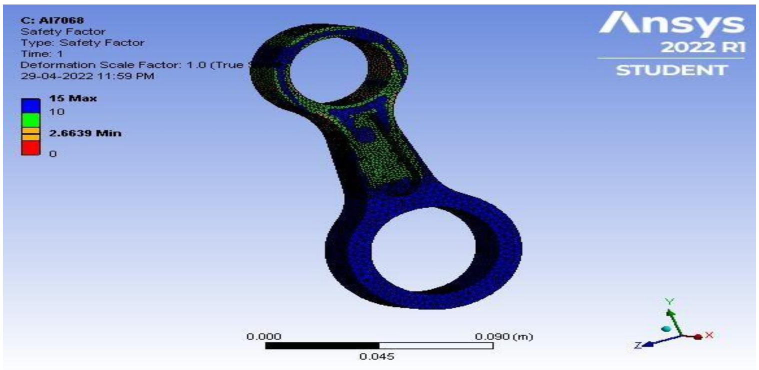
Sketch-3 of Connecting Rod

Analysis Of Connecting Rod In Ansys Software For Al7068





Total Deformation



Safety Factor

Equivalent Von-misses Stress

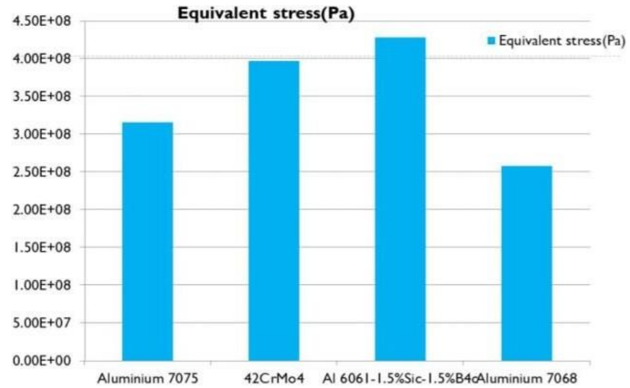
Mechanical Properties added in engineering data:

Materials	Ultimate Tensile stress (MPa)	Tensile Yield Strength (MPa)	Young's Modulus (GPa)	Poisson 's ratio	Density (gm/cc)
Al 7075-t651	570	500	71.7	0.33	2.81
42CrMo$_4$	650	350	200	0.33	7.7
Al6061 alloy	422	390	293.63	0.33	2.7
Al7068	710	683	73.1	0.33	2.85

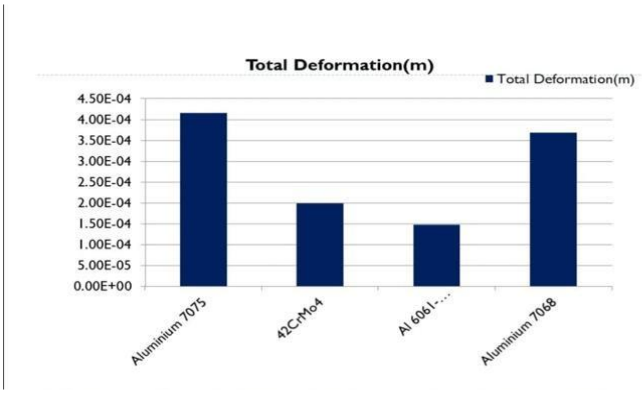
All dimensions are in mm

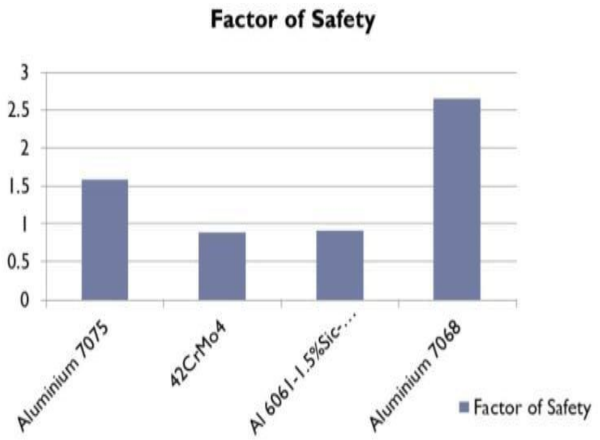
Experimental Results

When the Net force of 43181.117 N is applied on the Connecting rod at small end, Al 7068 shows the best result compared to Al 7075-T651, 42CrMo$_4$ and Al6061-1.5%SiC-1.5% B$_4$C.Al 70
68 shows less weight compared to remaining materials and have high factor of safety and minimum stress. Even though Al 7068 has high deformation, the material can be used in Connecting rod, due its low cost of production and manufacturing. Al 7068 can be used in Low and medium speed engines. It can be used at high temperature applications.



Graphical Representation of the obtained Results:





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CONCLUSIONS

- The requirements for manufacturing connecting rod are it should have high strength; less weight and it should have long life for the subjected load. Deformation of connecting rod should be less and it should be easily manufactured with minimum cost of production and fuel consumption should be minimum.
- The above factors are to be achieved when connecting rod is designed and manufactured material of the connecting rod is vital and should be selected to meet the considerations.
- Strength, weight and Young's modulus varies from material to material. So, the selection of material is important in designing process.
- Considering the above requirements, we observed through our analysis the material Al 7068 casting process is suitable for manufacturing connecting rod.

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