Chief Editor

Dr. A. Singaraj, M.A., M.Phil., Ph.D.

Editor

Mrs.M.Josephin Immaculate Ruba

EDITORIAL ADVISORS

1. Prof. Dr.Said I.Shalaby, MD,Ph.D.
   Professor & Vice President
   Tropical Medicine,
   Hepatology & Gastroenterology, NRC,
   Academy of Scientific Research and Technology,
   Cairo, Egypt.
2. Dr. Mussie T. Tessema,
   Associate Professor,
   Department of Business Administration,
   Winona State University, MN,
   United States of America,
3. Dr. Mengsteab Tesfayohannes,
   Associate Professor,
   Department of Management,
   Sigmund Weis School of Business,
   Susquehanna University,
   Selinsgrove, PENN,
   United States of America,
4. Dr. Ahmed Sebihi
   Associate Professor
   Islamic Culture and Social Sciences (ICSS),
   Department of General Education (DGE),
   Gulf Medical University (GMU),
   UAE.
5. Dr. Anne Maduka,
   Assistant Professor,
   Department of Economics,
   Anambra State University,
   Igbariam Campus,
   Nigeria.
6. Dr. D.K. Awasthi, M.SC., Ph.D.
   Associate Professor
   Department of Chemistry,
   Sri J.N.P.G. College,
   Charbagh, Lucknow,
   Uttar Pradesh. India
7. Dr. Tirtharaj Bhoi, M.A, Ph.D,
   Assistant Professor,
   School of Social Science,
   University of Jammu,
   Jammu, Jammu & Kashmir, India.
8. Dr. Pradeep Kumar Choudhury,
   Assistant Professor,
   Institute for Studies in Industrial Development,
   An ICSSR Research Institute,
   New Delhi- 110070, India.
9. Dr. Gyanendra Awasthi, M.Sc., Ph.D., NET
   Associate Professor & HOD
   Department of Biochemistry,
   Dolphin (PG) Institute of Biomedical & Natural Sciences,
   Dehradun, Uttarakhand, India.
10. Dr. C. Satapathy,
    Director,
    Amity Humanity Foundation,
    Amity Business School, Bhubaneswar,
    Orissa, India.

ISSN (Online): 2455-7838
SJIF Impact Factor : 6.093

EPRA International Journal of

Research & Development

(IJRD)

Monthly Peer Reviewed & Indexed
International Online Journal

Volume: 4, Issue:6, June 2019

Published By
EPRA Publishing

CC License
BY NC ND

SJIF Impact Factor: 6.093 Volume: 4 | Issue: 6 | June | 2019 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Peer Reviewed Journal

ANALYSIS OF ROLLER SWAGING MACHINE

Dr.R.P.Swamy[1]
[1]*Associate Professor, M.E.D, UBD College of Engg, Davangere, Karnataka*

Dr. Ramesh B T[2]
[2.] *Assistant Professor, M.E.D, Jain institute of Technology, Davangere, Karnataka*

Mr. Manjunatha A R[3]
[3.] *Assistant Professor, M.E.D, Jain institute of Technology, Davangere, Karnataka*

Mr. Jaya Naik J[4]
[4] *Assistant Professor, M.E.D, Jain institute of Technology, Davangere, Karnataka*

ABSTRACT
The Roller swaging Machine is designed and the individual components were analyzed, the required force to draw the terminal or the threaded stud is provided by the Hydraulic system, the Roller dies are used in order to obtain the reduction in the diameter of specific dimensions. To carry out the modelling of all parts was done in Design software Autodesk Inventor V15 using standards, and then imported in analysis software Ansys Workbench V15 to perform static structural analysis. Standard properties, materials, suitable boundary and loading conditions are applied for both analyses and required outputs are mentioned and displayed in results. Results in analysis showed that the required reduction in the diameter of the component or the terminal (threaded stud) is achieved, and stresses and deformation in the parts were analyzed in an assembled condition by providing proper boundary conditions.

1. INTRODUCTION

During the swaging process, diameter of a rod or the terminal in this paper is reduced by passing it through a die. The die movement can be to and fro motion or a rotation. The other method can be by using a customary of rollers. The work pieces are held stationary and die rotates to a specific angle. The dies provide radial blow force which causes the change in dimension of the component and flow in metal, which acquires the respective shape of the respective die cavities. In Tube swaging the diameter of tube can be precise by means of the internal mandrels. For tubes of small diameter, rods of smaller diameter used as mandrel and internally shaped tubes by means of different shaped mandrels.

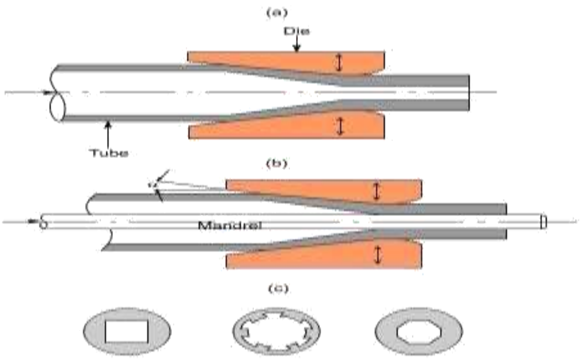


Figure 1.(a) Swaging without a mandrel, (b) Swaging with a mandrel, (c) Different cross-sections obtained by swaging process.

The swaging process is multipurpose. The range of the swaging can be maximum up to 200 mm and in the case of diameter can be around 0.5mm to 1mm. 30-35 parts per minute can be the production rate, depending on the complication in the part's shape and its usage. The tolerance ranges of ± 0.04 mm to ± 0.4 mm along with upgraded mechanical properties. During the process to obtain good surface finish and increase the life of the die lubricants are used. As the swaging processed components has vast application field it also involves usage of many different materials. The material used in the project is stainless steel studs or the terminals. The fig.1 shows the different rollers for different shapes, the swaging process has basically 4 types with and without the mandrel in the in feed technique and similarly with and without mandrel in the Recess method. The roller swaging is incremental process as shown on the figure where the respective dimensions are reduced gradually [1].

