Design And Fabrication of Connecting Rod By Using Semi Solid Squeeze Casting Technique With Aluminium Alloy 6061

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Abstract- *Semi solids squeezed casting is a process of combining both casting and forging processes.By adoption of these processes can eradicate several complications rose during the casting process.They are many processes to increase the strength and hardness of a component but this is a most subsequent method. The aim of this project is to fabricate a component by using semi solid squeezed testing process.*

In this theses design and fabrication of connecting rod is made by using semi solids squeezed casting process by using aluminium alloys 6061.Connecting rod is an engine component the transverse motion from a piston to a crankshaft as a function of cam shaft Connecting rods are commonly made from cast aluminum alloy and powder metallurgy technique and designed to withstand thermal and dynamic stresses from combustion and piston movement.

The overall efficiency of the engine depends up on the weight of the moving parts in the engine like connecting rod and piston. The connecting rod is subjected to both tensile and compression stress rapidly. Hence in the present work is focused on fabrication of connecting rod with an aluminium alloy 6061 via semi solid squeeze casting technique.

The aim of this thesis to design and fabricate a connecting rod by using semi solid squeezed casting technique used in the petrol engine. The design is done by using empirical relations from standard data book [1].2D drafting and 3D modelling is prepared by using these dimensions. To evaluate the performance the couple field analysis is made which consisting of both structural and thermal analysis is carried out. Comparing the both conventional structural steel and aluminium alloy 6061.

I. INTRODUCTION

The need for innovative casting techniques and materials with enhanced mechanical qualities has been pushing research communities due to the automobile and aerospace industries.Parts made by conventional casting techniques are not as robust as those made via forging. The development of casting faults, such as porosity, segregation, hot tears, etc., is the main disadvantage of casting procedures. A relatively new method of creating components is called squeeze casting, which is a kind of metal forming. This process's primary benefit is its capacity to remove micro-porosity, which produces isotropic qualities and reduces component machining.
Many different metals have been treated using this method, from high melting alloys of iron and nickel to low melting alloys of lead and zinc.

The additional advantage of injecting a partially form ed alloy slurry is that shrinkage porosity is almost nonexistent. The manufacture of structural elements with good mechanical qualities that can also withstand further heat treatments or wel ding operations is made possible by the low or even absent por osity. While retaining many of the benefits of die-casting, including good dimensional tolerances, high production rates, high surface quality, complex near-net-shape parts, and thin sections with minimal need for finishing operations, semi-solid processing offers better performance than die-casting [6]. Furthermore, SSM processing extends die life in comparison to conventional die-casting because of decreased cycle times and the risk of hot tearing because of the lower temperature of the metal slurry (no overheating), as well as associated lower energy consumption [4,6,7]. These factors also contribute to lower stress associated with the lower injection temperatures and speeds (i.e., lower mold attack and erosion, lower thermal shock).

Applications In Automotive Engine:

The connecting rods in internal combustion engines nowadays are typically composed of steel. However, it can also be composed of cast iron for use in scooters or aluminum due to its special qualities, such as low weight to strength ratio, high impact strength, and durability, or titanium because of its affordability for high-performance engines and combination of strength and lightness. The connecting rod piston and crank shaft angle are constantly changing as the piston rises and falls during crank shaft rotation, and the connecting rods are not firmly fastened at either end. Rather of being cast, the connecting rods in racing engines are composed of a solid billet of metal known as "billets rod."

The connecting rods for Ford 4.6-liter engines and Chrysler 2.0-liter engines are composed of powder metallurgy, which offers extremely precise control over size, shape, and weight while minimizing material consumption and machining.

Commonly Used Materials For Manufacturing Of Connecting Rod:

Steel is typically used to make connections in cars because of its great strength, durability, and affordability; nevertheless, because of its high-density, high-speed engines' crank shafts are subjected to undue stress. This causes the engine's RPM to be restricted. Moreover, larger inertia loads—such as those resulting from heavier crankshafts and steel connecting rods—decrease engine speed declaration rates and acceleration. To get around the aforementioned issues, light alloying elements like titanium and aluminum are being utilized in high-speed engines. Connecting rods made of aluminum are preferred over titanium due to their lower density and cost. They do, however, have comparatively poor strength and fatigue life.

