Verification and Analysis of Stress-Strain Curve of Sheet Metal by using Three Roller Bending Machine

[1]C. S. Jadhav, [2] Prof. P. S.Talmale
[1]M.E Student, [2]Assistant Professor,
[1] Department of Mechanical Engineering,
[1]K.C.T'S. L. G. N. Sapkal College of Engineering,Nashik, Maharashtra

Abstract—**Roller bending process is used to transform a sheet or plate into hollow cylindrical shapes implementing plastic deformation techniques. Cylindrical and conical shells are basic component of vessels and structures used for various engineering applications. In these cases, it is important to bend the sheet safely and working for longer life. In bending operation a metal sheet is subjected to sequential bending stresses for different position of top roller. Advanced techniques are used for verification of stress values up to ultimate tensile strength of material. In this paper work has been carried on analytical, FEA analysis. Stresses produces in sheet metal are comparing with analytical and FEA. Also stress-strain curves obtained in analytical and FEA analysis are nearer to each other.**

IndexTerms—**Stress, Deformation, Bending Moment, Bending Moment Expression Pyramidal Three Roll, Sheet-Bending, Springback, Residual Stresses.**

I. INTRODUCTION

Roll bending process is the plastic deformation of a metal that uses a set of rolls to bend flat plates into various shapes such as cylindrical, conical or ovals. Three roll bending is a continuous three-point bending process with negligible change in plate thickness. Many different types of roll bending machines have been developed over the past few decades to adapt to various forming production specifications. However the three-roll asymmetric model produces more accurate final shape, capable of forming a wider range of plate thicknesses, and especially this type of machine can be loaded and unloaded much faster than a three-roll pyramidal model.

II. LITERATURE REVIEW

Gandhi and Raval [1] developed the analytical model to estimate the top roller position as a function of desired curvature, for multiple pass three-roller forming cylinders. Gandhi and Raval [2] proposed that the developed analytical model for the range of the range of the machine setting parameters such as top roller position and center distance between bottom rollers, work should be extend to check the validity of developed model at different material property parameters, machine specifications and plate dimensions. Zemin Fu [3] an analytical model and finite element model are proposed for investigating the three rollers bending forming process. A reasonably accurate relationship between the down word inner roller displacement and the desired spring back radius of the bent plate is yielded by both analytical and finite element approaches, which all agree well with experiments. Kalyani abhinav [4] reported that the different sheet metals are considered and different loads are applied and parameters are obtained. From all the condition conclude that the normal stress is maximum only in stainless steel. Total deformation and maximum principal elastic strain is higher for aluminum. Ahmed ktari [7] proposed that the desired curvature radii were established by varying the distance between the two bottom rollers and the position of the upper one.

Reported papers on roller bending in literature mainly focuses on the forces, top roller displacement, radius of curvature. In the reported work manufacturing sequence of large cylindrical shell along with some commonly observed defects during roller bending were discussed. Stresses produces in sheet metal are comparing with analytical and FEA. Also stress-strain curves obtained in analytical and FEA analysis are nearer to each other.

III. ANALYTICAL ANALYSIS

As top roller position is the function of loaded radius of curvature (R), center distance between bottom rollers (a), radius of the bottom rollers (R_b) and radius of the top roller (R_t), a/2 is half distance between the imaginary roller to one sided bottom rollers. Initial position of top roller from point 'O' to the center of dotted circle, as well as initial position of sheet metal shown by straight line (x-x), when the top roller displaced by some amount as shown in Fig.1 (U), next position will be the shown by dark circle i.e. final position of top roller, hence sheet metal form a curved shown by line (x'-x'). The top roller position can be calculated by Eq. 1.

$$U = C_1 R^{m}{}_1 \qquad (1)$$

Where, constants c_1 and m_1 were obtained as a function of center distance between bottom rollers (a)

$$C_1 = Pa^{Q} \qquad (2)$$

$$m_1 = (-0.00002)\ a^{-S} \qquad (3)$$

So, unified empirical equation is given by Equation A

$$U = P\,(a)^{Q}\,(R)^{(-0.00002)}\; a^{-S} \qquad \text{(A)}$$

Where, P, Q and S are constants, which depend on bottom roller radius (R_b). From the P versus t, Q versus R_t and S versus R_t plots, constants P, Q and S were obtained by applying the generalized method of least square and method of differential corrections to the generated dataset as a function of bottom roller radius (R_b) is given by Eqs. (4 - 6).

