Forging Simulation for Connecting Rod using AFDEX

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Abstract- The purpose of this paper is to simulate the closed die forging process, prediction of defect and eliminating it to increase the product life. The task is to simulate the connecting rod using AFDEX software. To achieve this objective CAD technology is combined with this process simulation tools to enable modeling of connecting rod. Two iterations are analyzed to facilitate completely filling of material enabling minimize material scrap and forging stages and hence reduce the overall cost of manufacture. Results of forging trails showed a high level of confidence in the simulation tools.

Keywords-AFDEX, closed die forging, connecting rod, stresses.

I.INTRODUCTION

Forging is a manufacturing process involving the shaping of metal using localized compressive forces. The blows are delivered with a hammer or a die. Forging is often classified according to the temperature at which it is performed cold forging, warm forging, or hot forging. For the latter two, the metal is heated, usually in a forge. Forged parts can range in weight from less than a kilogram to hundreds of metric tons. Forging has been done by smiths for millennia the traditional products were kitchenware, hardware, hand tools, edged weapons, and jewelry. Since the Industrial Revolution, forged parts are widely used in mechanisms and machines wherever a component requires high strength; such forgings usually require further processing (such as machining) to achieve a finished part.[3] Today, forging is a major worldwide industry. In this paper it describes all about the overall functionality of the connecting rod. In earlier research works, a three-dimensional model using MSC/DYNA is earlier versions of software that are used to simulate a closed die forging process. [2] In the recent paper different die configurations and billet shapes are experimented in order to produce the best configuration and subsequently supported by forging simulation package called Super Forge for process optimization and they got to know that Super Forge simulations seem to give the desired results. Closed die forging is a very complicated process and the measurement of actual forces for real material is difficult and cumbersome. For this resign a simulation process is adopted. Hence the computer simulation modeling technique has been adopted to get the estimated load requirement. The objective of this research work is to simulate and analyze the closed die forging process. Three-dimensional modeling of component and the corresponding dies are performed by CATIA software, while simulation and analysis of forging are performed by AFDEX (Advisor as friend for Forging Design Experts) software, having the capability of checking the die filling, defect formation.[11] The prominently used simulation software in the forging industry can also determine and display a variety of useful parameters such as, the effective plastic strain, effective strain rate, effective stress, material flow, temperature, force-time relationship, final shape, nodal velocity, under fill/fill of die cavity, graphs like volume change v/s stroke, node v/s stroke, lode v/s stroke etc.,. It is observed that the software can be effectively used to study the overall functionality and optimize the forging simulation process to maximize the mechanical strength, minimize material scrap or improve yield and forging stages and hence reduce the overall cost of manufacture. [4]

II.SIMULATION

Simulation is the imitation of the operation of a real-world process or system over time. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors/functions of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time. [1]

Simulation is used in many contexts, such as simulation of technology for performance optimization, safety engineering, testing, training, education, and video games. Often, computer experiments are used to study simulation models. Simulation is also used with scientific of natural systems or human systems to gain insight into their functioning. Simulation can be used to show the eventual real effects of alternative conditions and courses of action. Simulation is also used when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply not exist. [7]

III. METHODOLOGY

For the present analysis, the steps are enlisting in below Figure. Initially we considered a part or component for the analysis and then developed the CAD model of the component using Catia software. Corresponding to the CAD model, we designed suitable dies. With respect to the process, material composition and properties given for the product, select the suitable die material. Finally forging simulation is carried out by using the forging simulation software called AFDEX (Advisor as friend for Forging Design Experts). If any defects are present, changes are made in the dies. This leads to improved results in the final product. This forging simulation process will continue till we get product with least defects.

