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SIMULATION AND ANALYSIS OF COLD ROLLING PROCESS ALUMINIUM ALLOY NL

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A B S T R A C T

In the cold rolling process, roll diameter, roll speed, and contact length play very important role. In the present study, a finite element 3D model has been developed to investigate the effect of cold rolling process on the non linear aluminium alloy.Ansys software was used to develop the FEA model. Athree-dimensional Elastic-FEA model has been developed to simulate the cold rolling process. The angular velocity of the work rolls ranged from 30 to 480 revolutions per minute (r.p.m.) and the rigid roll diameter ranged from 100 to 300 mm. In this paper, aluminium alloy strip has been used for cold rolling process and studied the effect of rolling process on the aluminium alloy

Keywords: Cold rolling process, Stress, Strain and Deformation

1. INTRODUCTION

In its earliest period, the rolling of flat materials was absolutely limited to those metals of sufficient ductility to be worked cold, and it is probable that it was first performed by goldsmiths or those manufacturing jewelry or works of art. During the fourteenth century, small hand-driven rolls about half an inch in diameter were used to flatten gold and silver and perhaps lead. However, the first true rolling mills of which any record exists were designed by Leonardo da Vinci in 1480. During the same period, lead was also beginning to find increasing use for roofing, for flashing, for the fabrication of gutters, and for other purpose.

1.1 Different type of cold rolling

The various types of rolling mills are characterized in many ways; single stand mills and multi stand mill as depicts in Figure 1.4. Single-stand millsare frequently classified on the basis of their roll arrangements. Multistand mills eitherby the number of stands or their commercial use, and unusual types of mills by the manufacturer'sname or a generally accepted designation of the mill

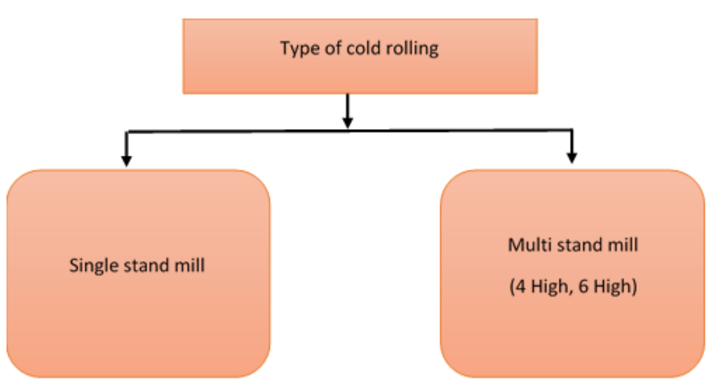


Fig 1 Type of Cold rolling process

In modern cold-rolling practice, two-high, four-high, and cluster-type mills, including Sendzimir mills, constitute the principal examples of single-stand mills as shown in Figure 1.5. However, the Steckel mill has found considerable commercial use, but in steckel mill, the strip should be thought of as drawn rather than rolled since the deformation energy is supplied by the tensile force exerted on the strip on the exit side of the mill.

As the years progressed various rare types of mills have been proposed to provide certain advantages, such as flatter or thinner strip and greater simplicity of construction and/or operation. Although some of these mills have been developed in the laboratory to the extent that they have reduced samples of strip, they have not as yet found acceptance for commercial cold-rolling operations[1-10].

In previous decade, the design of metal-forming tools, was mostly based on the knowledge gained through experience, and designing the optimum tool often required a protracted and expensive trial and error process.In the cold rolling process the cold roll pushed the sheets in to the rolls, one sheet at a time and

a catcher piled the sheets up on the exit side of the mill, usually on an annealing box bottom. If a second pass were to be required, the whole pile of partially cold-roll side of mill. In the cold rolling process, the polished rolls were used to achieve the glossy finish on the steel sheet surface. However, tin mills usually maintained a few single-stand mills (not arranged in tandem) to offer ordinary flattening passes and for nonglossy finishes. The proper lubrication maintenance was given to the bearings in an effort to prevent excessive temperature gradients which is occurs from the rolls due to the frictional heating at the roll necks. The continuous tandem mills using 4-high roll stands introduce as a high-speed mill, the slow-speed, two-high mills fell in to general disuse. Narrow two-high mills find rare use today in research work and commercial rolling operations where the short rolls present no serious bending problems [11-13].