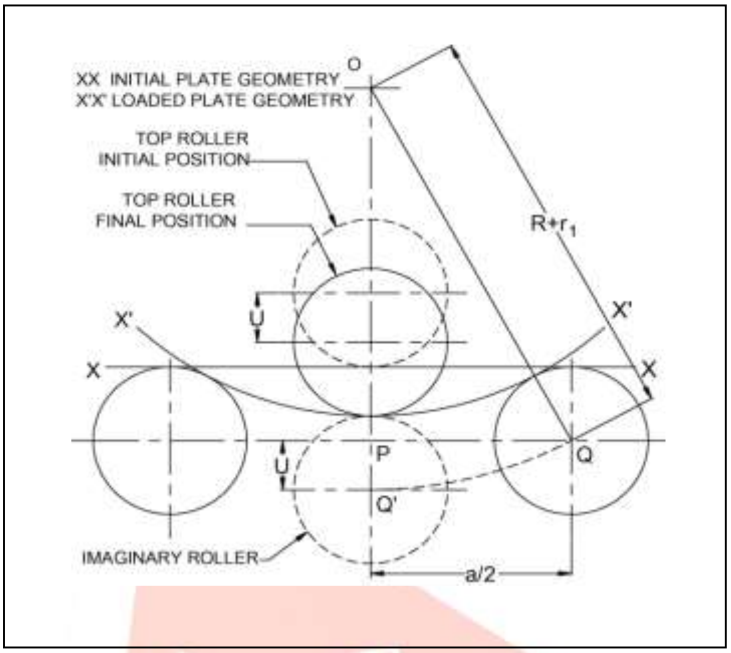

Fig.1 Top roller position for radius of curvature

$$P = 0.198R_b^{-0.2582} \qquad (4)$$

$$Q = 2.1199R_b^{-0.0057} \qquad (5)$$

$$S = 1.133R_b^{-0.0373} \qquad (6)$$

From Equation A we get Equation B as,

$$U = (0.198R_b^{-0.2582})\; a^{2.1199Rb-0.0057}\; R^{(-0.00002)a-(1.133Rb-0.0373\;)} \qquad \text{(B)}$$

A. To find the strain for thickness t = 2 mm, 3 mm , 4mm of plates

In bending a thin sheet to a bend radius more than three or four times the sheet thickness, it may be assumed that a plane normal section in the sheet will remain plane and normal and converge on the center of curvature as shown in Fig.1

The original length of fiber CD_0 is assumed as ls, the change in length due bending is calculated at fiber AB_0 at distance y from middle surface, is given by,

$$l = \rho\theta \qquad (7)$$

$$ls = (\rho + y)\,\theta \qquad (8)$$

The axial strain of fiber AB_0 is given by

$$\varepsilon_1 = \ln(ls/lo) + \ln(1+(y/\rho)) \qquad (9)$$

$$\varepsilon_1 = \varepsilon_a + \varepsilon_b \qquad (10)$$

IV. FEA ANALYSIS

Three dimensional solid models for the three roller bending machine is modeled using CATIA V5. Fig. 2 shows the image of the machine assembly. This is model assembly considering in static condition. Boundary condition of model is displacement of top roller, thickness of plate and base of model is fixed on both sides.