Rotary or Roller swaging involves the usage of number of dies orchestrated consistently along the side of the work-piece. The Roller swaging dies rotates around or along the moment of the work-piece while providing a radial movement of short strokes, at the same time. In this manner, the deformation occurs in the tube or the terminal or the stud in this project inferable from the multidirectional forging and high-frequency loading technique [2]. Move manufacturing is a misshaping procedure used to diminish the cross-section of a cylindrical (or rectangular) work-piece by going it through an arrangement of limiting rolls that have grooves coordinating the coveted state of the last part. Move manufacturing is a producing procedure that uses the rolls.

Basically the Roller Swaging Machine can be classified 2 sections, the first section is the Roller Die section and the second section is the Hydraulic cylinder Section, The Roller Die section involves the reduction of the diameter of the terminal by using the roller die. The Hydraulic cylinder Section provides the pull Force used to draw the Terminal or the Stud through the Roller Die.

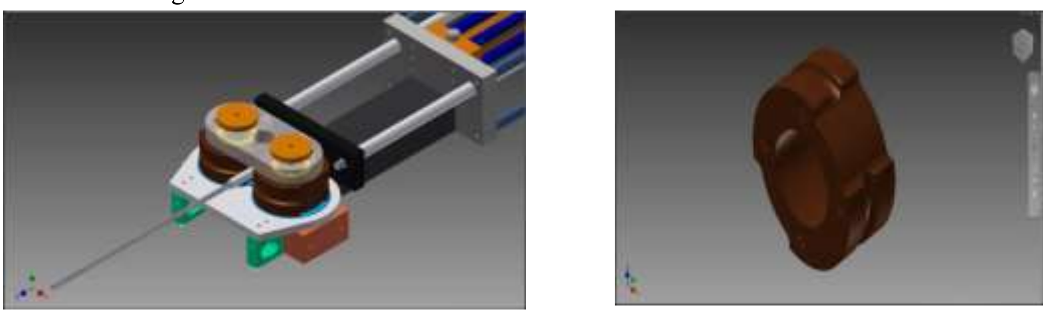
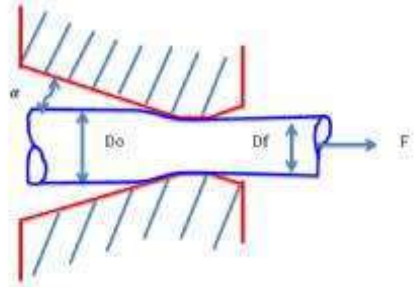


Figure 2 : Assembly of the Roller Die along with the other Supporting Components and Rollers Die

1.1 Pull force required for the Deformation

Consider a cylindrical component or Stud of initial diameter d0, let the length be lo, exposed to the axisymmetical extrusion lacking the friction, the deformation (redundant). Let df be the Final diameter.



The following notation used in the further derivation

- r = radius of wire
- r1, r2 = radius of wire at the entrance and at the exit
- let x be = axial position
- σx= axial, σr= radial, σt=tangential stress
- p = die normal pressure
- μ = coefficient of friction
- φ (r) = profile functions
- σ' = effective stress
- ε'= effective strain
- σ_0 = yield stress in simple tension
- k = strain hardening coefficient
- ε_x'= axial, ε_y' =radial, ε_y' tangential plastic strain
- L = length of die
- σ_d = draw stress
- σ_b = back pull
- $\beta = 1 - r/r_1$
- $\lambda = (\beta_2 - \beta)^{1/2}$
- F.F. = frictional force

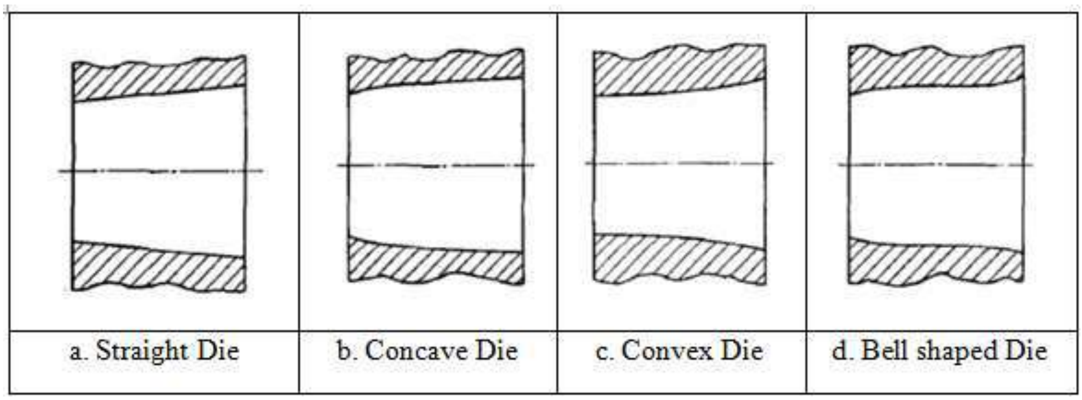


Figure 3: Die profiles.

The different shaped die profiles are shown in the fig 3, which includes the straight die, cone shaped die or the concave die, convex die and bell shaped die. The dies were studied and the straight die and the other shaped dies were compared with each other for drawing stresses that were needed to deform the component or wire to a required shape.

1.2 Stress Relationships for a Straight Die.

Considering a straight cone shaped die with a profile expressed methodically as the follows,

$$x = L\left(\frac{r - r_2}{r_1 - r_2}\right).$$

$$\alpha = \varphi' = \frac{1}{\tan\theta} = \frac{L}{r_1 - r_2}$$

By replacing the values 'p',

$$r(\mu-\alpha)\frac{d}{dr}\left(\frac{\sigma_x}{\sigma_0}\right)+2\mu(1+\alpha^2)\left(\frac{\sigma_x}{\sigma_0}\right) = 2\alpha(1+\mu\alpha)\left[1-2\left(\frac{k}{\sigma_0}\right)\ln\left(\frac{r}{r_1}\right)\right].$$

First order differential equation can be showed as,

$$\frac{\sigma_x}{\sigma_0}=\left(\frac{\sigma_b}{\sigma_0}\right)\left(\frac{r}{r_1}\right)^{-A}+\left(\frac{B}{A}\right)\left[1+2\left(\frac{k}{\sigma_0}\right)\frac{1}{A}\right] \times\left[1-\left(\frac{r}{r_1}\right)^{-A}\right]-2\left(\frac{B}{A}\right)\left(\frac{k}{\sigma_0}\right)\ln\left(\frac{r}{r_1}\right)$$

Where "A" and "B" are given as,

$$A=\frac{2\mu(1+\alpha^2)}{\mu-\alpha}$$

$$B=\frac{2\alpha(1+\mu\alpha)}{\mu-\alpha}.$$

The boundary conditions are obtained at the entrance, the axial stress σx of the wire or terminal is identical to back pull σb.