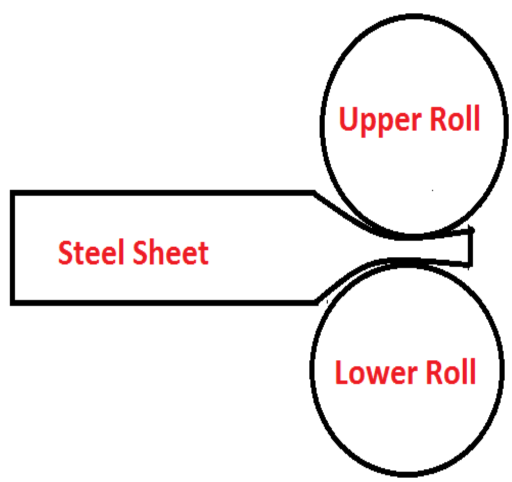


Fig. 2 Two high mill

M. Kazeminezhad et al. They investigated the rolling pressure and rolling force in the flat rolling process on the slab. During the slab analysis, the differences of width of contact area between the rolls and wire during rolling is considered. By using a modified Eulerian numerical method, two differential equations are derived and solved. The reduction in height, yield stress of wire on the rolling process are analyzed. Based on results, it has been observed that in the flat rolling of wire, there exists a maximum in the pressure distribution similar to that of the strip rolling process. Also, the effects of reduction in height, friction coefficient and yield stress on the neutral angle are examined. and measured rolling force[14]. Licheng Yang et al. developed the finite element model to study the hot rolling process of a slab. The developed 2D models of the roll and the slab are used to investigate the effect of different input process parameters (initial rolling temperature, slab thickness, rolling speed, friction coefficient, and reduction rate on the rolling force, normal force, and effective stress distribution). Furthermore, friction distribution in the deformation zone is also calculated based on 3D models [15]. Liu X et al. The technique to investigate the roll deformation accurately and efficiently is dynamic for the strip quality in terms of shape control of a six-high rolling mill. The different calculation methods of roll deformation, like FEM and the influence function method, have been usually used because of their accuracies. But, the calculation time is too long to be applied to the real-time control.M. H. Parsa et al. investigated the behavior of the NiTi alloy during the rolling process. As Nickel-Titanium alloy is expected as new category of smart materials that make the space in in industry and surgical treatment, because of their super elasticity and shape memory properties. The aim of author was to evaluate the deformation behaviour of NiTi, alloy during rolling by using experimental and simulation base [18]. In this paper, Simulation model has been developed and to analyze the total deformation, equivalent stress and strain of aluminum alloy slab during the rolling process by FEM model.

2. METHODOLOGY AND 3D BASED FEM MODEL

2.1 Material selection

Aluminum alloy NL have been used in this study. Aluminum alloy NL sheet are generally used in the automotive industries, puff panel, corrugation and profile sheet. Table 2 show chemical composition of the Aluminum alloy. Dimensions of cold rolling mill component are mentioned in Table 2.

Table 1 Chemical Composition of Aluminum alloy

Element	Si	Fe	Mn	Cu	Mg	Zn	Ti	Li	Cd
% of composition	0.3	0.3	0.05	4.8	0.05	0.01	0.15	0.9	0.25

Table 2 Aluminum Alloy NL properties

Parameter	Value
Density	2.77e-006 kg mm^-3
Specific Heat	8.75e+005 mJ kg^-1 C^-1
Young's Modulus MPa	71000
Poisson's Ratio	0.33
Bulk Modulus MPa	69608
Shear Modulus MPa	26692
Yield Strength MPa	280

2.3. Development of 3D model

Almost all the problems related with the engineering and sciences are governed by the differential or integral equation. With the help of this equation, the user get an exact or closed to the solution to the particular problem being studied. However, the complex shape, size, properties and boundary conditions are seen in the real problems. Generally it mean that an exact solution cannot be determined in an acceptable amount of time.The Finite Element Method (FEM) provide a platform to achieve the approximate solution of the real word problems. Finite element method is a numerical approach for determined the approximate solution of the engineering & sciences problems.

