

NUMERICAL INVESTIGATION ON COPPER CLADDING ON ROLLING PROCESS TO DETERMINE EFFECT OF STRESSES ON DIFFERENT TIME PERIOD

Sandeep Kushwaha ¹, Dr. Shiv Kumar ², Prof. Ranjeet Kumar ³

ME Scholar¹, Director², HOD³

Department of Mechanical Engineering^{1,2}

Vaishnavi Institute of Technology and Science Bhopal, India

Abstract

A finite element model of the rolling processes for nonlinear Copper alloy has been developed for I-section flat rolling stock with rectangular cross section. This model can be used to analyze the flat rolling of Cladded Copper Alloy rectangular strips under a series of different parameters, providing the rolling designer with a tool that he can use to understand the behavior of the copper as it flows through the different passes.

The models developed, take into account all of the non-linearity present in the rolling problem: material, geometric, boundary, and heat transfer. A coupled thermal-mechanical analysis approach is used to account for the coupling between the mechanical and thermal phenomena.

The model predicts the equivalent stress, equivalent elastic strain, total deformation, total thickness % reduction and equivalent stress for rollers, for rolling processes. The FE model results are an improvement over the results obtained through the classical theory of rolling. The model also demonstrates the role that contact, friction generated frictional stresses plays in the rolling process.

The analysis performed shows that the Cladded Copper Alloy in rolling can be accurately modeled using the elastic-plastic formulation, with a von Mises yield surface. The FE models also demonstrate that the Cladded Copper Alloy in rolling can be modeled using the rigid-visco plastic formulation, for high temperature where the flow stresses is a function of the strain and the temperature.

Keywords— Aluminium alloy, rolling process

I. INTRODUCTION

Rolling is the process of lowering the thickness or changing the cross segment of an extended work piece by compressive forces applied through a hard and fast of rolls. Most rolling is performed through hot running, referred to as warm rolling, due to the big amount of deformation required. Hot-rolled steel is generally free of residual stresses, and its homes are isotropic. Hot rolling are that the product can't be held to shut tolerances, and the surface has a characteristic oxide scale. Steelmaking provides the maximum not unusual utility of rolling operations. The series of steps in a metal rolling mill to show the kind of merchandise made. Similar steps arise in different primary steel industries. The paintings starts offevolved out as a solid metallic ingot that has just solidified. While it's far still hot, the ingot is located in a furnace wherein it remains for lots hours till it has reached a uniform temperature during, in order that the metal will flow always throughout rolling. For steel, the favored temperature for rolling is around 1200_C (2200_F). The heating operation is known as soaking, and the furnaces in which it's miles done are known as soaking pits. From soaking, the ingot is moved to the rolling mill, wherein it's miles rolled into one among three intermediate shapes called blooms, billets, or slabs. Rolling is one of the maximum important business metal forming operations. Hot Rolling is employed for breaking the ingots down into wrought merchandise which include into blooms and billets, which can be eventually rolled to different products like plates, sheets and many others. Rolling is the plastic deformation of substances due to compressive pressure carried out via a fixed of rolls. The pass section of the work piece is reduced with the aid of the procedure. The cloth receives squeezed between a pair of rolls, due to which the thickness gets reduced and the length gets accelerated. Mostly, rolling is done at excessive temperature, referred to as warm rolling due to requirement of massive deformations. Hot rolling outcomes in residual stress-unfastened product. However, scaling is a major hassle, because of which dimensional accuracy isn't maintained. Cold rolling of sheets,

foils and many others is gaining significance, due to excessive accuracy and shortage of oxide scaling. Cold rolling additionally strengthens the product because of work hardening.

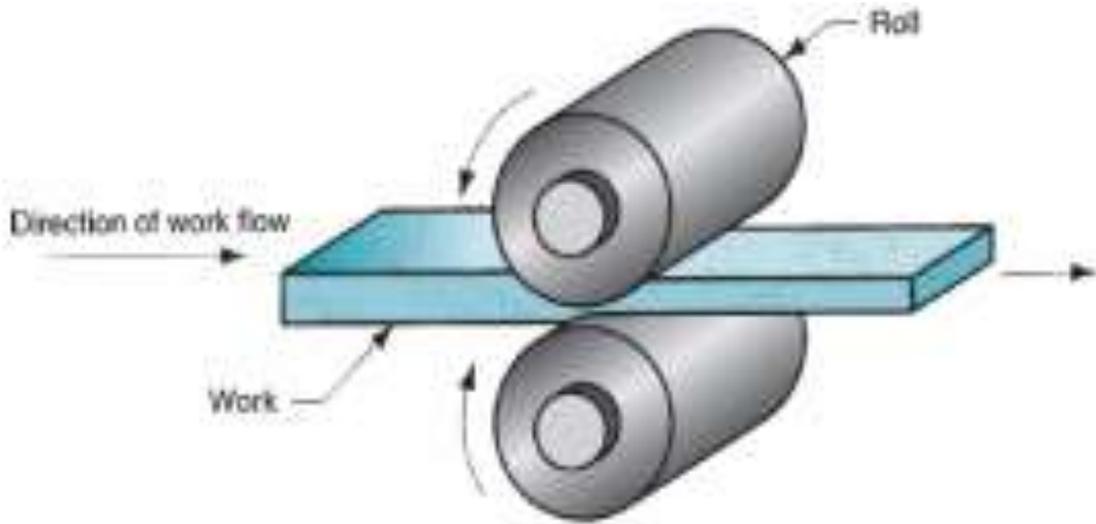


Fig. 1.1 Rolling Process

II. Various Rolling Processes and Mills

Transverse rolling or Roll forging in this operation (additionally called move rolling), the go phase of a spherical bar is fashioned by using passing it via a pair of rolls with profiled grooves. Roll forging usually is used to provide tapered shafts and leaf springs, table knives, and hand equipment; it also can be used as a initial forming operation, to be accompanied by way of other forging approaches.