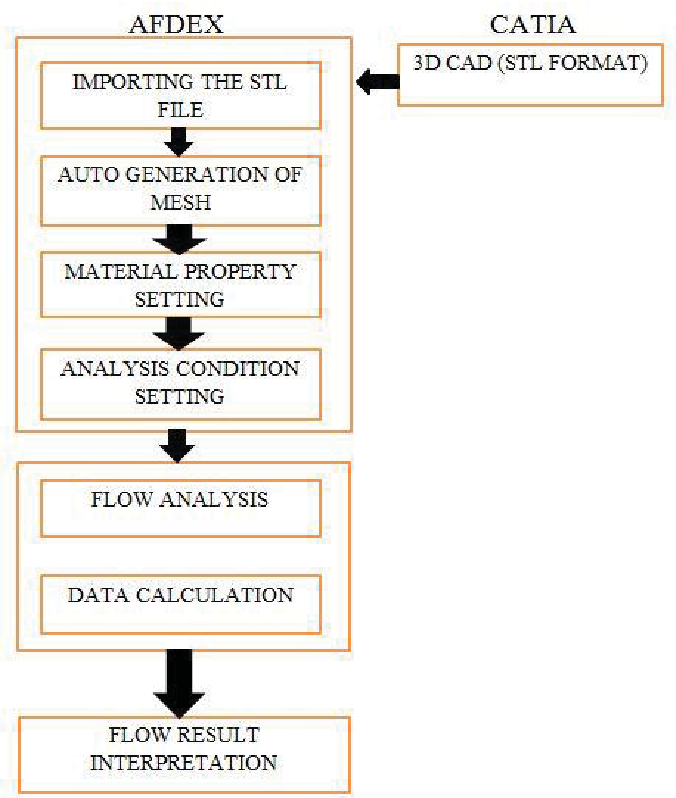


Fig: 1 Methodology

After the simulation got over with least defects, then the product goes for production. Figure shows part drawing of the connecting rod considered for the analysis. The work piece material considered for the present analysis is AISI 1015 low-carbon steel. The chemical composition, Mechanical properties of AISI 1015 low-carbon steel are presented in Table 1 and Table 2.

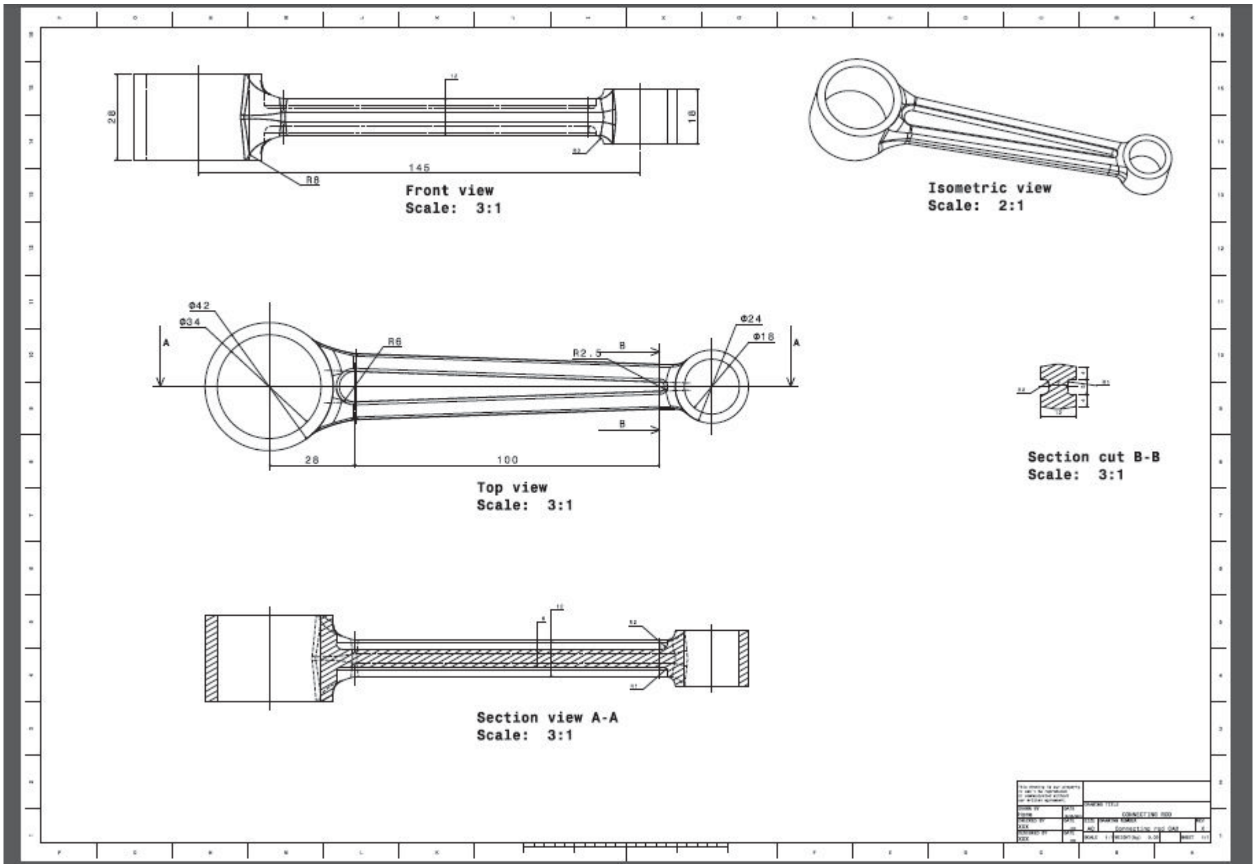


Fig: 2 Part drawing of connecting rod

Table: 1 Chemical Composition of AISI 1015 low carbon steel in % [2]