Connecting rod

II. LITERATURE REVIEW

Squeeze casting is a new casting technique that has been developed recently to improve the utilization of aluminum alloys. Squeeze casting, also known as liquid metal forging, is a casting technique in which molten metal is forced to solidify on a closed die that is positioned between hydraulic press plates. Squeeze castingoffers several distinct advantages over traditional casting techniques, including gas porosity and free shrinkage, which result in components with higher mechanical qualities and higher integrity. Numerous studies on the squeeze casting parameters of magnesium and aluminum alloys, as well as their composites, have been published in academic journals. It has been demonstrated that the melt temperature, die temperature, and pressure intensity are some of the key factors influencing the quality of squeeze cast components [17]. Given how closely the microstructure and casting factors connect to the mechanical properties of the components, it is very critical to comprehend the implications of process parameters. Malki et al.'s research [18, 19] has examined the impact of squeeze casting parameters on the LM13 aluminum alloy's microstructure, density, hardness, and macrostructure.

Aluminium Alloy 6061:

Heat-treatable aluminum alloy 6061 has a strength greater than 6005A and is classified as medium to high strength. Weldability and corrosion resistance are excellent, despite the material's decreased strength in the weld zone. Its fatigue strength is medium. In temper T4, it forms well in cold conditions, whereas in temper T6, it forms poorly. Not appropriate for extremely intricate cross sections.

Material	**Percentage (%)**	
	Min	**Max**
Manganese (Mn)	0	0.15
Iron (Fe)	0	0.7
Magnesium (Mg)	0.8	1.2
Silicon (Si)	0.4	0.8
Copper (Cu)	0.15	0.4
Zinc (Zn)	0	0.25
Titanium (Ti)	0	0.15
Chromium (Cr)	0.04	0.35
Others each	0	0.05
Others total	0	0.15
Aluminium (Al)	Balance	

Properties:

1. Density-2.70 g/cm³
2. Melting Point650 °C
3. Thermal Expansion23.4 x10^-6 /K
4. Modulus of Elasticity70 GPa
5. Thermal Conductivity166 W/m.K
6. Electrical Resistivity0.040 x10^-6 Ω .m
7. Highly corrosion resistant & good strength

DIMENSIONS OF CONNECTING ROD:

Specifications	**Dimensions in ‘mm’**
Flange & web thickness	5
Width of section B	20
Height of section H	25
Length of the connecting rod	163

L	
Big end dia	48
Small end dia	25

III. EXPERIMENTAL SETUP

Squeeze casting techniques continue to combine gravity die casting with closed die forging. Metals have changed to solidify when applied pressure is applied in a closed die. The rapid heat transfer produced by the functional pressure and the abrupt interface of the melted metal with the die surface causes a porous free casting with mechanical qualities that soon lead to the twisted product. There are several names for the squeeze casting process, including liquid metal, extrusion casting, and squeeze forming. It provides a high metal yield, minimal shrinking porosity, cheap operating costs, and a great surface polish. The tight connection between the liquid metal and the mold results in increased rates of heat removal through the metal mold border and premium quality castings. The indirect and direct methods are basically where the method is divided into two categories. A unique advantage of the squeeze casting approach over the predicted die casting method is that squeeze pressure is applied through the die-closing punch, which is a direct process. Alternatively, squeeze pressure is applied while the secondary ram closes the die, which is an indirect process.

1. The squeeze casting method's internal soundness, which is attained under pressure during the solidification process, makes it suited for critical applications.
2. Porosity due to shrinking is absent.
3. Both wrought alloys and casting alloys are suited for long-term freezing and can be squeezed to finish.
4. The cycle times for squeeze casting are earlier.
5. High-quality reusable dies and thin die coatings combined allow for good dimensional reproducibility. The components are formed by applying the appropriate pressure to the die, which is then recycled.
6. The components' forging quality has developed by squeeze casting.
7. Exceptional surface polish, distinct form, and precision in dimensions.