σ_x (axial stress) at r = r2 is equal to draw stress σd desirable to complete the process,

$$\left(\frac{\sigma_d}{\sigma_0}\right)=\left(\frac{\sigma_b}{\sigma_0}\right)\left(\frac{r_2}{r_1}\right)^{-A}+\left(\frac{B}{A}\right)\left[1+2\left(\frac{k}{\sigma_0}\right)\frac{1}{A}\right] \times\left[1-\left(\frac{r_2}{r_1}\right)^{-A}\right]-2\left(\frac{B}{A}\right)\left(\frac{k}{\sigma_0}\right)\ln\left(\frac{r_2}{r_1}\right)$$

1.3 Stress Relation for Concave shaped Die

Let us consider cone shaped die with convex shaped profile as shown in Figure c. the profile of the die,

$$x=L\left(\frac{r-r_2}{r_1-r_2}\right)^{\frac{1}{2}}=\frac{L}{\sqrt{\beta_2}}(\beta_2-\beta)^{\frac{1}{2}}$$

Then

$$\varphi'=\frac{dx}{dr}=\frac{L}{2r_1\sqrt{\beta_2}}(\beta_2-\beta)^{-\frac{1}{2}}=\frac{H}{\lambda}, \qquad H=\frac{L}{2r_1\sqrt{\beta_2}} \quad \text{and} \quad \lambda=(\beta_2-\beta)^{\frac{1}{2}}.$$

By placing the value of p and altering variables, the equilibrium equation develops,

$$\tfrac{1}{2}[-H(1-\beta_2)+\mu(1-\beta_2)\lambda-H\lambda^2+\mu\lambda^2]\frac{d}{d\lambda}\left(\frac{\sigma_x}{\sigma_0}\right)+2\mu(H^2+\lambda^2) \times\left(\frac{\sigma_x}{\sigma_0}\right)=2H(\mu H+\lambda)\left[1-2\left(\frac{k}{\sigma_0}\right)\ln(1-\beta)\right]$$

For the convex die,

$$\left(\frac{\sigma_z}{\sigma_0}\right) = 0.8311 - 0.1212\gamma - 0.0290\gamma^2 - 2.3524\gamma^3 - 0.1517\gamma^4$$
$$- 0.0496\gamma^5 - 2.4346\gamma^6 - 0.1138\gamma^7 - 0.6479\gamma^8 + 1.3661\gamma^9$$

$$\sigma_d = 1.1109\,\sigma_0 \quad \text{for the straight die,}$$
$$\sigma_d = 1.1274\,\sigma_0 \quad \text{for the concave die,}$$
$$\sigma_d = 1.0950\,\sigma_0 \quad \text{for the convex die, and}$$
$$\sigma_d = 1.0839\,\sigma_0 \quad \text{for the bell-shape die.}$$

From the theoretical calculations the draw stress for concave is higher and the convex die has lesser required than the straight die as shown above.

2. ANALYSIS OF THE DIFFERENT COMPONENTS

2.1 Analysis of the Rollers Die

The Rollers were modelled in Autodesk Inventor and further the analysis was carried out in Ansys Workbench.15, since the modelled has symmetric shapes, the analysis was carried out using symmetric conditions for the roller Die. As the Roller Die is symmetric in nature for the analysis purpose the die is considered, which reduces the solving time and proper Mesh can be performed to the required conditions.

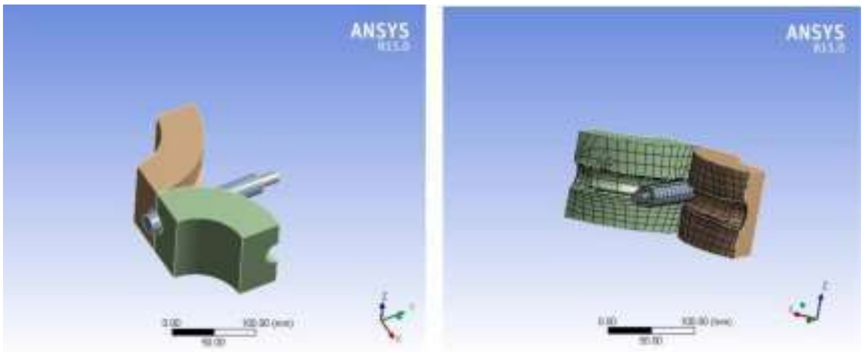


Figure 5: 3 D Model of the Roller Dies and Meshed component

In the fig 5 shows the meshed element with Nodes 3665 and the Elements 1047 with Tri and Quad elements. The boundary conditions are that the Rollers are given revolute and the displacements to the terminal or the stud. The force varies in the range of 20000 N to 50000 N based on the terminal size and the wire rope size. The Deformation Results and the related results of the terminals are discussed in the following stages. The material properties of the terminal and the Roller Dies are as follows, Terminal or the Stud Material is Stainless Steel and Roller Die Material is OHNS

Density	7.75e-006 kg mm^-3
Young's Modulus MPa	1.93e+005
Poisson's Ratio	0.31
Bulk Modulus MPa	1.693e+005
Shear Modulus MPa	73664

Density	7.81e-06 kg mm^-3
Young's Modulus MPa	1.93e+005
Poisson's Ratio	0.29
Bulk Modulus MPa	1.5317e+005
Shear Modulus MPa	74806

The material of the Terminal or the stud usually is Stainless Steel in special cases involves the usage of other materials like copper, aluminum etc. The results from the FEA analysis show that the directional deformation is 2.33 mm which is the reduction in the diameter of the terminal or the Stud.