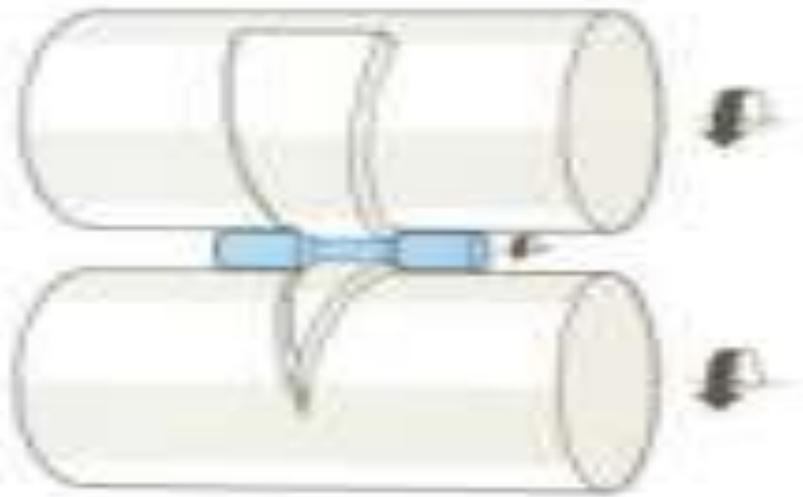


Fig. 1.3 Transverse rolling

Skew Rolling- A process similar to roll forging is skew rolling, typically used for making ball bearings (Fig. 5.8). Round wire or rod is fed into the roll gap, and roughly spherical blanks are formed continuously by the action of the rotating rolls.

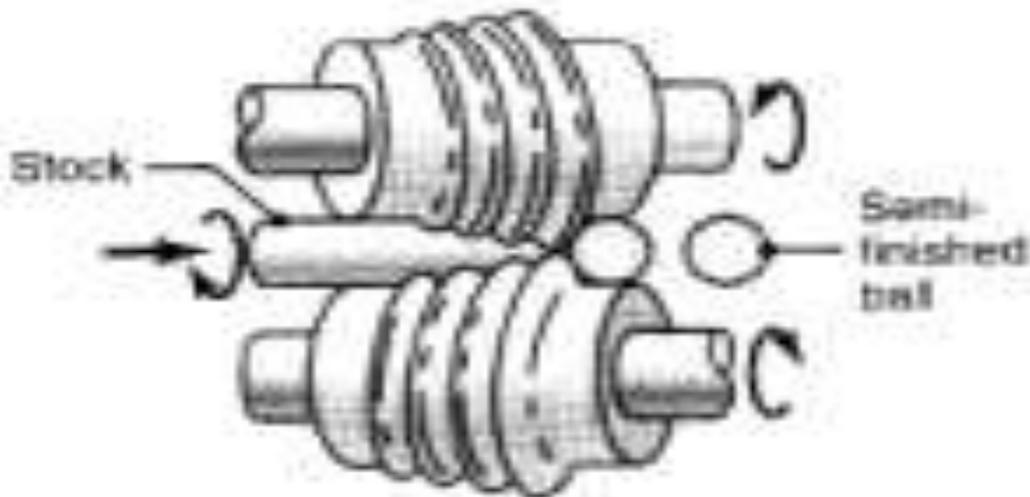


Fig. 1.4 Skew Rolling

Ring Rolling In ring rolling, a thick ring is multiplied into a largediameter thinner one. The ring is positioned among two rolls, considered one of that's pushed at the same time as the alternative is idle. Its thickness is decreased by using bringing the rolls nearer together as they rotate. Since the quantity of the hoop cloth remains consistent during plastic deformation (extent constancy), the reduction in ring thickness outcomes in an growth in its diameter. Typical programs of ring rolling are big jewelry for rockets and generators.

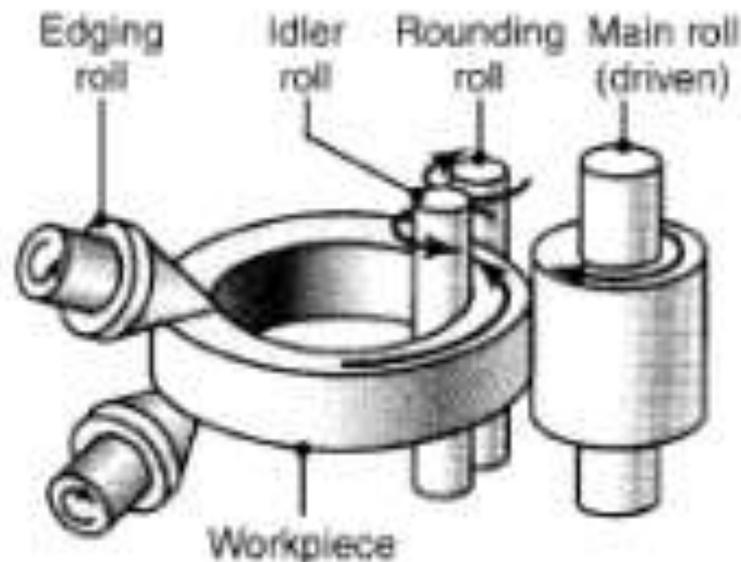


Fig. 1.5 Ring Rolling

Thread Rolling. Thread rolling is a chilly-forming system by using which directly or tapered threads are fashioned on spherical rods or wire. The threads are shaped at the rod or twine with every stroke of a couple of flat reciprocating dies (Fig. Five.10). In any other method, threads are fashioned with rotary dies, The thread-rolling technique has the benefits of generating threads with precise electricity (because of cold running) and without any loss of fabric (scrap). The floor finish produced is very clean, and the procedure induces compressive residual stresses on the workpiece surfaces, as a result enhancing fatigue life.