The model shown above is meshed in ANSYS along with the metal sheet used for bending. The meshed model is shown in the Fig.3

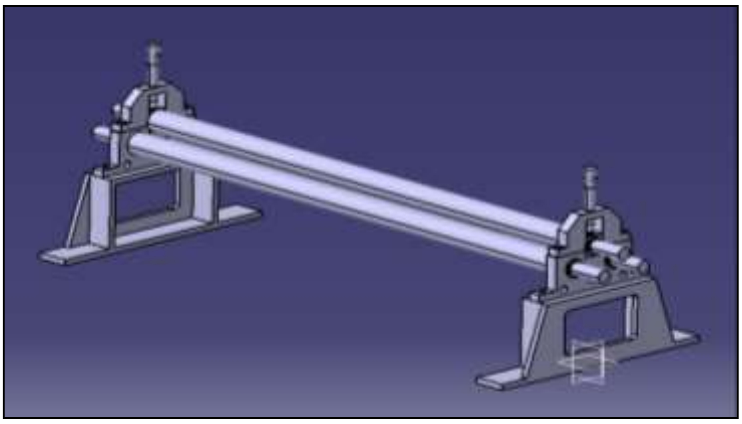

Fig.2 3D Model for three roller bending process

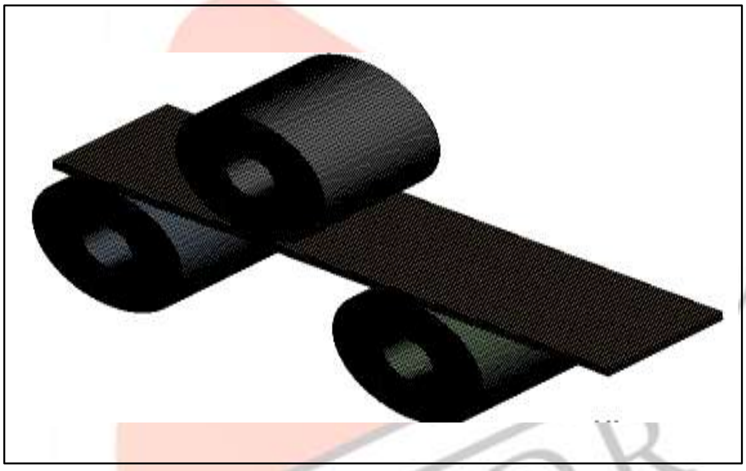

Fig.3 Meshed model for three roller bending process

In bending operation a metal sheet is subjected to sequential bending stresses for different position of top roller. For thickness t = 2 mm, 3 mm, 4 mm.