2.3 Finite Element Model

In this rolling process there is elastic entry zone. This elastic entry zone is basically plastic deformation zone, elastic compression zone and elastic recovery zone at the exit of deformation zone, shown in Figure 3

Where

H0= Strip thickness at entry

Hf= Strip thickness at exit section

V0= strip velocity at entry

Vf= strip velocity at exit

W0= Width of strip

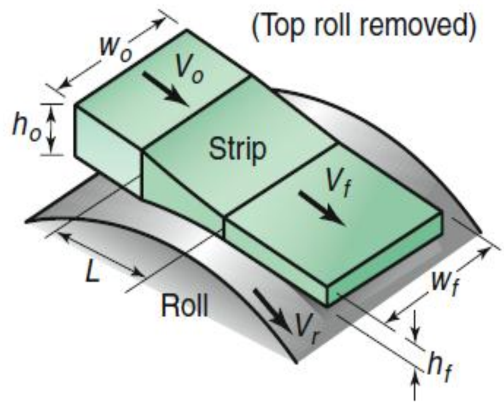


Fig. 3 Schematic of the rolling process of cold strip

2.3 Model development

The Ansys software used to design the rolling process. Ansys software is capable to develop the different type of geometry, assembly, sheet metal work and so on with using different type of module. Figure 4 shown the model of cold rolling process.

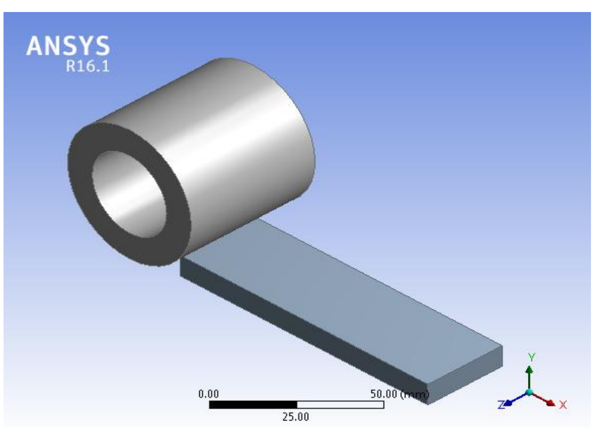


Fig. 4 3D model of the Rolling Process

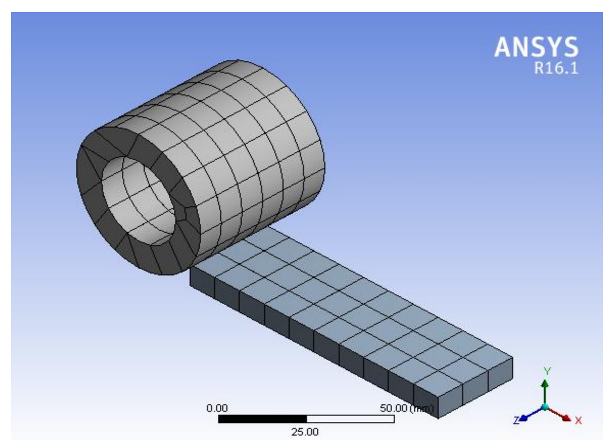


Fig. 5 Meshed 3D model of the Rolling Process

2.4 FE mesh

Meshing play very important role in the finite element analysis. Meshing divide the one element in to the finite number of element. Generally, as per requirement researcher takes the fine, medium and coarse mesh size. Simulation time is directly proportional to the Mesh size.