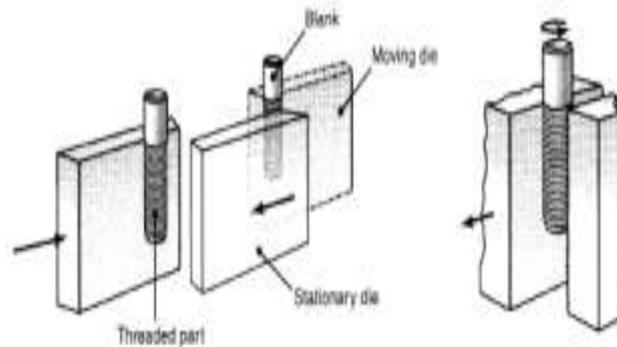


Fig.1.6 Thread Rolling

Rotary Tube Piercing or Roll Piercing: Ring rolling is a specialised hot working procedure for making seamless thick-walled tubes. It makes use of two opposing rolls, and subsequently it's far grouped with the rolling processes. The method is based on the precept that when a strong cylindrical part is compressed on its circumference, as in Figure, excessive tensile stresses are advanced at its center. If compression is excessive enough, an internal crack is fashioned.

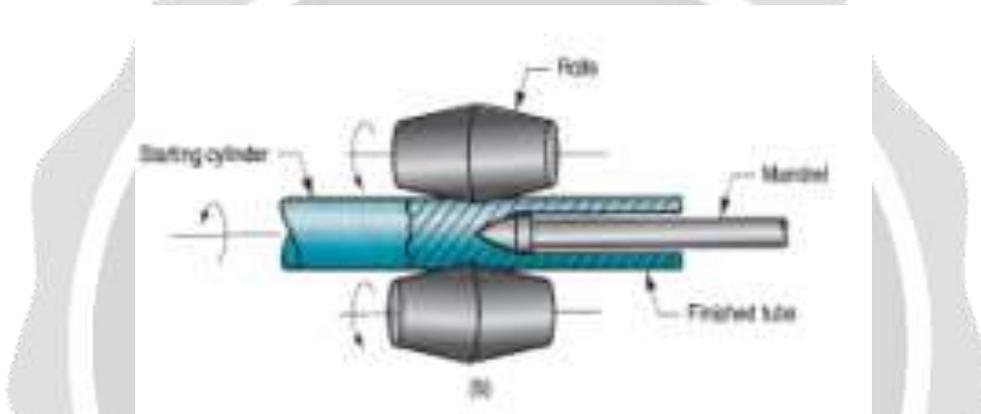


Fig. 1.7 Rotary Tube Rolling.

III. Hot rolling

In warm rolling the cloth is rolled at a temperature better than its recrystallization temperature. The benefit of hot rolling is twofold. First, at expanded temperature the strength of any metal or alloy is reduced. Thus the compressive force required for deformation is relatively less and consequently smaller capacity rolling stand can be used for rolling operation . The 2nd advantage of rolling a cloth at a temperature better than its recrystallization temperature is that a huge amount of plastic deformation may be imparted with out getting it strain hardened. With stress hardening, the deformation strain will increase as increasingly deformation takes place rendering the fabric difficult and brittle. As a result, the fabric will become increasingly difficult to be deformed, and beyond restriction, deformation leads to numerous faults or defects. The ferrous uncooked material for rolling various shapes is the ingot that's forged out of molten metallic. In case of low carbon steels the ingot is quite large. It is first rolled into blooms. The blooms are rolled into smaller sizes, called billets. Large structural sections consisting of rails, beams, girders, channels, attitude sections, and plates are rolled out of blooms, whilst billets are rolled into smaller structural sections, bars, plates, and strips. Alloy steel and stainless-steel, produced in mini steel flora, are usually forged into smaller sizes of ingots. Non-ferrous metals like aluminum are forged into extensive slabs, from which plates, sheets, and strips are acquired. The above exercise nevertheless is going in older flowers. However, the existing trend is to put in non-stop casting devices to cast smaller sections without delay from liquid metallic and for this reason do away with bloom rolling. In a few continuous casting vegetation, billets of small pass sections may also be continuously cast, accordingly getting rid of even the billet rolling mill. Installation of continuous casting effects in big saving in capital cost of the rolling plant in addition to rolling procedure cost. Non-ferrous alloys of aluminum, brass, nickel-silver, and so forth., are constantly cast in bar or strip form. Rolling of ingots to blooms and blooms to billets, and further rolling of blooms and billets to different usable merchandise like structural sections, bars, plates, and strips are all rolled thru warm rolling. Some of the products produced thru warm rolling process are illustrated