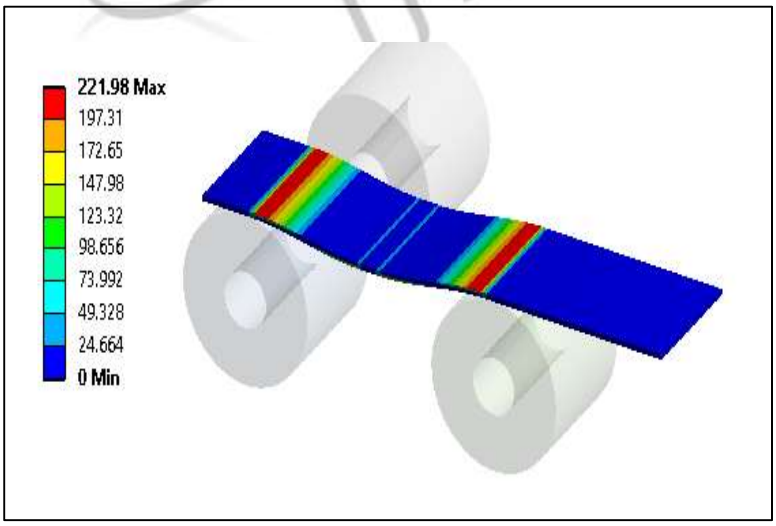

Fig.4 Maximum principal stress plot for t = 2 mm

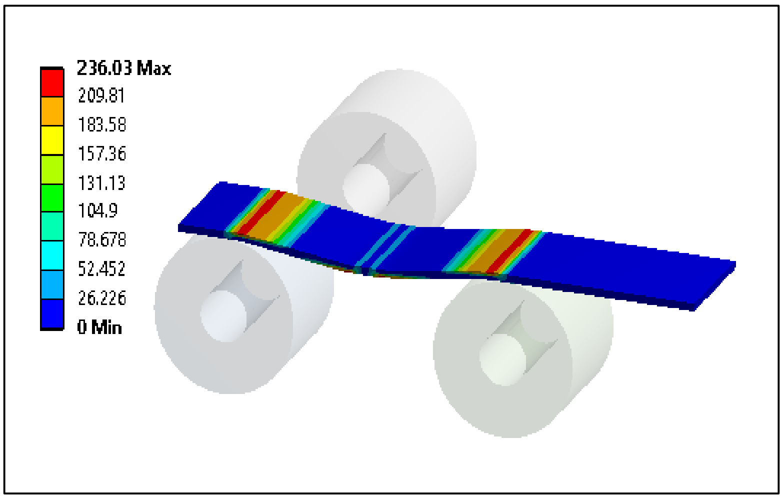

Fig.5 Maximum principal stress plot for t = 3 mm

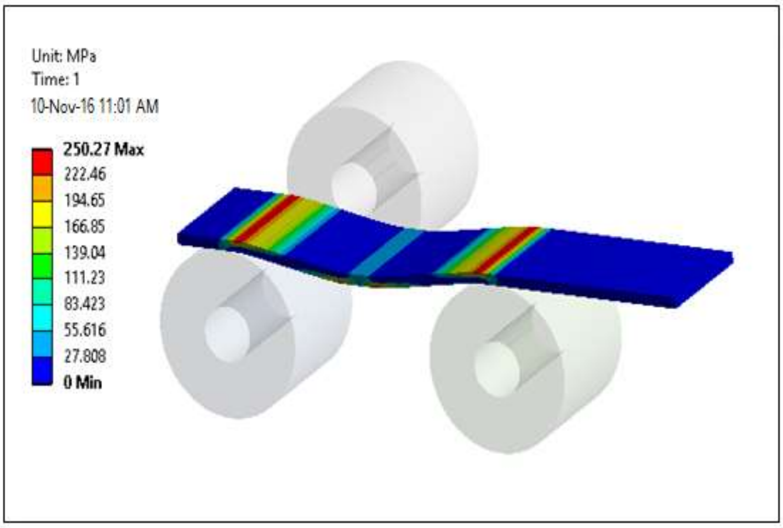

Fig.6 Maximum principal stress plot for t = 4 mm

V. RESULT AND DISCCUSSION

After analytical and Finite element analysis of certain parameters by changing the position of top roller and conditions on three different sheet metals, results are obtained. Here considering all the maximum valves obtained and graphs are plotted accordingly.

Table 1 Stresses produces in sheet metal are comparing with analytical and FEA

Parameter / Thickness mm	Analytical stress Mpa	FEA Stress Mpa
2	351.17	341
3	364.85	357
4	380.95	372

Stress Vs Strain Curve from analytical and FEA analysis for 2 mm , 3 mm, 4 mm sheet thicknesses.