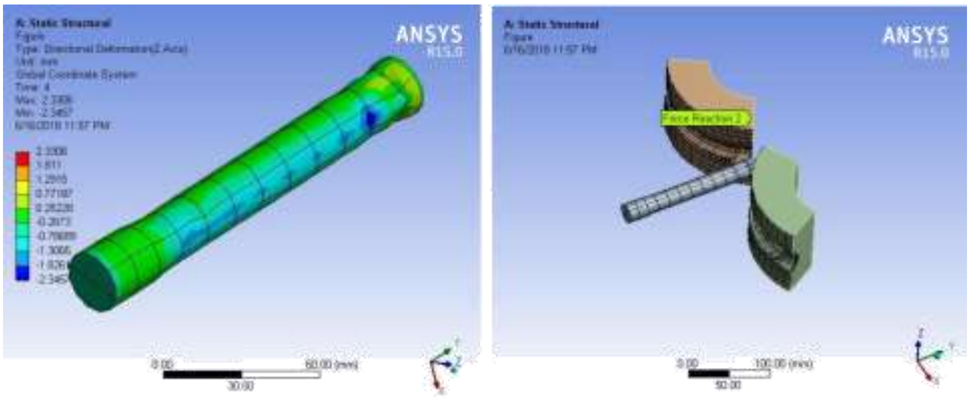


Figure 6: Stud or Terminal's Directional deformation and Force Reactions

In the fig 6 shows that the terminal or Stud directional Deformation in z- axis which shows the gradual reduction in the diameter of the stud. For the Theoretical calculations the process was considered to be friction less as the roller moves along with the terminal in the same direction of the rollers.

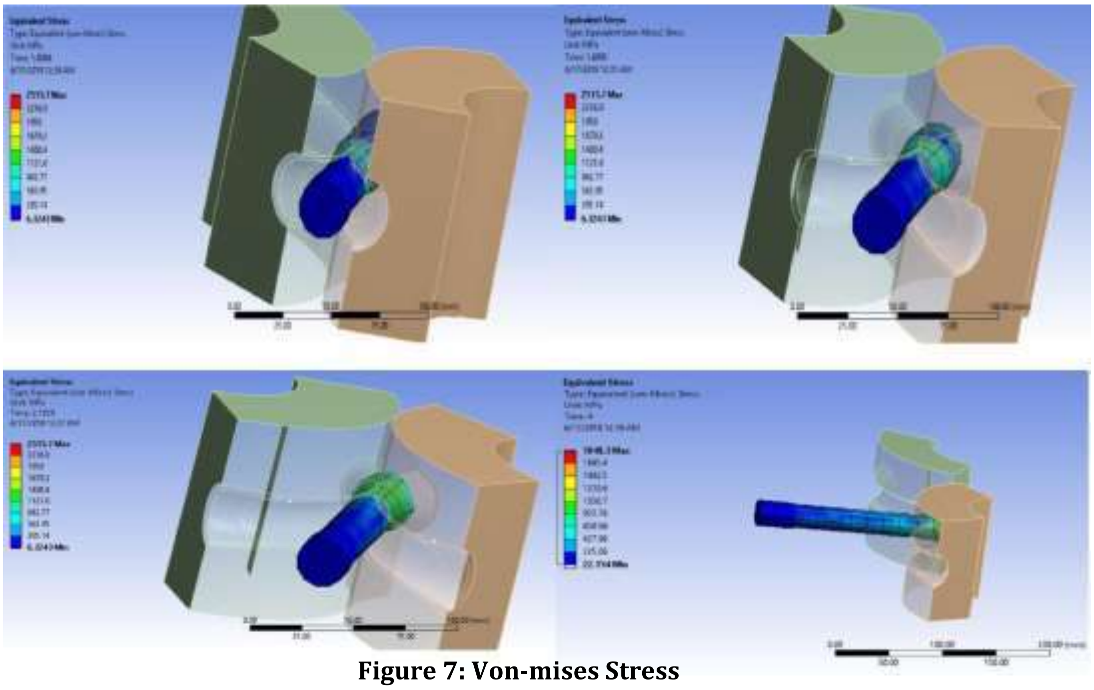


Figure 7: Von-mises Stress

The fig 7 shows the gradual reduction in the terminal diameter, von mises stress developed in the terminal.

Parameters	Theoretical	FEA(Ansys Results)
Reduction in Diameter(mm)	2.33 mm	2.65 mm

2.2 Spur Gear Analysis

The Modelling of the Spur Gear was done in Autodesk Inventor and the analysis was carried out in Ansys workbench.

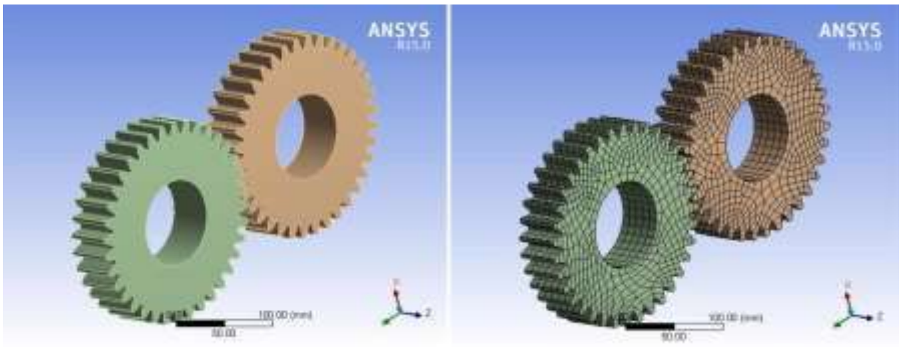


Figure 8: Model of the Spur Gear and Meshed Spur Gear

In the Fig 8 shows the meshed Spur Gear with the Nodes 455693 and Elements of 94232 which contains Quad and tri elements. In the Fig 9 represents the boundary conditions provided to the Spur gear, the center of the gear are provided frictionless support, and moment is given to the gear and remote displacement.