IV .Cold rolling

When rolling of a fabric is performed at room temperature or beneath the recrystallization temperature of the material, it is known as bloodless rolling. Obviously, the advantages of warm rolling is absent in cold rolling. The resistance to deformation is greater. Furthermore, for the duration of rolling, strain hardening takes vicinity, i.E., the energy of the cloth regularly will increase with increase in degree of deformation in the unique material. However, there are some advantages additionally. The first one is set controlling the grain length and thereby accomplishing the desired mechanical houses of the completed rolled material. When the enter fabric is bloodless rolled, the grains of the enter material get elongated along the direction of rolling. Thus the powerful grain size is decreased, because the floor area of every grain will increase whereas their extent stays the equal. With next passes of rolling, the elongated grains damage and the grain size will become step by step smaller and the fabric receives tougher and harder. After a positive percent of volumetric deformation, the cold rolled cloth will become too tough and brittle to be rolled similarly profitability. At this stage, the cold rolled fabric is annealed, that is nothing however heating the fabric in a impartial ecosystem (heating in presence of oxygen is averted to prevent oxidation) above its recrystallization temperature. By adjusting the time for which the rolled material is stored at this better temperature (soaking time), the size of the newly fashioned grains of the annealed material may be intently managed. Cold rolling is usually executed to supply flat rolled merchandise like sheet, plate, strip, and foil. When the length of the rolled product is simply too huge, the cloth is wound and used within the coil shape. In cold rolling, since the degree of deformation, i.E., discount in thickness of the flat product in any rolling bypass, is saved low to avoid excessive roll keeping apart force, several rolling passes are usually required along with considered necessary wide variety of intermediate annealing. A variety of rolling passes with grain deformation in the identical route offers a directional bias to the diverse mechanical homes of bloodless rolled merchandise. Such directional bias (anisotropy) regularly remains even after annealing after final bypass of rolling. This directionality of properties must be taken care of for the duration of next processing of bloodless-rolled material

Objective of the Work

The survey with the modern-day writing three dimensional limited element techniques (FEM) had been applied for discover the temperature area and warm anxiety subject of work roll. In the existing work, three dimensional temperature conveyance of labor pass amid shifting procedure is mimicked making use of FEM. It is observed that coupled 3 dimensional re-enactments of heat profiles and thermal investigation is an excessive amount of convoluted in nature. thermal examination of warmth move is reproduced in ANSYS 16 and ANSYS sixteen Transient Thermal particular is utilized for the investigation of conduction, convection and radiation some portion of the roller on this examination. A diagnostic model count on the form of paintings flow temperature towards the finish of whole operation and low reiteration will drives the best which means of warmth change impact.

IV. LITERATURE REVIEW

Martha P. Guerrero, Carlos R. Flores, Antonino Perez and Rafael Colas[1] constructed up a warm temperature exchange display for Hot rolling paintings is available in 1999. Three fashions have been actualized to decide the temporary warm temperature circulation. Limited contrast method was utilized for the era of two fashions and some other produced by using incorporating the warmth circulation to the roll. A fourth version was relentless nation primarily based model created through the incorporation of the warm temperature movement. It is inferred that every model has its very own unique esteem, and that every one of them ought to be utilized whilst a whole research of the shifting conditions is required. Another model for constructing up the temperature and stress fields in paintings movements amid Hot rolling changed into used by F.D. Fischer, W.E. Schreiner, E.A. Werner and C.G. Sund [2] in 2004. They for the maximum part focused on using the solution for the temperature area of a transferring warmth supply as a valid and programmable expression allows predicted the temperature discipline near the surface layer of a work roll. They considered the grinding and surface touch variables for these counts. Likewise important expressions for the anxiety discipline near the floor layer are open. Warmth is exchanged by means of a moving warm temperature wellspring of thickness. A few past commitments do not reect at the fact of a transferring warm temperature source, and their domino affects on this manner are at any charge dubious. C. H. HUANG and T. M. JU [3] in 1994 built up a version for the investigation of surface heat attributes of the operating come in hot rolling process. They utilized the - dimensional opposite exam [4-6] of conjugate inclination approach. It was a minimization technique, related to parent the floor warm execution of a move which changed into applied in steel moving factories with water circulation cooling. From their investigation, it can be discovered that no past facts is required for the utilitarian styles of time shrewd and space astute deviation of the floor layer temperature and warmth ux. The brief temperature film inside the roll is modified from the introduced take a look at data and fills in as the mimicked statistics for the backwards research. The results make clear that the evaluation of surface temperature and warmth flux receives to be noticeably mediocre

when the temperature estimations are removed too a protracted way from the surface, due to a thin heat layer. Sudipta Sikdar and Shylu John[7] centered a model for finding the work circulate temperature in a Hot strip method by using the impact of water flow introduction and other controlling Parameters. Water fly cooling is applied to disseminate the nice and cozy power from the body of a flow amid its rehased improvement inside the completing stands of a hot strip technique. The temperature dissemination of the are available each remain of completing segment of a Hot strip system has been numerically investigated through a systematic model. The impact of move introductions, warm exchange coefficient at flow fly interface locale and piece phase temperature has been assessed via this model, and their effect on paintings pass temperature has been recreated. The trade of movement point has located that the effect is unimportant.

V. MODELING AND ANALYSIS

The procedure for solving the problem is:

Create the geometry.

Mesh the domain.

Set the material properties and boundary conditions.

Obtaining the solution

Finite Element Analysis of Steel Shaft

Analysis Type- Modal analysis

Preprocessing

Preprocessing include CAD model, meshing and defining boundary conditions.