Six meshing methods available for 3D geometries:

- Tetrahedrons: Patch Conforming (TGrid based) & Patch Independent (ICEM CFD based).
- Sweep: Generates prisms or hexahedral
- MultiZone: Mainly hexahedral elements
- Hex Dominant
- CutCell mesh: Generates Cartesian CutCell mesh
- Automatic: Combines Tetrahedral Patch Conforming & Sweep Mesh based on complexity of the geometry

- Interoperability between different meshing methods

Mainly two types of meshing method uses in ANSYS Workbench:

- Tetrahedral elements
- Hexahedral elements

Based on the literature survey, it come to know that the hexahedral elements are respond a little faster as compare to other. While the choice of the mesh type does not seem to be significant, tetrahedral elements are more compatible with all geometries. Thus tetrahedral elements are used for meshing. Figure 5 shown the mesh of rolling process.

3. RESULTS AND DISCUSSION

The results and discussion section has been divided in two different category. The first one is the dynamic analysis of aluminum alloy NL steel and other one is the dynamic analysis of stainless steel NL. In this study, 278 nodes and 30 element has been selected in meshing zone for the sheet and 672 nodes and 96 element has been selected in meshing zone for the both work roller. The node is the junction of the elements. This numbers are clearly indicate th

3.1 Analysis of Aluminum alloy NL

4. The dynamic analysis of rolling process has been investigated with respect to aluminum alloy NL and boundary conditions as mentioned in material specifications Table1. The friction less solid to solid contact has been assigned. In the contact selection, the roller outer surface has been selected as a contact body and the sheet upper surface as a target body. Furthermore, the joint module has been applied on the roller and sheet. The revolute ground to roller was assigned to roller. The translation ground to sheet was applied for the steel. This both is the boundary condition of the roller and the sheet for their movement. Upper roller was rotate in 180 degree clock wise direction on the aluminum alloy sheet for the analysis. In this simulation the sheet is moving in the X direction and work roller is moving at their own axis. The nonlinear effect and displacement both are consider in the dynamic analysis. The total deformation of the aluminum alloy has been recorded. The Figure 6 shown the total deformation of aluminum alloy. The maximum deformation 114.89mm has been observed in sheet. 289 MPa normal stress has been observed in the simulation. Figure 7 shows the normal stress intensity in X direction. The equivalent stress also has been recorded in this analysis. Figure 5.3 depicts the equivalent stress in the aluminum alloy sheet. The value of maximum equivalent stress 820 MPa was observed during the rolling process. 0.25 mm/mm equivalent plastic strain has been recorded as shown in figure5.4. 0.00062 mm/mm equivalent elastic strain has been recorded as shown in figure 5.5.e density of the meshing. The 10 mm element size has been selected in this study.Fig 8 shown the Equivalent stress in the aluminum alloy 820.6 MPa stress has been recorded.Stress solutions allow to predict safety factors, stresses, strains, and displacements given the model and material of a part or an entire assembly and for a particular structural loading environment. A general three-dimensional stress state is calculated in terms of three normal and three shear stress components aligned to the part or assembly world coordinate system. Figure 10 depicts the displacement of sheet Table 3 Stress and strain of rolling sheets

Table 3 Stress and strain of rolling sheets

Type of Material	Equivalent stress (MPa)	Normal stress (MPa)	Equivalent plastic strain	Equivalent elastic strain
Aluminum alloy	820.6	289.91	0.25	0.0055