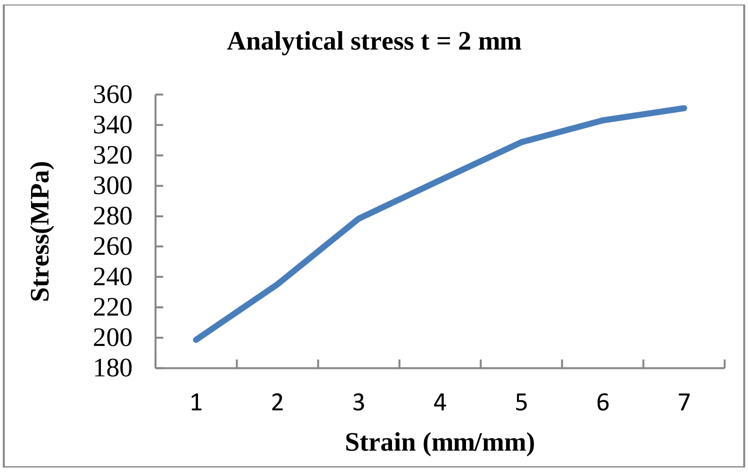

Fig.7 Analytical stress vs. strain for t = 2 mm

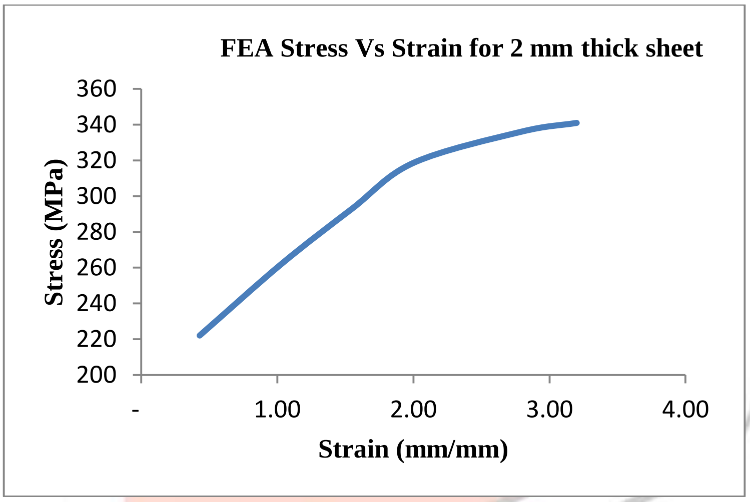

Fig.8 FEA stress vs. strain for t = 2 mm

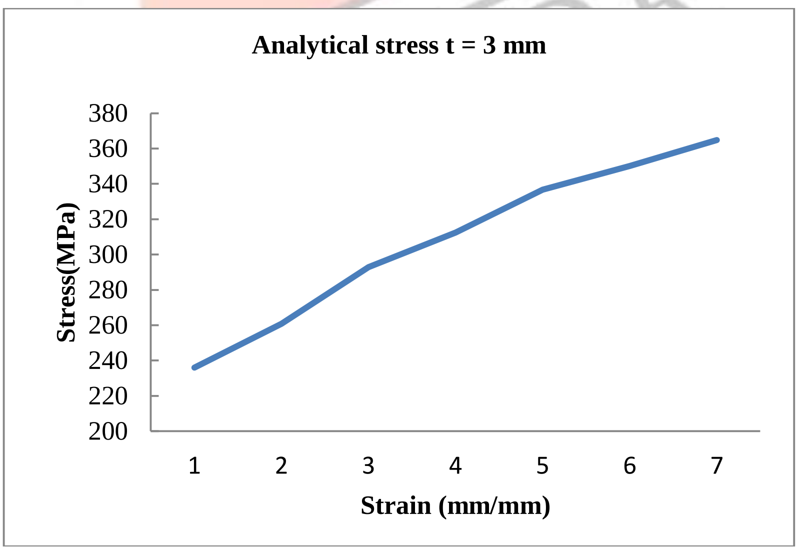

Fig.9 Analytical stress vs. strain for t = 3 mm

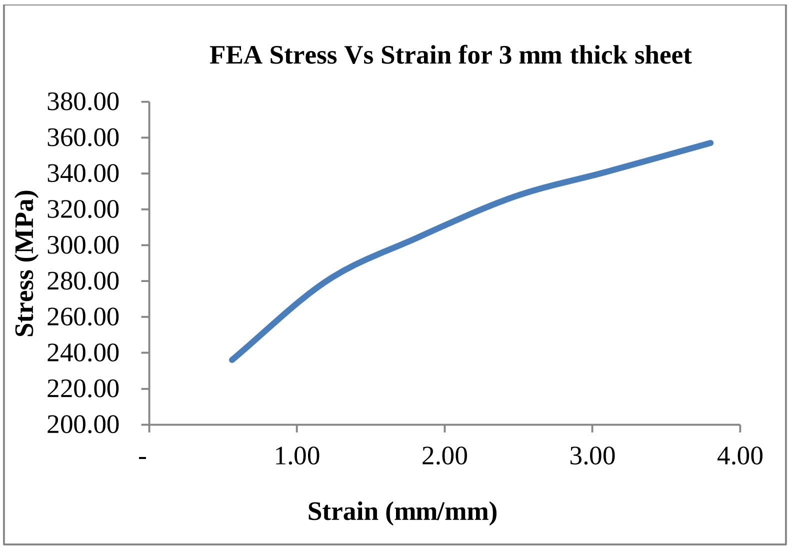

Fig.10 FEA stress vs. strain for t = 3 mm