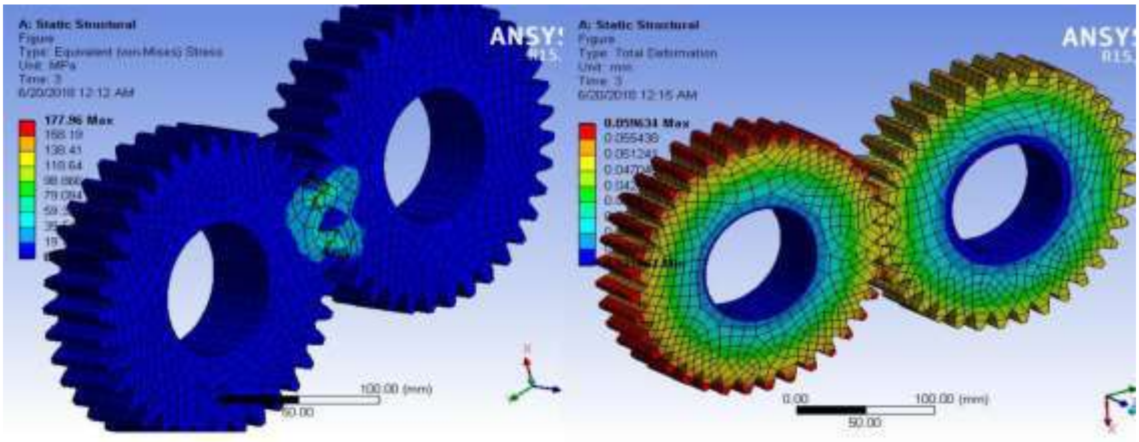


Figure 9 and represents the Von mises and the total deformation.

2.3 Single Teeth Analysis for Contact-Stress

The Spur Gear is modelled in the Autodesk Inventor 15, and the contact analysis is carried out in the Ansys work bench. And for the contact analysis the single gear tooth is preferred as which is compared with the Hertz Contact values using the respective equations.

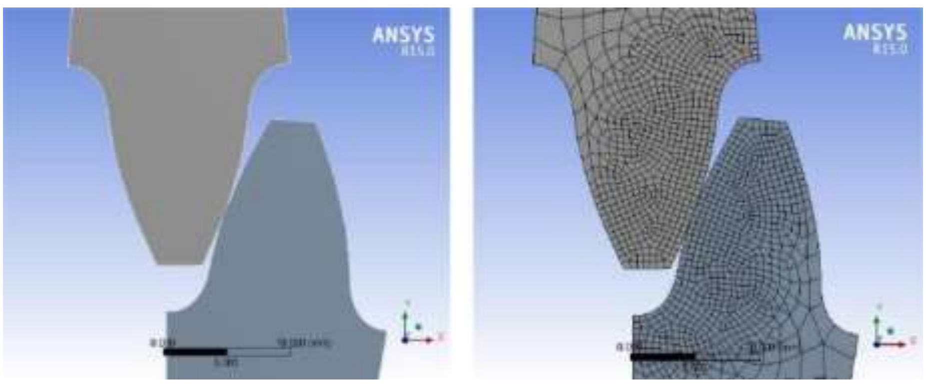


Figure 10: Spur Gear Tooth in Contact and Spur Gear Tooth in Mesh

The fig 10 represent the meshing of the single Spur Gear tooth which is meshed with a general mesh with given priority to the curvature and proximity. Consist of Nodes =651010 and Elements=153360.

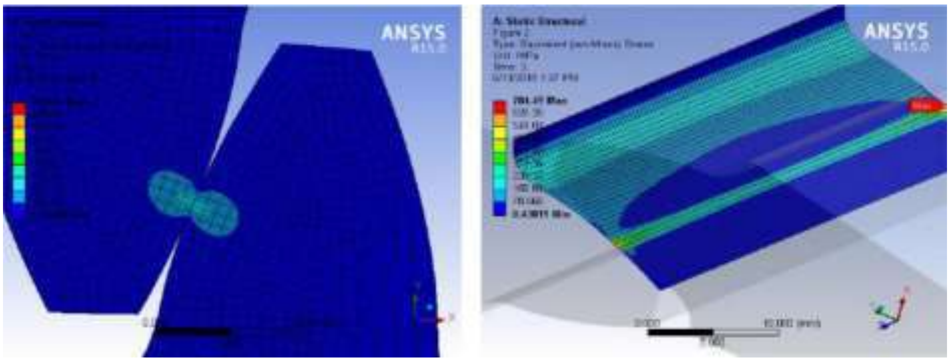


Figure 11: Equivalent Stress at the contact and Equivalent Stress at the Surface

The above Fig 11 represents position of contact stress and represents the von-Mises stress and the value of the contact stress which is compared with the theoretical value of the Hertz Contact stress. The Hertz equation for contact stresses in the teeth is given by the equation, The FEA results from the ANSYS Workbench software for the Maximum contact stress is equal to 704 Mpa.

2.4 Analysis of the Mechanism

The following results are for the components which are involved in the process of providing the pull force of 20 to 25 KN, the required analysis are carried out in the Ansys Workbench 15.0.

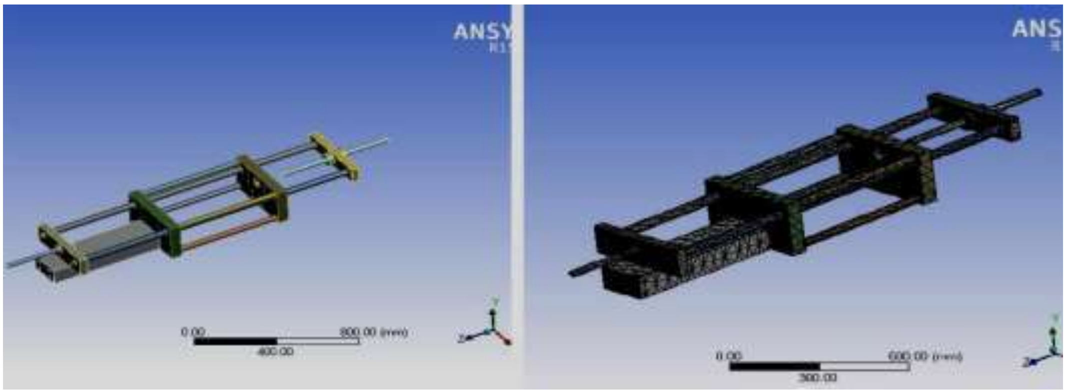


Figure 12 : Components involved in the and Meshing of the components analysis

In the Fig 12 shows the meshing of the components along with the terminal (stud) with Nodes 63115 and the Elements 32372. The boundary conditions involved the static structural Analysis with few of the structures fixed and force ranging from 20000N to 25000N, based on the terminal size and wire rope size.