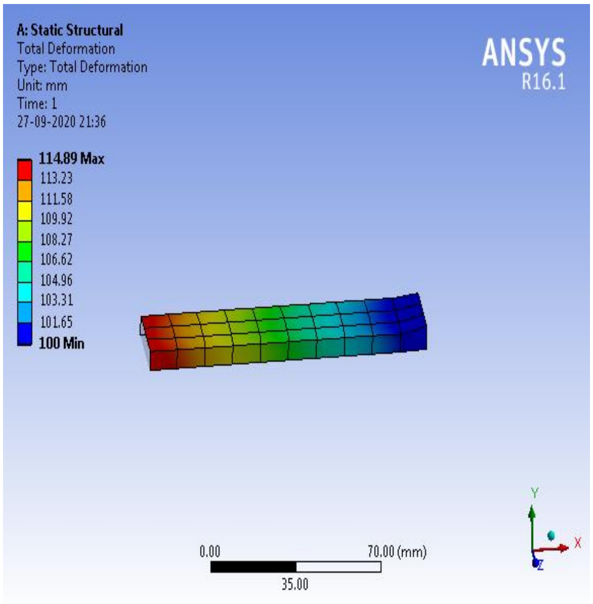
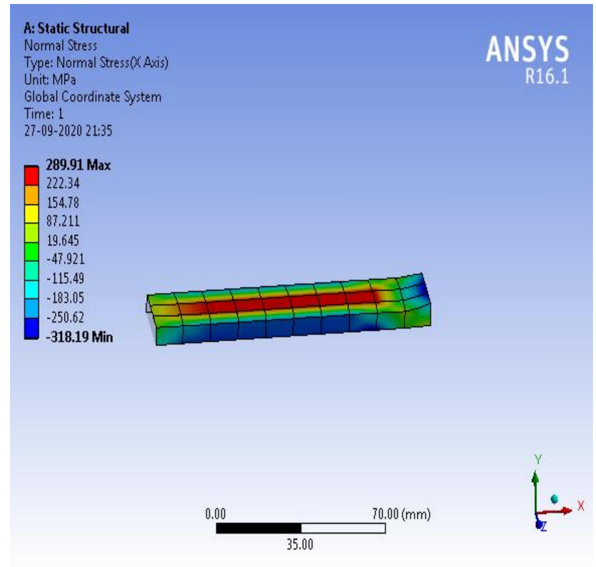


Fig. 6 Total deformation of aluminium alloy



Fig, 7 Normal stress intensity in X direction.