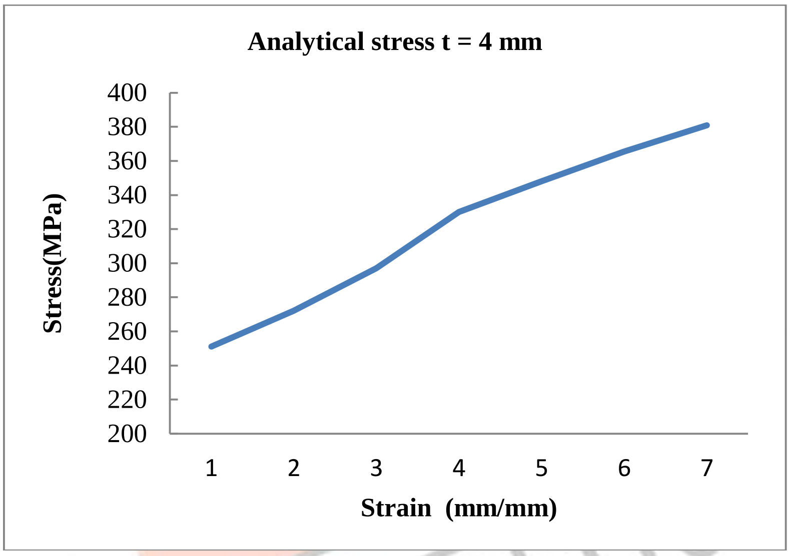

Fig.11 Analytical stress vs. strain for t = 4 mm

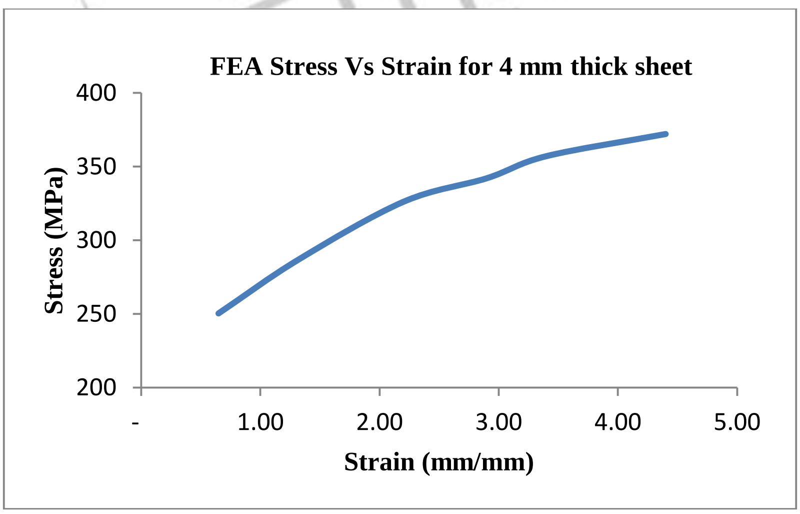

Fig.12 FEA stress vs. strain for t = 4 mm

VI. CONCLUSION

Analytical results are compared with FEA results on Pyramid type three roller bending machine, from this it is concluded that,