Element	**Weight %**
C	0.48-0.55
Mn	0.60-0.90
P	0.04 (max)
S	0.05 (max)

Table: 2 Mechanical Properties OF AISI 1015 low carbon steel[5]

Density ($\times$1000 kg/m^3)	7.7-8.03
Poisson's Ratio	0.27-0.30
Elastic Modulus (GPa)	190-210
Tensile Strength (Mpa)	636.0
Yield Strength (Mpa)	365.4
Elongation (%)	23.7
Reduction in Area (%)	39.9
Hardness (HB)	187
Impact Strength (J) (*Izod*)	16.9

Modeling in CATIA software

3D modeling software CATIA is used to model the part, billet, and dies. Modeled components are shown in Figures.

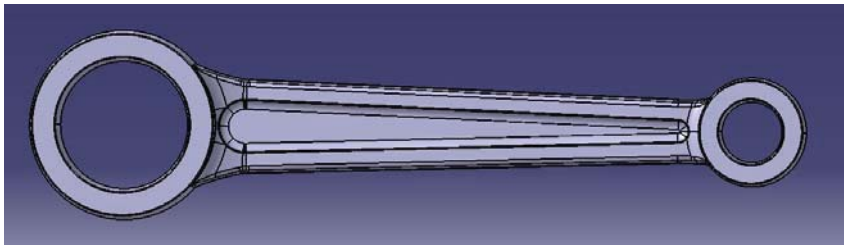


Fig: 3 3D model of billet

For simulation purpose, machining allowance of 0.5 should be added for all sides of the component. But in manufacturing, machining allowance should be added depending on physical structure of the component. In connecting rod intricate portions are pocket creation, cutting operations. Forging cannot be done in those intricate portions. Above figure shows connecting rod after neglecting intricate portions to facilitate smooth forging. [5]

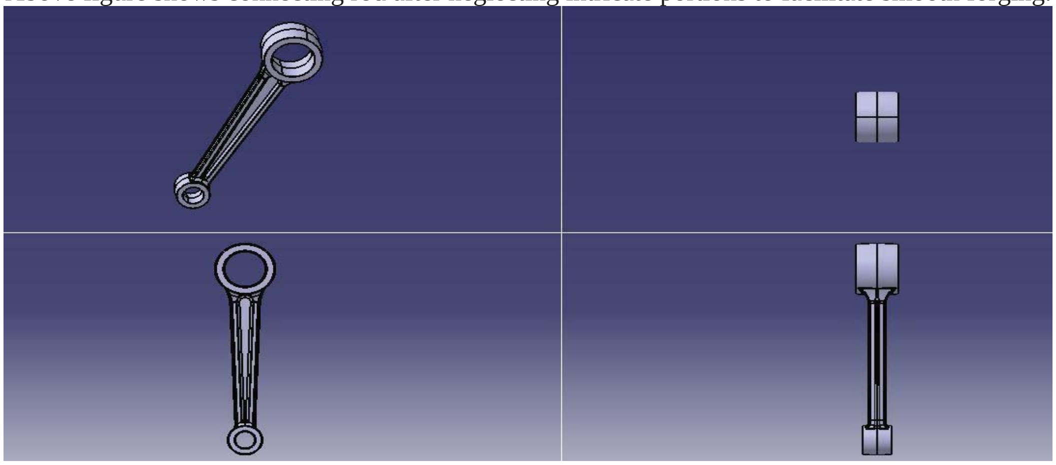


Fig:4 Modeled component of the connecting rod after neglecting intricate portions and adding 0.5 mm machining allowance for all sides of the component

CATIA provides option of Boolean operation by which specific shape can be subtracted or added to the other shape. If the part is simple, Boolean operation can be used to design the upper die and lower die. Even though AFDEX allows dies and billets to move in X, Y and Z directions and rotate about X, Y and Z directions it causes lot of problems in positioning, if they are aligned manually. So care must be taken while modeling dies and billet in CATIA.