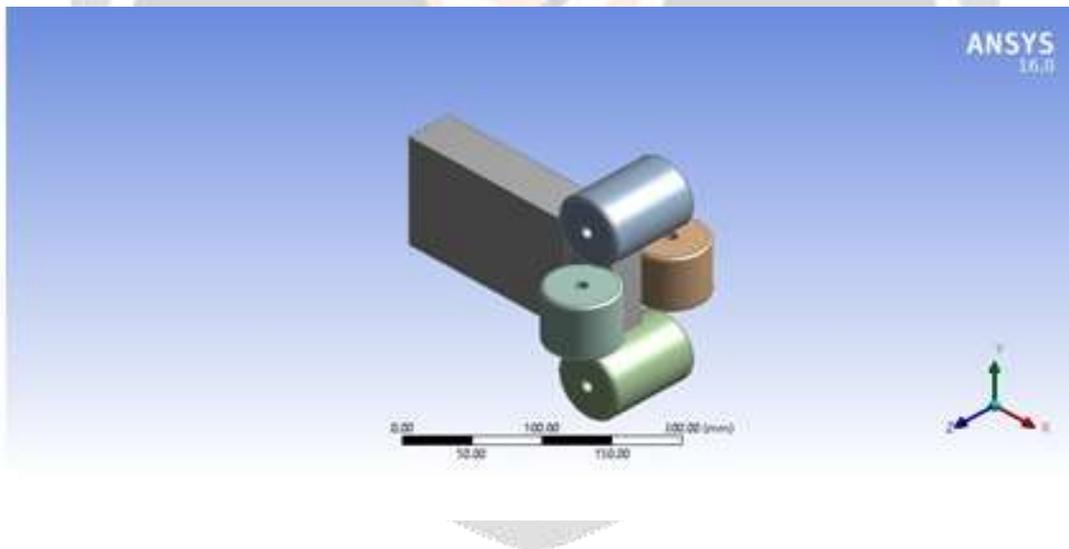


Figure: 5.1 Model of Solid shaft with Two Crack

4.1.2 Meshing

The group of nodes and elements is known as meshing this process is done to determine convergence of solution the phenomenon convergence of solution is a relation between accuracy, degree of freedom and no. of nodes and elements as the quantity of nodes and elements are increased at variable iteration a convergence of solution is obtained. Meshing are of different types i.e. Tetrahedral, Quadrahedral, Hexahedral, Square mesh and triangular mesh, tetrahedral mesh gives better convergence during finite element simulation a stiffness matrix, damping matrix, stress matrix is solved on ANSYS at each and every node and element by iteration methods like runge-kutta etc. to determine convergence of solution

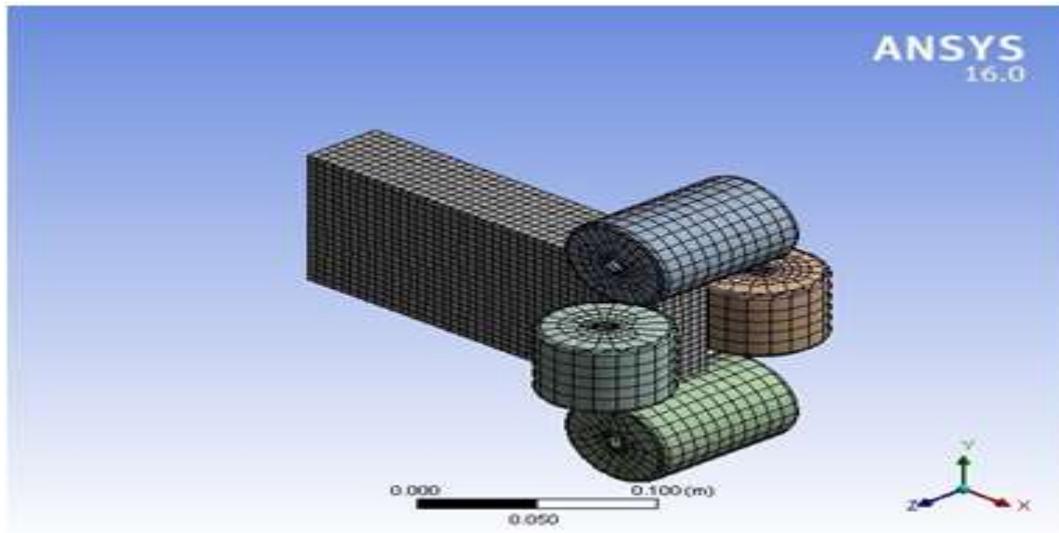


Figure No.: 4.2 Mesh domain of rolling process

VI. RESULT AND DISCUSSION

5.2 Study of Total Deformation for Non-linear Cladded Copper Alloy

Table 5.1 Tabular Representation of Billet Total Deformation with respect to unit time

| S . N o . | Time [s] | Minimum [m] | Maximum [m] |
|-----------------|----------|-------------|-------------|
| 1 | 8.58 | 1.57 | 1.76 |
| 2 | 5.11 | 8.25 | 1.02 |
| 3 | 0.1015 | 1.49 | 2.03 |
| 4 | 0.15051 | 2.05 | 3.01 |
| 5 | 0.20413 | 2.60 | 4.08 |
| 6 | 0.25015 | 3.10 | 5.00 |
| 7 | 0.3045 | 3.69 | 6.09 |
| 8 | 0.35086 | 4.23 | 7.02 |
| 9 | 0.40952 | 4.91 | 8.19 |
| 10 | 0.45057 | 5.44 | 9.01 |
| 11 | 0.50422 | 6.06 | 0.10084 |
| 12 | 0.55672 | 6.73 | 0.11134 |
| 13 | 0.60246 | 7.31 | 0.12049 |
| 14 | 0.65472 | 7.97 | 0.13094 |
| 15 | 0.70077 | 8.56 | 0.14015 |

| | | | |
|---|---------|---------|---------|
| 5 | | | |
| 1 | 0.75676 | 9.27 | 0.15135 |
| 6 | | | |
| 1 | 0.80035 | 9.83 | 0.16007 |
| 7 | | | |
| 1 | 0.85104 | 0.10467 | 0.17021 |
| 8 | | | |
| 1 | 0.90096 | 0.11088 | 0.18019 |
| 9 | | | |
| 2 | 0.95507 | 0.1172 | 0.19101 |
| 0 | | | |
| 2 | 1 | 0.12302 | 0.2 |
| 1 | | | |