- Analytical has predicted the roller positions for different radius of curvature for bending the sheets on three roller bending machine with good accuracy and Results found by FEA are close.
- Stresses and strain values are found in analytical as well as in ANSYS and are in agreement with each other.
- Stresses observed in ANSYS as well as in analytical are within the acceptance limit of ultimate tensile strength of the mild steel.
- Less variation of stress- strain curve for analytical and finite element analysis results shows accuracy of the method.

.

REFERENCES

[1] A.H. Gandhi and H. K .Raval, "Analytical and Empirical Modeling of Top Roller Position for Three Roller Cylindrical Bending of Plates and its Experimental Verification" Journal of material processing technology, 2008197 268–278.

[2] A. H. Gandhi, Dr. H. K. Raval "Analytical Modeling of Top Roller Position for Multiple Pass (Three Rollers) Cylindrical Forming of Plates" November 5-10 2006, IMECE2006.

[3] Zemin Fu,Weichen Bingkun Hu "Analytical Modeling and Numerical Simulation for Three-Roll Bending Forming of Sheet Metal" 14 June 2013 PP 1639-1647.

[4] Kalyani Abhinav & Prof. K. Annamalai , "Analysis of Sheet Metal Bending by using Finite Element Method" School of Mechanical & Building sciences, VIT University Chennai, India, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 2 Issue 1, January- 2013.

[5] Yogesh Srivastav & Suyog Shinde, "Dynamic Simulation and Analysis of Plate Roll Bending Process for Forming a Cylindrical Shell" , Larsen and Toubro limited, Mumbai – 400072, HTC 2010.

[6] V.K.Tailor, A.H. Gandhi, "Finite Element Analysis of Deformed Geometry in Three Roller Plate Bending Process" October 7-10 2008 MSEC 20O8.

[7] Ahmed Ktar, Zied Antar Nader Hadder and Khaled Elleuch "Modeling and Computation of the Three Roller Bending Process of Steel Sheets" JOMSAT 26(1)(2012)123-128.

[8] Adsul A. N. Chavan S.G. and Gore P. N. "Review of Theories Regarding Material Bending" International Journal of Scientific & Engineering Research, Volume 4, Issue 10, October-2013 1293 ISSN 2229-5518.

[9] Nitin P. Padghan, Ketan K. Tonpe, Dr. C. N. Sakhale "Calculation of Setup variable for Process of Bending and Rolling Operation using Analytical approach and Finite Element Method" JETIR (ISSN- 2349-5162)

[10] Promod Vishwakarma, Vaibhav Bankar, "Design and Analysis of M.S Roller in Sheet Metal Rolling Machine" ISSEN – 2455-1597 Volume-2 Isssue- 2, March-April-2016, Page No-21-23

[11] P. S. Thakare, P. G. Mehar, Dr. A .V. Vanalkar "Productivity Analysis of Manually Operated And Power Operated Sheet Bending Machine-A Comparative Study",Vol.2, Issue 2, Mar-Apr-2012 PP 111-114.

[12] Zhengkun Feng, Quan Hoang Tran , Hendri champliaud "Fe Study for Reducing Forming Forces and Flat end Areas of Cylindrical Shapes Obtained by the Roll-Bending Process" (2014)467-475.

[13] Mahesh Gadekar, Amol, "Design and Development of Three Roller Sheet Bending Machine", ISSN 2321-8169, Voi-3 Issue-8 ,5132-5135

[14] Vaibhav Suresh Deore, Gauri Rajendra Bauskar, Karan Sanjay Bhadane, Siddhesh Mukesh Gaikwad "Pyramid Type Plate Bending Machine" IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | p ISSN : 2321-7308