2.5 Results of the Individual Components

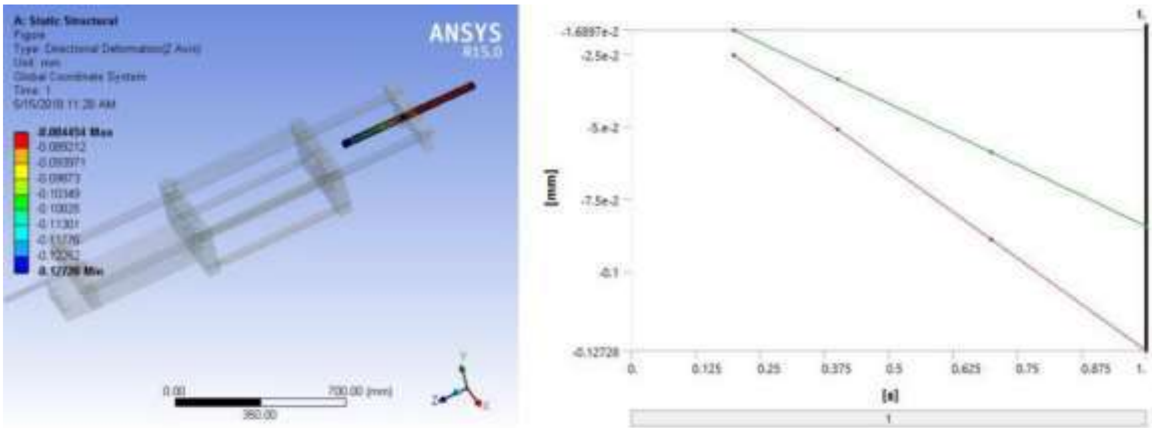


Figure 13: Deformation results in the screw rod and Deformation vs. time

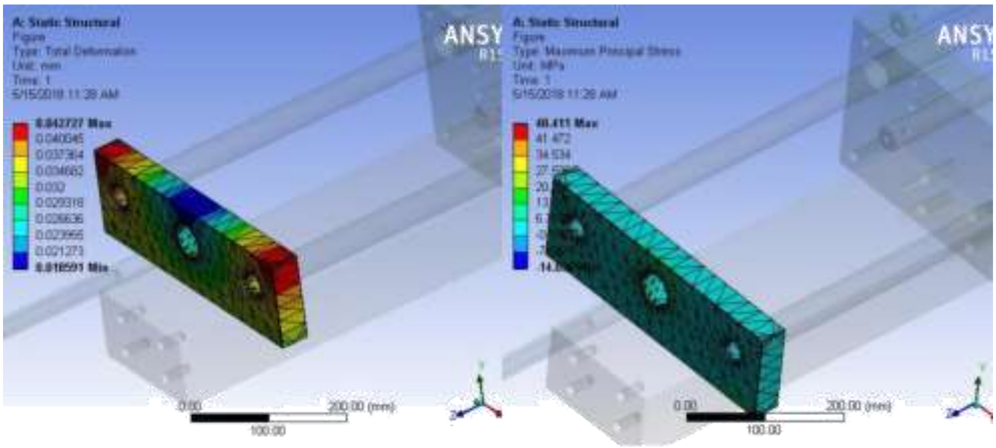


Figure 14 : Total Deformation and Maximum Principal Stress

The fig 13 to fig 14 shows the stress values and the deformation results of the plate which holds the threaded terminal (Stud).

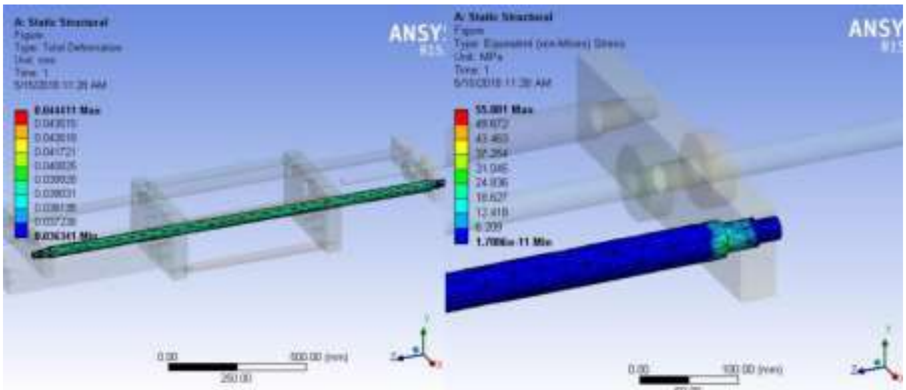


Figure 15 : Total Deformation and Von mises stress

The Fig 15 shows deformation and the von mises stress for the long cylindrical component which transfers the force from the hydraulic cylinder to pull the terminal through the Roller Die. The Fig 16 shows the Von mises stress and the Principal stress for the screw rod

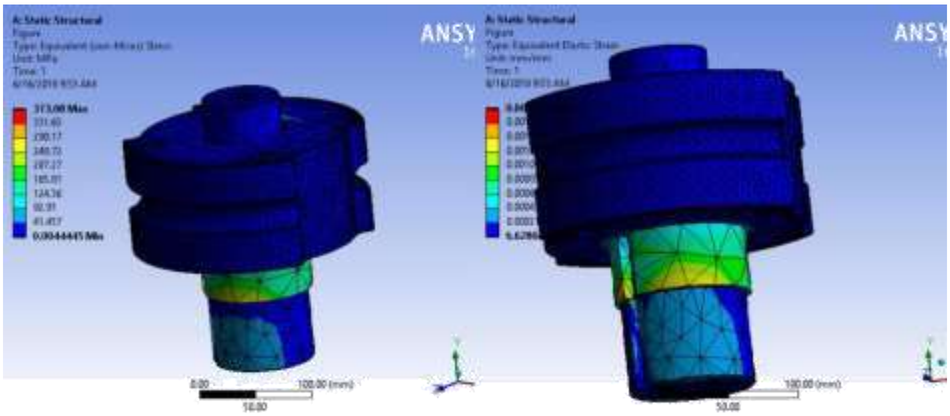


Figure 16 : Von mises stress and Maximum Principal Stress

2.7 Analysis of the Roller Die along with the support and the Bush

The Roller Die must also withstand the radial forces that are produced during the swaging process; hence the analysis of the Roller Die along with the bush and the support cylinder is necessary.