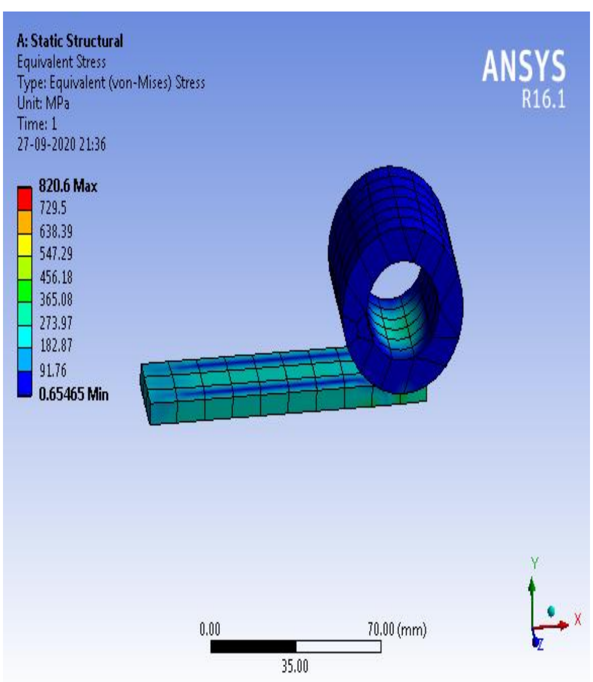


Fig 8Equivalent stress in the aluminium alloy

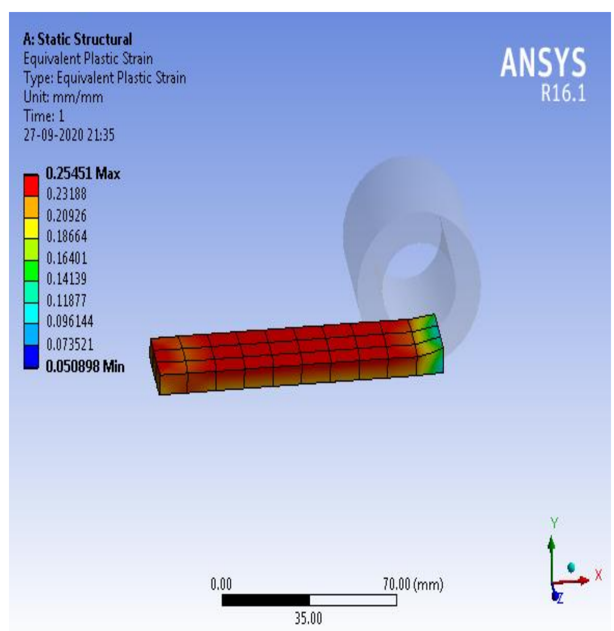


Fig 9 Equivalent plastic strain in Aluminium alloy sheet

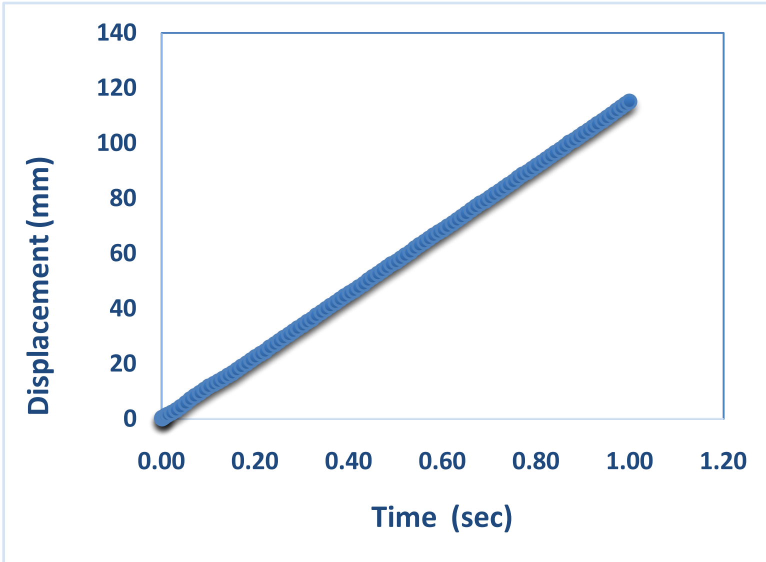


Figure 10 Displacement of aluminium alloy sheet with respect to time

5. CONCLUSION

The present project work based on the comparative investigation and analysis of an aluminum alloy for the automobile industries and sheet fabrication industry. The dynamic analysis of rolling process, responses are stress, strain and deformation of rolling sheet has been analysed.

The simulation induced stress and strains values for the carbon steel is less compared to stainless steel and also it improve the fatigue life of helical spring.

The following conclusion has been drawn from the results analysis:

1. The equivalent stress (vonmises stress) induced in aluminum alloy is 820.6MPa.

2. The equivalent elastic strain induced in aluminum alloy is 0.0055

3. The normal stress in aluminum alloy is 289.19MPa

REFERENCES

1. Robert W. L. Cold rolling of steel. Manufacturing engineering and material process. Marcel dekker, 1978, New York Basel.

2. Kalpakjain S. and Schmid S. Manufacturing Engineering and Technology, 2010,Person Prince hall.

3. A. Geleji, "Forge Equipment, Rolling Mills and Accessories", Akademiai Kiado, Budapest, 1967, pp. 442-446.

4. J. I. Greenberger, "Rolling of Metals", Iron and Steel Engineer Year Book, 1959, pp. 215-223.

5. C. W. Starling, "The Theory and Practice of Flat Rolling", University of London Press Ltd., London, 1962, p. 29. * "ABC of Iron.

6. E. C. Larke, "The Rolling of Strip, Sheet, and Bate", The MacMillan Company, New York, 1957, p. 41.

7. Ref 5 "New Type of Rolling Mill for Accurately Rolling Steel Strip", Iron and Coal Trades Review, July 15,1910, 81, p. 87.