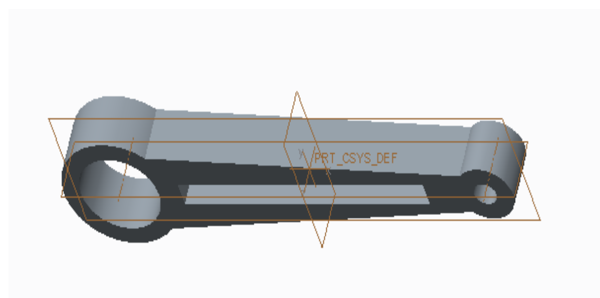
Al-8% SiC particles have been created using squeeze casting, sand casting, and chill casting techniques, and their mechanical and microstructure characteristics have been compared [22]. The microstructure of chill and sand casting products has grown, leading to a decrease in quality for both engineering and non-engineering applications. However, squeeze cast yields may still be used in their cast state for industrial requests requiring high-quality parts.

Experimental setup:

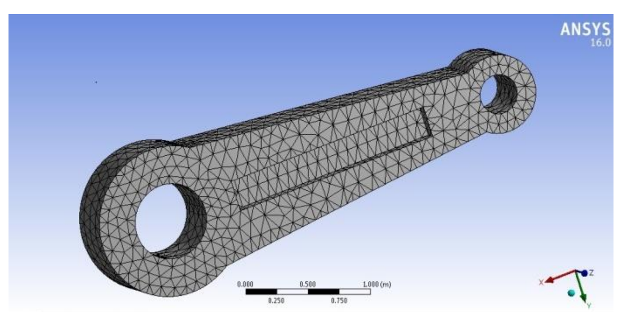
A cast iron die measuring 150*100*10 mm (length*breath*thickness) is made for a rectangular specimen in the semi-solid squeezed process using aluminum alloy 6061 (AA6061). After heating the die to 2700C, molten metal AA6061 is poured into the die cavity at 5750C, and the die is left undisturbed to solidify.

Analysis:

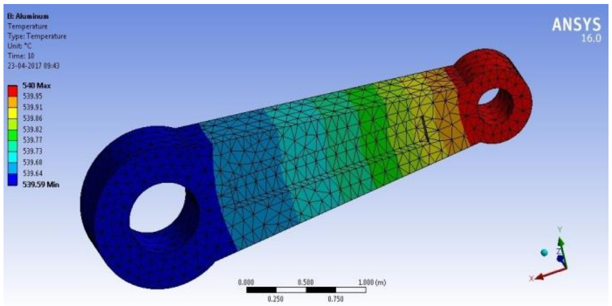
Coupled field analysis of connecting rod using al6061



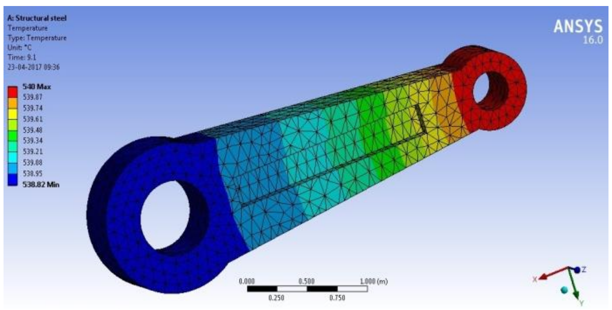
The two-wheeler chassis model that was imported using the IGES (initial graphical exchanging standard) format from Creo parametric is seen in the above image.



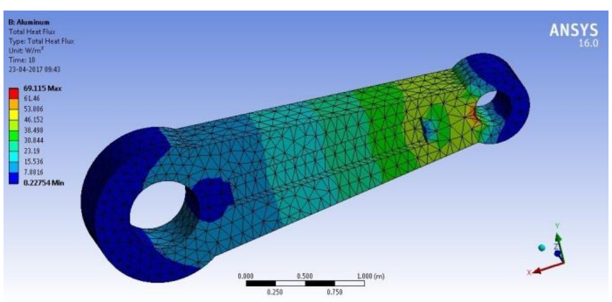
The above image is showing mesh model of object, meshing is used to deconstruct complex problem in to number of small problems using finite element method