As the given part has circular cross-section along Y axis, a cylindrical billet is used. Dies and billets are drawn in such a manner that they are all aligned in the same axis. As AFDEX accepts only .STL files, upper die, lower die and billet are saved with .STL extension. All the files of dies and billets with .STL extension are imported to AFDEX database.

Table: 3 FORGING PARAMETERS [8]

Type of Forging	**Hot Close-Die- Forging (HCDF)**
Work Piece Material	AISI 1015(T=800-1200C)
Die Material	Tool steel H 13
Press Type	Crank press
Friction Type	Coulomb Friction
Coefficient of Friction	0.3
Draft angle for die for ease of ejection	5-7 degree

IV.RESULT AND DISCUSSION

A. EFFECTIVE STRESS-

Figure 5(a) and 5(b) shows effective stress of the connecting rod that ensures the stress on the connecting rod while forging. In figure 5(a) shows maximum effective stress is +1.531E+2 in 2.88 seconds with partial flash on connecting rod. In figure 5(b) shows the modified billet is forged and the effective stress is +1.160E+2 in 7.42 seconds with complete flash around the billet that ensures the better strength of connecting rod. The different color highlights effective stress at each intersection point of die contact with billet and the global coordinates shows the values of effective stress at different orientation of connecting rod.

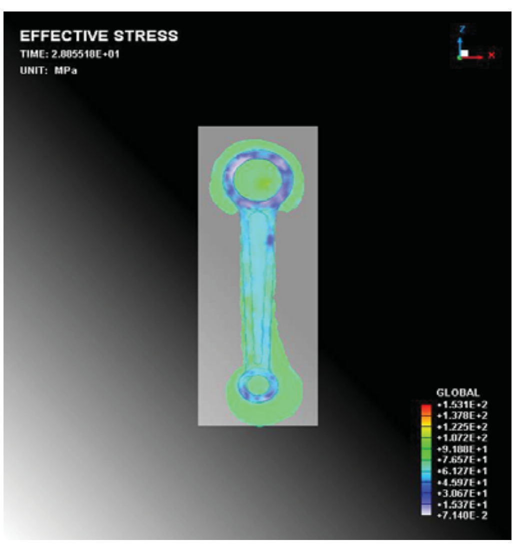


Fig: 5(a)

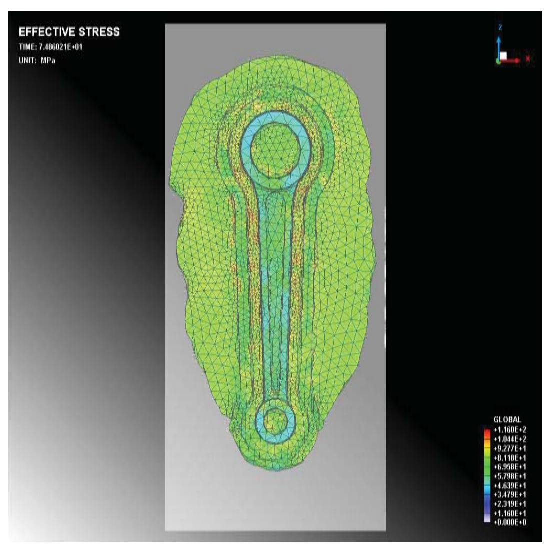


Fig: 5(b)

B. TEMPERATURE-

The temperature gradient is a physical quantity that describes in which direction and at what rate temperature changes most rapidly around the particular location. Temperature is an objective comparative measure of hot or cold. In Fig 6(a) it shows the accurate temperature at each node of billet the temperature changes on the rate of stroke and the die contact on the work material.

The different color indicates the temperature changes on billet with according to the change in stroke rate. The maximum temperature changes are found at the die contact with maximum stress on the billet at initial stages the flash is less and the temperature is comparatively low. In fig 6(b) the rate of volume of billet is increased and the time of stroke is also increased for this temperature gradient on billet is also increased.