8. W. Rohn, "Anwendung Kleinster Walzendurchnesser and Fortbildung von Mehrrollenwalzwerken", Stahl u. Eisen, 1932, 52, p. 821.

9. M. G. Sendzimir, "The Sendzimir Cold Strip Mill", Journal of Metals, September, 1956, pp. 1154-1158.

10. J. Puppe, "Walzwerkswesen Dritterband, Verlag Julius Springer, Berlin, 1939, p. 620.

11. The Modern Strip Mill", AISE, Pittsburgh, Pennsylvania, 1941, pp. 229-257.

12. J. Davies, R. W. Jackson and J. A. Tracy, "Design Criteria, Development, and Test Activities for a Six-Stand Tandem Mill Hydraulic Screw-Down System", Chapter in "Hydraulic Control of Rolling Mills and Forging Hants", Iron and Steel Institute, (Pub. 142), 1972, pp. 55-100.

13. Kobayashi S., Oh S.I. and Altan T., Metal Forming and Finite Element Method, New York: Oxford University Press, 1989.

14. Kazeminezhad, M.; Taheri, K.A. 2006. Calculation of the rolling pressure distribution and force in wire flat rolling process, J. Mater. Process. Manuf. Sci. 171(2): 253-258.

15. Ref Licheng Yang, Jinchen Ji, Jingxiang Hu, A. Romagos, Effect of process parameters on mechanical behavior in hot-slab rolling. ISSN 1392 - 1207 MECHANIKA. 2011. 17(5): 474-479.5. D.Gopinatha, Ch.V.Sushmab 2015. "Design and Optimization of Four Wheeler Connecting Rod Using Finite Element Analysis." Science direct, Materials Today: Proceedings 2 (2015) 2291 – 2299.

6 J.P.Fuertes, C.J.Luis, R.Luri, D.Salcedo, J.León and I.Puertas 2016. "Design, simulation and manufacturing of a connecting rod from ultra-fine grained material and isothermal forging." Elsevier, Journal of Manufacturing Processes 21 (2016) 56–68

7. Hippoliti, R., 1993, "FEM method for design and optimization of connecting rods for small two-stroke engines," Small Engine Technology Conference, pp. 217-231.

8 A. Strozzi, A. Baldini, M. Giacopini, E. Bertocchi, S. Mantovani 2016. "A repertoire of failures in connecting rods for internal combustion engines, and indications on traditional and advanced design methods." Elsevier, Engineering Failure Analysis 60 (2016) 20–39.

9. R A Savanoor, Abhishek Patil, Rakesh Patil and Amit Rodagi. Finite Element Analysis Of IC Engine Connecting Rod by Ansys IJMERR Vol. 3, No. 3, July 2014

10. Shubham Chougale Thermal And Structural Analysis Of Connecting Rod of An IC Engine JETIR June 2017, Volume 4, Issue 06

11 Mohammed Mohsin Ali H, Mohamed Haneef 2015. "Analysis of Fatigue Stresses on Connecting Rod Subjected to Concentrated Loads at the Big End." Science direct, Materials Today: Proceedings 2 (2015) 2094 – 2103

12 Carmelo J. Luis, Javier Leon, Rodrigo Luri, Ignacio Puertas, Ivan Perez, Daniel Salcedo 2011"Development of Nano-Structured AA1050 by ECAE and Thermal Treatments." Scientific research, Soft Nanoscience Letters, 2011, 1, 120-129.

13 Moon Kyu Lee, Hyungyil Lee, Tae Soo Lee, Hoon Jang 2010. "Buckling sensitivity of a connecting rod to the shank sectional area reduction" Elsevier, Materials and Design 31 (2010) 2796–2803

14 Ahmed, G.M.S., S. E. Khany, and S.H. Shareef.2014. "Design, Fabrication and Analysis of a connecting Rod with Aluminium Alloys and Carbon Fibre." International Journal of Innovative 10.15680/IJIRSET. 2014.03100036