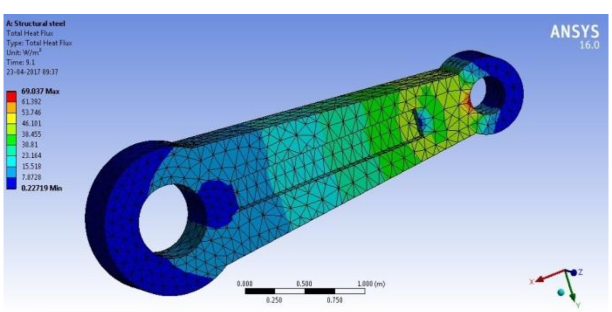
The above image shows temperature analysis of connecting rod of al7075



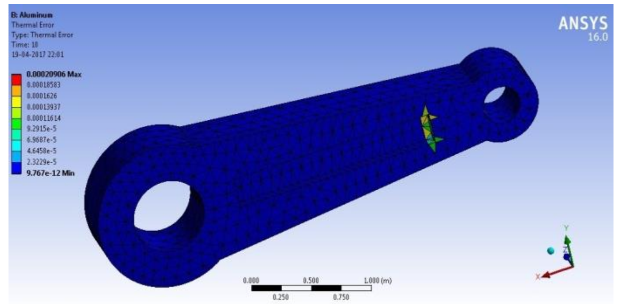
The above image shows temperature analysis of connecting rod of structural steel



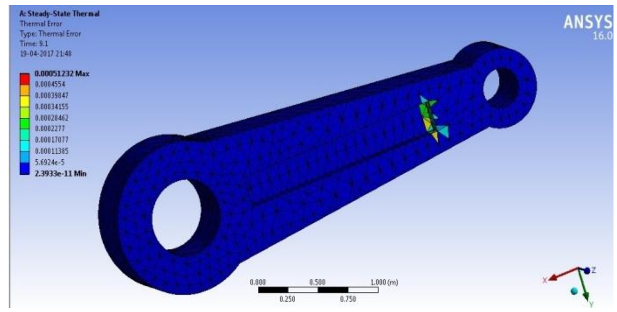
The above image shows total heat flux of connecting rod of al7075



The above image shows total heat flux of connecting rod of structural steel



The above image shows thermal error of connecting rod of al7075



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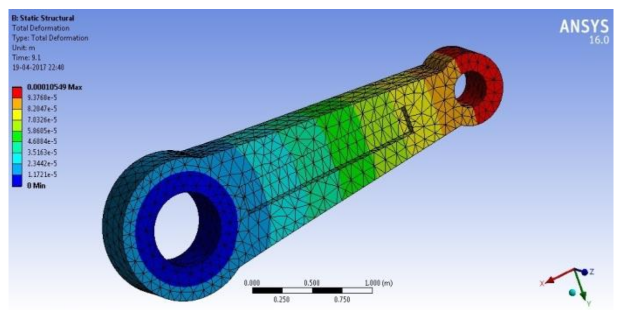
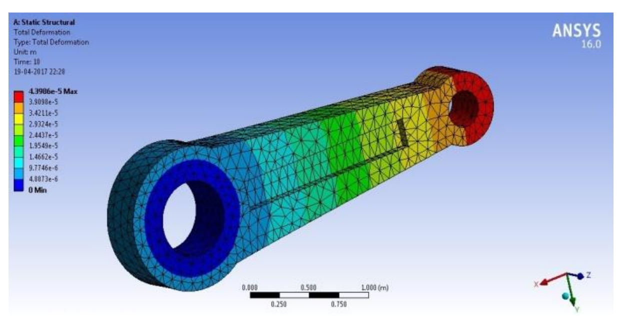
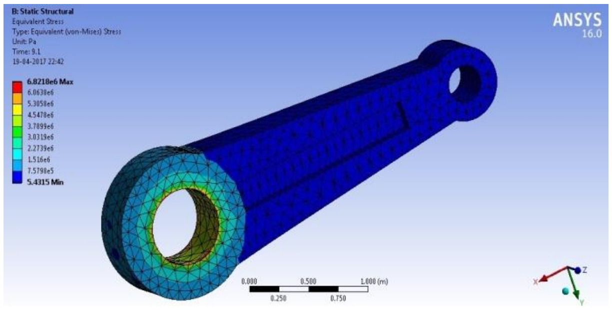