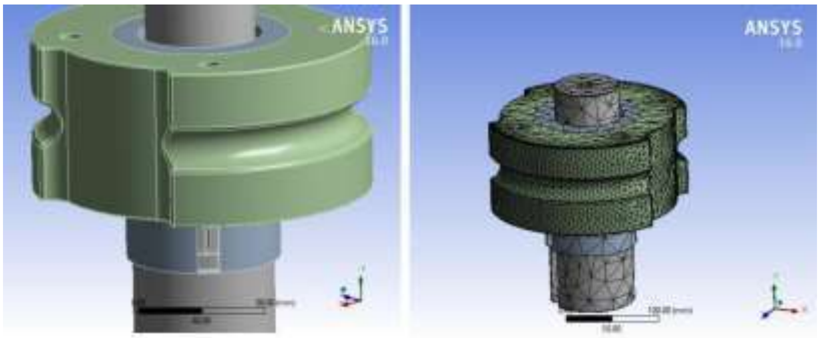


Figure 17 : Assembly of the Roller Die, Bush,Support cylinder and Meshed components

All the components are of same material OHNS, which withstands the high-load and fig 17 represents the boundary conditions, pressure is applied around 45 Mpa in a varied manner so that it resembles the actual loading conditions.

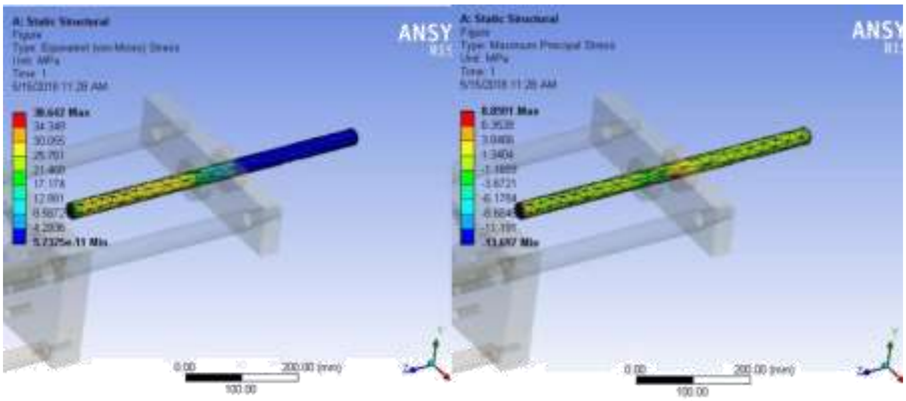


Figure 18 : Equivalent Stress and Equivalent Stress

The FEA analysis shows the equivalent stress which is highest in the Bush component and the support rod which supports the entire loading on it from the roller die during the swaging process. In Fig 19, Fig 20 shows that the stress distribution of components like roller dies, bush, support cylinder.

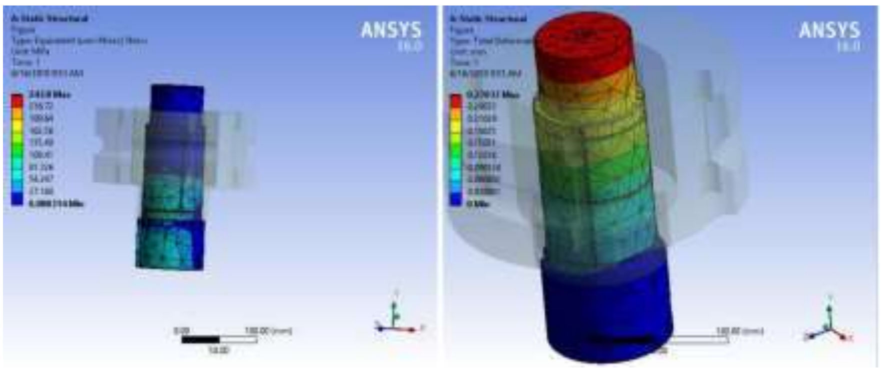


Figure 19: Equivalent Stress and Total Deformation

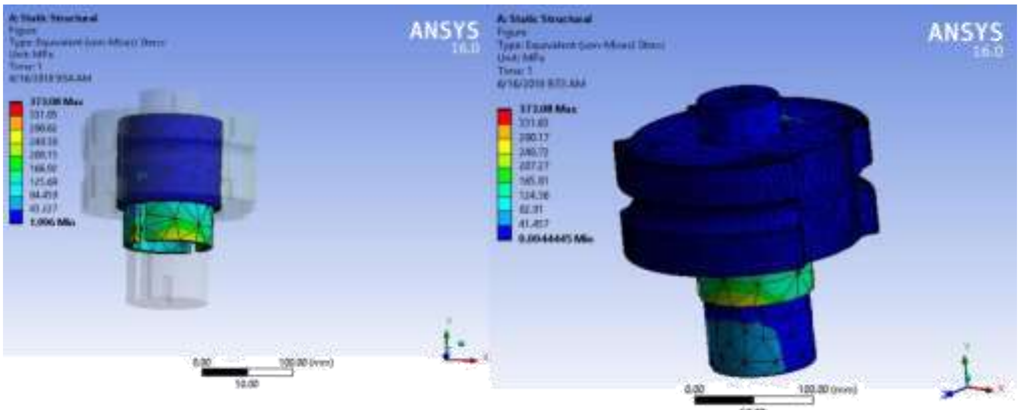


Figure 20 : Assembly of the Roller Die, Bush, Support cylinder and Meshed components

2.8 Cylinder Analysis

As we mentioned earlier, the simple design of the cylinder is the important dimensions of the entire Hydraulic System. In the fig 21 shows the total deformation of the cylinder the boundary conditions include fixing of the ends and the pressure applied to inner-surface cylinder.