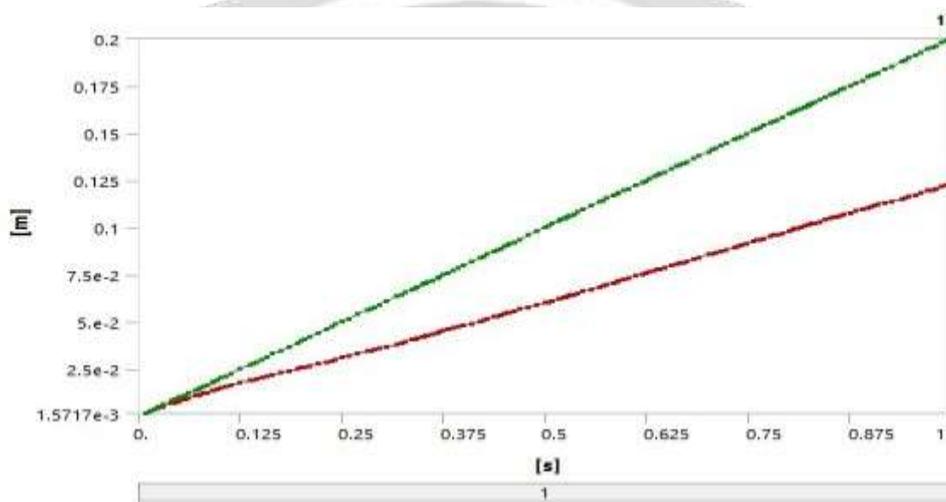


Figure No.: 5.1 Graphical representation of Total Deformation for Billet with respect to unit

Time

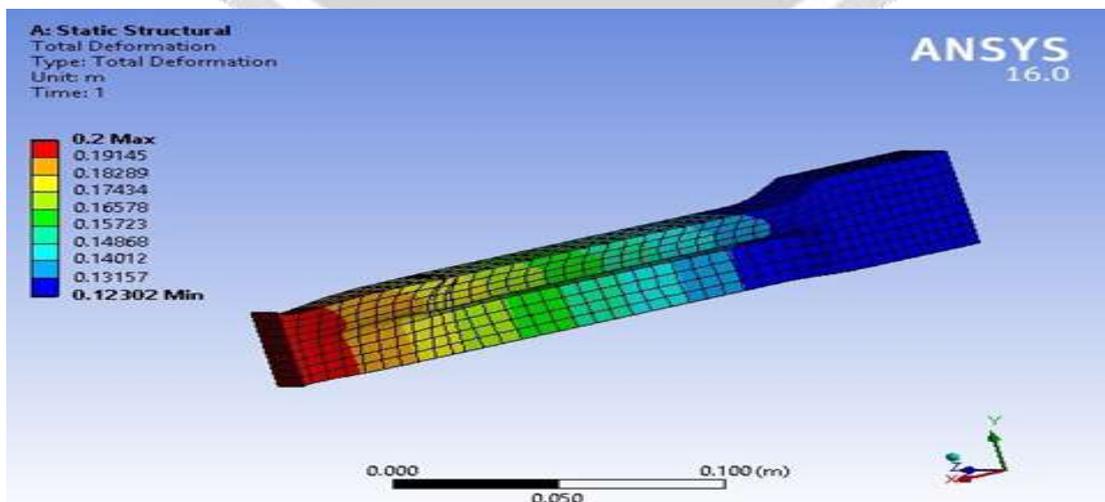


Figure No.: 5.2 Billet Total Deformation with respect to unit time

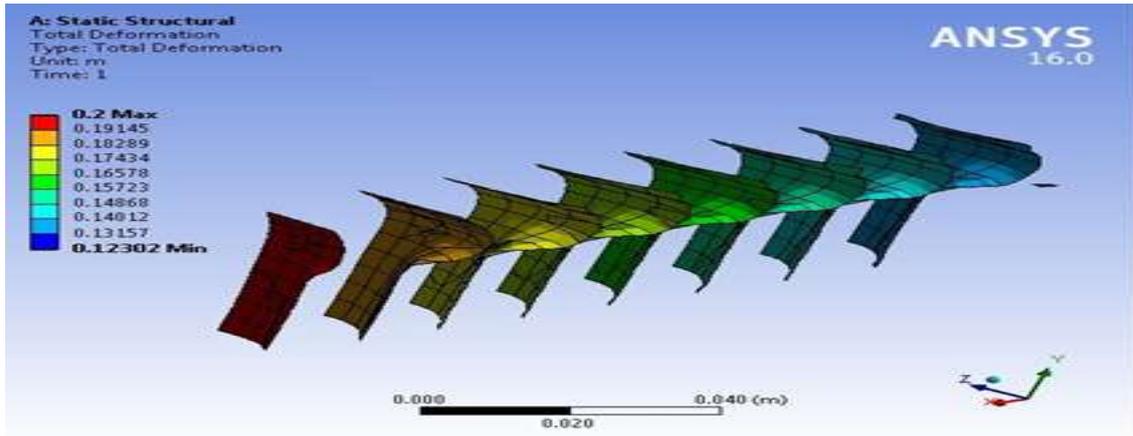


Figure No.:5.3 ISO-Surface of Billet Total Deformation with respect to unit time

5.3 Study of Equivalent Stress for Non-linear Cladded Copper Alloy

Table 5.2 Tabular Representation of Billet Equivalent Stress with respect to unit time