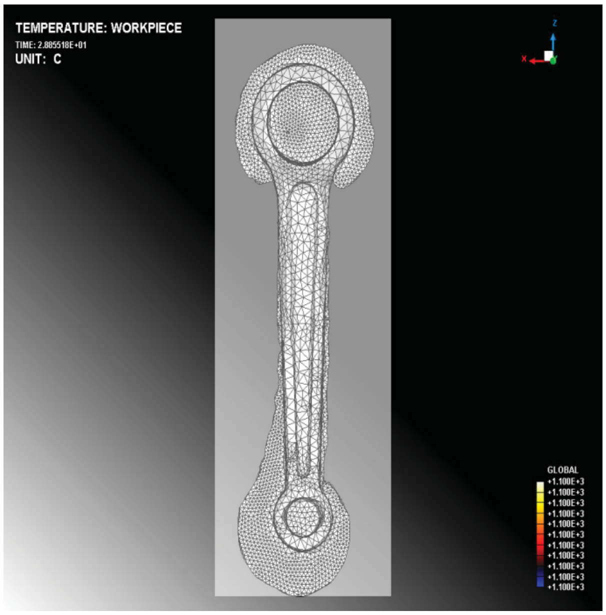


Fig: 6(a)

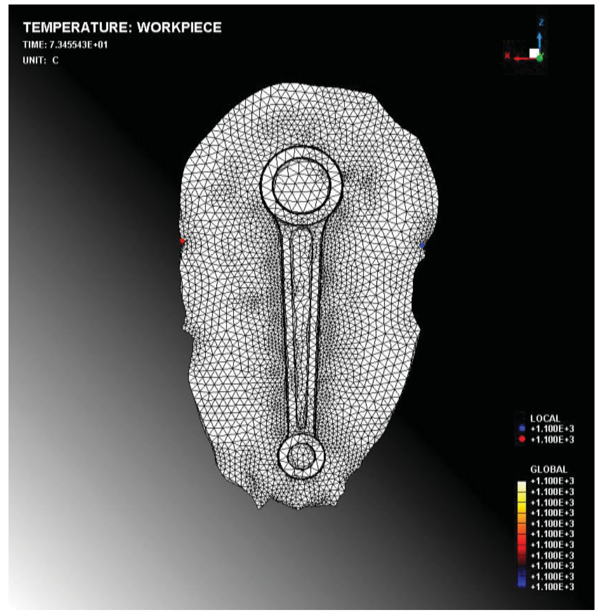
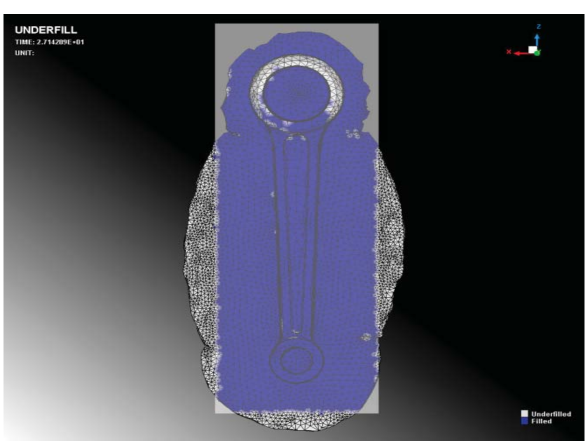


Fig: 6(b)

C. UNDER FILL-

Figure 7(a) shows incompletely filled cavity of billet, here the blue color indicates the filled portion of material and white color indicates the under filled state of billet.

But in the 2nd iteration the billet volume is increased at the bigger end of the connecting rod and slight modification are made on billet to avoid sharp corners of billet and shrinkage allowance is provided with 0.5% of total volume of the billet. Figure 7(b) shows the completely filled state of material without any cavity on surface of billet, by this it results better strength of the connecting rod.



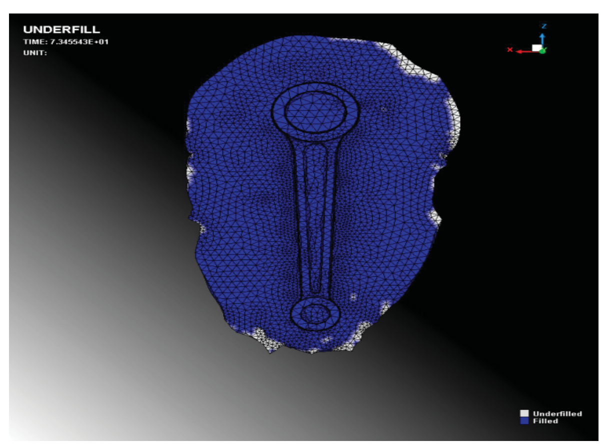


Fig: 7(a) Fig: 7(b)

V.CONCLUSION

In the present work 3D model of connecting rod component is simulated with AFDEX software to study on forging simulation and overall functionality of connecting rod.
Notable conclusions from this study are

- By adopting the AFDEX simulation software, it is possible to evaluate the flow analysis of material at each stage. Therefore distribution was good and no defect is observed.
- In first iteration there is lack of material to fill the cavity that leads to formation of defect. Where in the second iteration the volume of material is increased and design modification is done on the bigger end of connecting rod in order to achieve a defect free component.
- The second iteration resulted with reducing defects by complete filling of material is achieved and has good strength of workability.