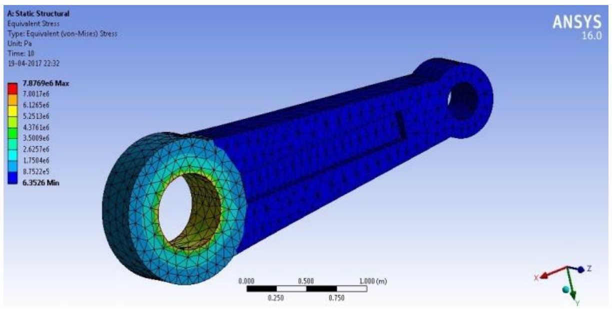
The above image is showing total deformation value of connecting rod of al7075



The above image is showing total deformation value of connecting rod of structural steel



The above image is showing equivalent stress value, it is also called as vonmisses stress which provides the average value of directional and principle stress using vonmisses theory of failure of connecting rod of al7075



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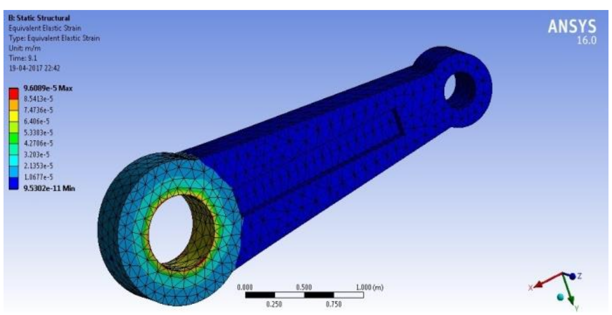
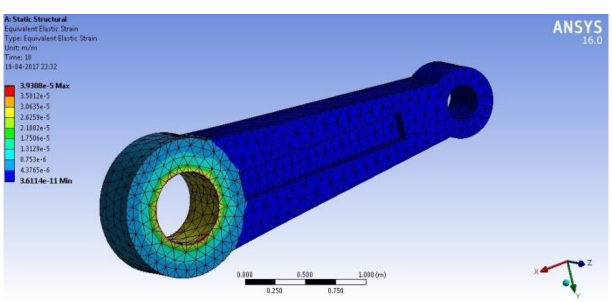


The above image is showing equivalent strain value, it is also called as vonmisses strain which provides the average value of directional and principle strain using vonmisses theory of failure of connecting rod of al7075



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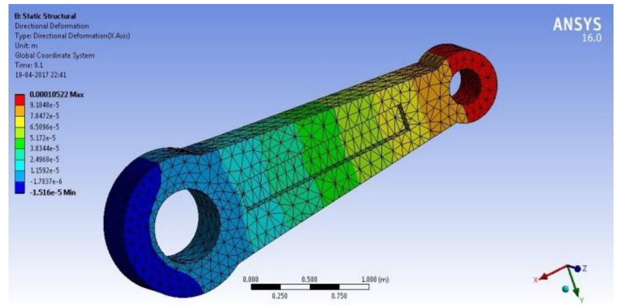
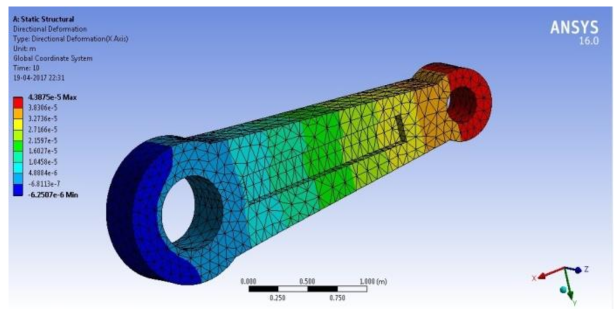
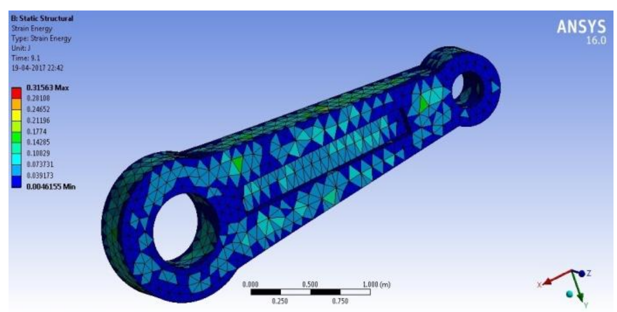