| S · N o · | Time [s] | Minimum [Pa] | Maximum [Pa] |
|-----------------------|----------|--------------|--------------|
| 1 | 1.16 | 651.35 | 3.37 |
| 2 | 5.11 | 2016.9 | 5.01 |
| 3 | 0.1015 | 2331 | 7.33 |
| 4 | 0.15051 | 7916.2 | 9.03 |
| 5 | 0.20413 | 12070 | 1.07 |
| 6 | 0.25015 | 14182 | 1.20 |
| 7 | 0.3045 | 26435 | 1.31 |
| 8 | 0.35086 | 47486 | 1.38 |
| 9 | 0.40952 | 59483 | 1.40 |
| 10 | 0.45057 | 77454 | 1.39 |
| 11 | 0.50422 | 1.03 | 1.36 |
| 12 | 0.55672 | 1.34 | 1.42 |
| 13 | 0.60246 | 1.73 | 1.42 |
| 14 | 0.65472 | 2.27 | 1.32 |
| 15 | 0.70077 | 1.88 | 1.35 |
| 16 | 0.75676 | 2.46 | 1.43 |
| 17 | 0.80035 | 3.18 | 1.43 |

| | | | |
|--------|---------|------|------|
| 1 8 | 0.85104 | 5.27 | 1.35 |
| 1 9 | 0.90096 | 5.48 | 1.36 |
| 2 0 | 0.95507 | 1.06 | 1.42 |
| 2 1 | 1 | 1.72 | 1.43 |