REFERENCES

[1]. "Simulation of Closed die forging for Stud Bolt and Castle Nut using AFDEX" by M. R. Doddamani, Uday M.
[2]. "Optimization of Connecting Rod Parameters using CAE Tools" Anil kumar Student, Mechanical Engineering GJUS&T, Hisar Kamaldeep Grover Assistant Professor, Mechanical Engineering Department GJUS&T, Hisar Balvinder Budania Assistant Professor, Mechanical Engineering Department OITM, Hisar .
[3]. "Finite Element Analysis of I.C Engine Connecting Rod‖: A Review Mukesh Kumar1, Veerendra Kumar2 1 Research Scholar, Department of Mechanical Engineering, Government Engineering College, Jabalpur –482011, (M.P), India 2 Professor, Department of Mechanical Engineering, Government Engineering College, Jabalpur –482011, (M.P), India
[4]. "Design and analysis of connecting rod by using cfrp material" M. RAVICHANDRAN1, R. ANBAZHAGAN2, BINU. K. SOLOMAN3 & C. JAGADEESH VIKRAM4 1,3,4M.Tech Student, Department of Automobile Engineering, BIST, Bharath University, Selaiyur, Chennai, Tamil Nadu, India 2Project Supervisor, Professor, Department of Automobile Engineering, BIST, Bharath University, Selaiyur, Chennai, Tamil Nadu, India
[5]. "Modeling and fe-analysis of connecting rod for cost and material optimization" Mr.Jayesh Ramani1, Prof.Sunil Shukla2, Prof.Sachin Jain3, Dr.P.K.Sharma4 1 M.Tech Student, Mechanical Department, NIIST-Bhopal (India) 2, 3 Assistant Professor, Mechanical Department, NIIST-Bhopal (India) 4Prof. & Head, Mechanical Department, NIIST-Bhopal (India)
[6]. "Analysis of Connecting Rod Using Analytical and Finite Element Method" Prof. N.P.Doshi, 1 Prof .N.K.Ingole2 1(Department of Mechanical Engineering, Bapurao Deshmukh College of Engg, Sewagram, India) 2 (Department of Mechanical Engineering, Datta Meghe College of Engg, Sawangi, India)
[7]. "FE-Analysis of Connecting Rod of I.C.Engine by Using Ansys for Material Optimization" Mr. J.D.Ramani*, Prof. Sunil Shukla**, Dr. Pushpendra Kumar Sharma*** *(M. Tech (Machine Design and Robotics) Student, Mechanical Engineering Department, NIIST Bhopal) ** (Assistant Professor, Department of Mechanical Engineering, NIIST, Bhopal) *** (HOD, Department of Mechanical Engineering, NIIST, Bhopal)
[8]. "Preform Shape Optimization of Connecting Rod Using Finite Element Method and Taguchi Method" Md. Israr Equbal1, Rajkumar Ohdar2, Md. Nadeem Bhat3, Suhail Ahmad lone4 1,2Department of Forge technology, NIFFT, Ranchi 834003, India 3Department of Foundry and Forge technology, NIFFT, Ranchi 834003, India, 4Department of Material science and Engineering, NIFFT, Ranchi, 834003, India
[9]. "Design of Connecting Rod for Light Weight Using C70S6 Material" Government College of Engineering Aurangabad (Maharashtra), India – 431005 1omdeepak2001@gmail.com
[10]. "Stress Analysis of Connecting Rod for Weight Reduction-A Review Christy V Vazhappilly"*, P.Sathiamurthi** Department of Mechanical Engineering, Jyothi Engineering College, Kerala, India Department of Mechanical Engineering, Kongu Engineering College, Tamil Nadu, India
[11]. "Design Optimization and Analysis of a Connecting Rod using ANSYS‖ G. Naga Malleshwara Rao Professor of Mechanical Engineering, Shri Shirdi Sai Institute of Science and Engineering, Anantapuramu, A.P, India