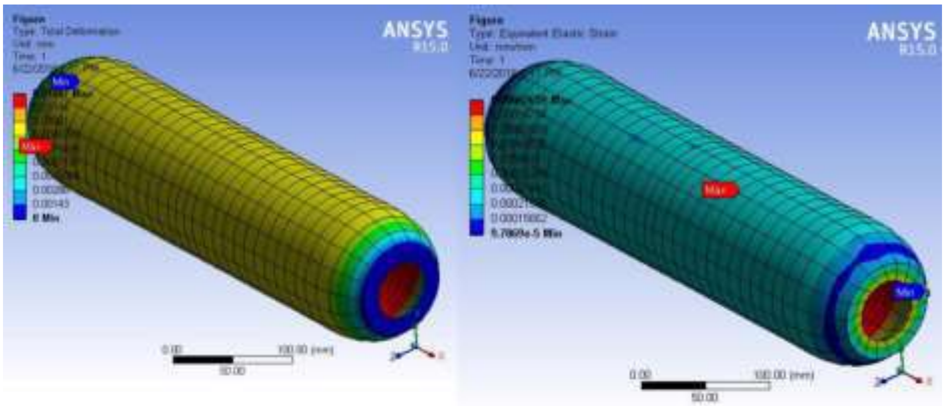


Figure 21 : Total Deformation and Equivalent elastic Strain

2.9 Piston Analysis

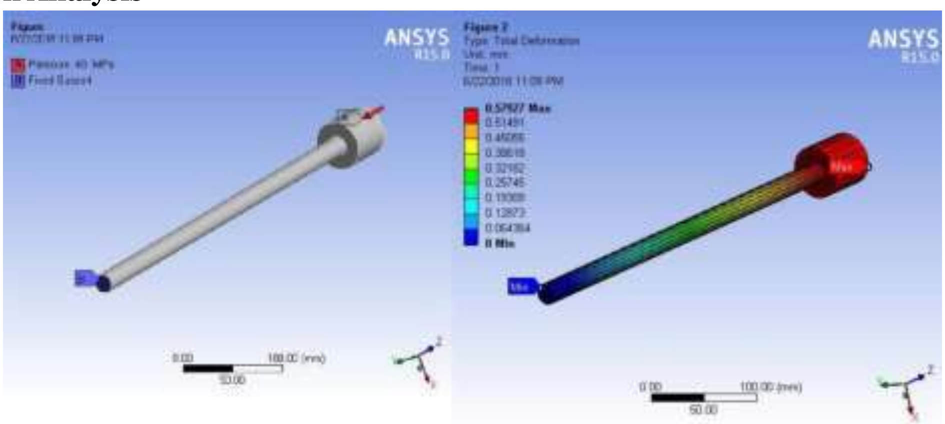


Figure 22: boundary Conditions and Total Deformation

In the fig 22 shows the Piston Rod and piston assembly and the meshed components with Nodes 23812 and Elements 5888. The boundary conditions, pressure are applied on to the face of the Piston is 40 Mpa and also one end the rod fixed. The FEA result signifies that the maximum stress obtained in the components are not more than the yield Strength of their respective materials.

CONCLUSION

- Roller Swaging Machine, as the name suggests involves using of rollers to perform the operation, the operation involves the reduction of the Terminal diameter which holds on to the wire rope.

- The Rollers are made of OHNS material which is more preferable for cold metal forming process such as Swaging process.
- The rollers are supported by spur gear which guides the rollers to rotate simultaneously, the Spur gear is designed according to the AGMA standards and analysis in Ansys Workbench and the modeling is done in Autodesk Inventor.
- The required pull force is produced by Hydraulic means and the stroke length is controlled by the lever, the stroke velocity is around 13mm/sec to 20mm/sec which may vary along with the pull force required for different wire rope size and Terminal size.
- The static analysis results suggest that the screw rod is subjected to maximum stress and deformation.
- The Roller Swaging machine can be further advanced or improved by usage of different materials and few modifications in the design or optimization.

REFERENCES

1. *L.W. Hu. "Analysis of die profiles in wire drawing", Journal of the Franklin Institute, 1957.*
2. *Zhang, Qi, Kaiqiang Jin, Dong mu, Pengju Ma, and Jie Tian. "Rotary Swaging Forming Process of Tube Workpieces", Procedia Engineering, 2014.*
3. *Zhang Yan, Huang Qiangui "Finite Element Analysis of Cold Extrusion Combination Mold Interference Fit" College of Mechanical Engineering, Heilongjiang Institute of Science and Technology, Harbin. Advanced Materials Research Vol 142 (2011) pp 266-269.*
4. *Putti Srinivasa Rao, Nadipalli Sriraj, Mohammad Farookh. "Contact Stress Analysis of Spur Gear for Different Materials using ANSYS and Hertz Equation", www.arcjournals.org.*
5. *Qi Zhang, Kaiqiang Jin, Dong mua, Pengju Ma, Jie Tian "Rotary swaging forming process of tube workpieces" 11th International Conference on Technology of Plasticity, ICTP 2014, 19-24 October 2014, Nagoya Congress Center, Nagoya, Japan.*
6. *S. Mulot b, A. Hacquin ", P. Montmitonnet a, J.-L. Aubin b "A Fully 3D Finite Element Simulation of Cold Pilgering" Journal of Materials Processing Technology 60 (1996) 505-512)*
7. *Yagız Azizoglua, Mattias Gardsback, Bengt Sjoberg, and Lars-Erik Lindgrenc "Finite Element Analysis of Cold Pilgering Using Elastic Roll Dies" International Conference on the Technology of Plasticity, ICTP 2017, 17-22 September 2017, Cambridge, United Kingdom.*
8. *Abdul Kareem F. Hassan*, Alyaa S. Hashim "Three Dimensional Finite Element Analysis of Wire Drawing Process" Department of Mechanical Engineering, University of Basrah, Iraq, Universal Journal of Mechanical Engineering 3(3): 71-82, 2015.*
9. *S Rajesh Kumar and R Manoharan "Design and Analysis of Composite Spur Gears Using Finite Element Method" Assistant Professor, Mechanical Engineering, SNS College of Engineering, Volume I, Issue VI, November 2014 IJRSI ISSN 2321 – 2705.*
10. *L. W. Hu "Analysis of Die Profiles In Wire Drawing" Department of Engineering Mechanics, The Pennsylvania State University, University Park, Pa.*
11. *S Rajeshkumar, R Manoharan. "Design and analysis of composite spur gears using finite element method", IOP Conference Series: Materials Science and Engineering, 2017*
12. *Yağız Azizoğlu, Mattias Gärdsback, BengtSjöberg, Lars-Erik Lindgren. "Finite ElementAnalysis of cold pilgering using elastic rolldies", Procedia Engineering, 2017.*
13. *Mulot, S,"A fully 3D finite element simulation of cold pilgering", Journal of Materials Processing Tech., 19960615*