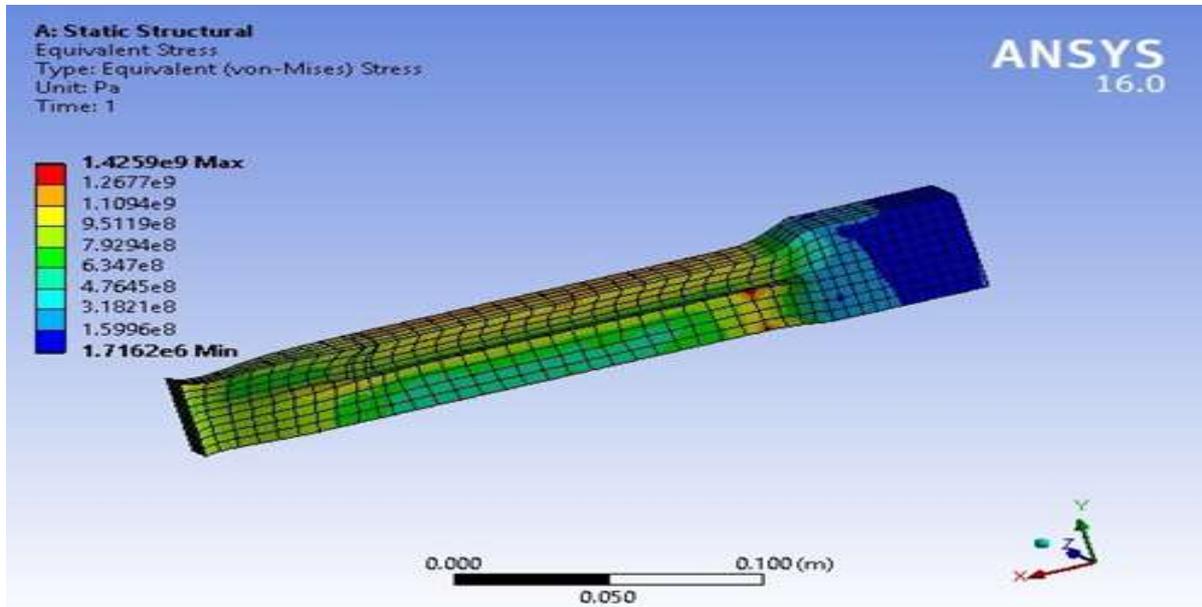


Figure No.: 5.5 Billet Equivalent Stress with respect to unit time

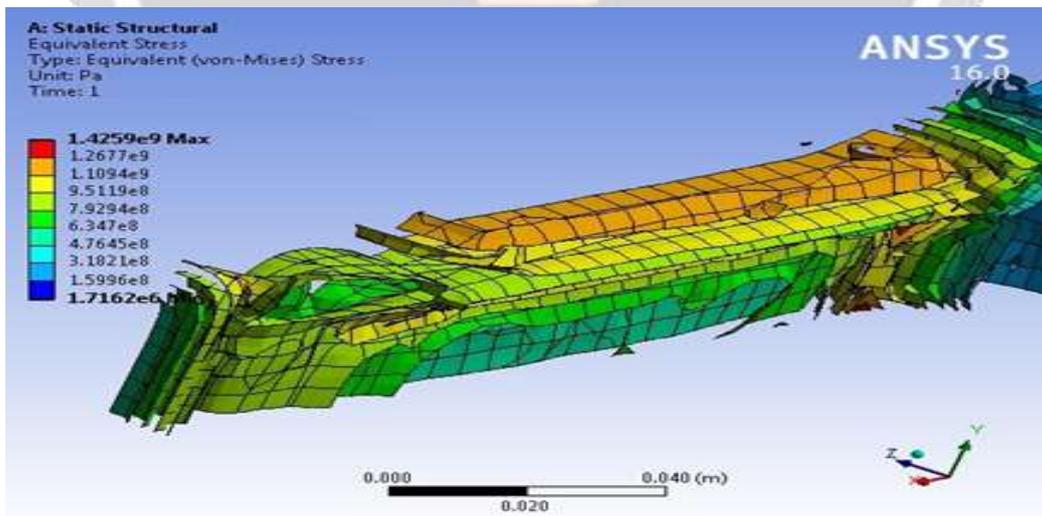


Figure No.:5.6 ISO-Surface of Billet Equivalent Stress with respect to unit time

VII .CONCLUSION

- When the symmetry assumption is used, it has been determined that the geometries acquired in experimental study mismatched to the geometry acquired in the finite detail evaluation. It has been decided that geometry of the paintings piece at the end of the experiments did not have the symmetric material distribution alongside the longitudinal symmetry axis. Consequently, using symmetry assumption has been located impractical for the unique case and it's miles important to model the real case.
- It has been found from the Iso-surface Stress distribution within the paintings piece that the deformation will increase along the longitudinal path of the paintings piece and reduces along the move course of the touch floor because of the variation of the pressure alongside the go route to the billet and roller as predicted to be.
- It became concluded that the FEA model in this study gives affordable consequences and this technique may be used for the layout of billet & Rollers and associated rolling system.
- According to the first-rate information of the author, this study is the primary one correctly finished to simulate rolling manner through the usage of finite element analysis.

7.2 Future Scope

- A observe can be performed to layout the rolling method via the usage of the predetermined very last geometry and optimize the amount of deformation at each roll skip to improve production efficiency and product nice Different load could be also analyzed for extraordinary mesh size to are expecting place imply strain and phone stresses for tyre.
- The evaluation can be completed considering extraordinary preliminary temperatures for the billets and the rollers
- In addition, the analysis can be accomplished the usage of distinct paintings piece substances. Results may be as compared with every different to apprehend the impact of labor piece material at the rolling technique.
- The finite element evaluation for wear of rollers can be achieved and compared with the rollers used in the forging industry.
- The consequences of the Ansys, that is a finite element solver, may be compared to the effects to be received by means of the usage of other finite detail programs inclusive of ABAQUES, QFORM3D, DEFORM™-3D or finite extent solver MSC. Etc

References

1. Asaro, R.J., & Lubarda, V.A., "Mechanics of Solids and Materials", Cambridge University Press, New York, (2006), pp. 461-501
2. Askenazi, A., & Adams, V., "Building Better Products with Finite Element Analysis", Onword Press, Santa Fe, (1999), pp 425-464
3. Barrett, C.R., Nix, W.D., & Tetelman, A.S., "The Principles of Engineering Materials", Prentice-Hall, Englewood Cliffs, New Jersey, (1973)
4. four. Bathe, K- J., Wilson, E.L., "Numerical Methods in Finite Element Analysis", Prentice Hall, NJ, (1976), pp.Eighty two-eighty three, 172-173, 176,184, 208, 246-249
5. Bathe, K.-J., "Finite Element Procedures in Engineering Analysis", Prentice Hall, Englewood Cliffs, New Jersey, (1982), pp. 301-305, 407-418
6. Belytschko, T., Liu, W.K., and Moran, B., "Nonlinear Finite Elements for Continua and Structures", John Wiley & Sons, Chichester, (2001), pp. 570-580.
7. Birchenall, C.E., "Physical Metallurgy", McGraw Hill, New York, (1959)
8. eight. Brick, R.M., Pense, A.W., & Gordon, R.B., "Structure and Properties of Engineering Materials", McGraw Hill, New York, (1977)
9. Boresi, A.P., & Chong, K.P., "Elasticity in Engineering Mechanics", 2nd version, John Wiley & Sons, New York, (2000)

10. Boresi, A.P., & Schmidt, R.J., "Advanced Mechanics of Materials", 6th edition, John Wiley & Sons, New York, (2003)
11. Burnett, D.S., "Finite Element Analysis: from ideas to packages", Addison- Wesley Publishing, Menlo Park, California, (1987)
12. Callister, W.D., "Materials Science and Engineering – An Introduction", 3rd edition, John Wiley & Sons, New York, (1994), pp. 149-153, 165-167, 349-350
13. thirteen. Chadwick, P., "Continuum Mechanics: concise principle and problems", Dover, New York, (1999)
14. Champion, E.R., "Finite Element Analysis in Manufacturing Engineering", McGraw Hill, New York, (1992), pp. 1-4
15. Christensen, R.M., "Theory of Viscoelasticity", second version, Academic Press, New York, (1982), pp. 90-94
16. sixteen. Cianci, M., "Leonardo da Vinci's Machines", Becocci Editore, Florence, (1999), p. 89.
17. Clark, D.S., "Physical Metallurgy for Engineers", second edition, Van Nostrand, Princeton, New Jersey, (1962)
18. Crisfield, M.A., "Non-linear Finite Element Analysis of Solids and Structures – Volume 1: Essentials", John Wiley & Sons, Chichester, (2001)
19. Crisfield, M.A., "Non-linear Finite Element Analysis of Solids and Structures – Volume 2: Advanced Topics", John Wiley & Sons, Chichester, (2003), pp. Ninety nine-one hundred and five, 182-184, 411- 424
20. Cook, R.D., et al., "Concepts and Applications of Finite Element Analysis", 4th edition, John Wiley & Sons, New York, (2002).