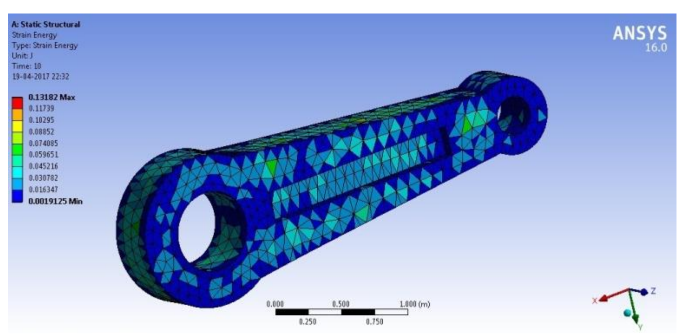
Directional deformationof connecting rod of al7075



Directional deformation of connecting rod of structural steel



Strain energy of connecting rod of al7075



Strain energyof connecting rod of structural steel.

Comparison of thermal and structural properties of connecting rod made up of structural steel and al7075

Connecting rod

die assembly

PROPERTIES	STEEL	Al6061
Pressure (Mpa)	7.15	6.82
Temperature (K)	540	532
Heat Flux (W/m^2)	69.037	69.115
Thermal Error	0.00051232	0.00020906
Total Deformation (m)	0.000043875	0.00010549
Equivalent Stress (Pa)	$7.8769e^{6}$	$6.821e^{6}$
Equivalent elastic Strain (m/m)	$3.9388e^{-5}$	$9.6089e^{-5}$
Strain energy (J)	0.13182	0.31563
Directional deformation (m)	$4.3875e^{-5}$	$1.0522e^{-4}$

IV. RESULTS & CONCLUSION

RESULTING COMPONENT

Semi-solid squeezed casting is used to create a connecting rod that is free of flaws and has a low weight to strength ratio after accounting for the design, analysis, and material selection elements. Figure displays the final component that was produced as a result of this work.

Final Fabricated Connecting Rod

V. CONCLUSIONS

Based on the literature review, numerous studies have been conducted on the materials used to make connecting rods. For example, material composition in the casting process between steel and aluminum, semi solid squeezed casting or regular cast steel. As a follow-up to earlier studies, semi SSSC is made from aluminum 6061, and connecting rods are made using the SSSC technique. The work's conclusions are as follows:

- In the connecting rods made by SSSC, non-dendritic primary a-Al particles are evenly distributed throughout the microstructure. Connecting rods made with SSSC have tensile strength and elongation that are greater than 16.35% and 23.40%, respectively, higher than those made with traditional liquid SC.
- Tensile strength is more in conventional casting (310 MPa) when compared with the SSSC (294 MPa)
- The mechanical properties of the connecting rod made by SSSC increase as the die temperature rises due to an increase in the size and form factor of primary a-Al particles. The mechanical characteristics of the connecting rod, however, deteriorate when the die temperature rises above 300 1C because the APD increases and the APS abruptly drops.
- There is a 14 MPa increase in compression strength (SSSC 264 MPa and casting 240 MPa).
- Conventional casting has a 280 MPa impact strength, but SSSC has a respectable variation of 337 MPa.
- Flexural strength is lower in comparison to conventional casting (276 MPa for SSSC and 298 MPa for conventional casting).
- The material's microstructure exhibits no significant alterations.

  ¬AlSi9Mg connecting rods made by SSSC were found to have reasonable process parameters, such as a squeezing pressure of 100 MPa, a pouring temperature of 575 1C, and a die temperature of roughly 250 1C.