SIMULATION OF ROLLING OPERATION ON AL- CSA COMPOSITES BY USING DEFORM 3D

[1]Siva Sankara Raju, [2]K.Pawan Sai Kumar,[3]G.Manoj Kumar,[4]I.Kiran Kumar, [5]Deepak Singh
[1] Assistant Professor, Aditya Institute of Technology and Management, Tekkali, India
[2,3,4,5] UG Students, Mechanical Engineering, Aditya Institute of Technology and Management, Tekkali, India

Abstract: In this study, rolling operation have been performed using DEFORM 3D software to know the behavior of materials at elevated conditions. DEFORM 3D is a robust simulation tool that uses the FEM to model complex machining process in three dimensions. This advance tool allows designers and engineers to reduce the need for costly shop floor trials and to reduce production and material cost. The Al- Coconut shell ash (CSA) composites have been subjected to rolling is analyzed in this software to know phase transformation and Microstructural changes at elevated conditions. This work aim to known the behavior of materials at rolled conditions and suggest appropriates for automotive sectors.

***Index Terms* – DEFORM 3D, FEM, Rolling, Al-CSA**

I. INTRODUCTION

Rolling is one of the most important industrial metal forming operations. Hot Rolling is employed for breaking the ingots down into wrought products such as into blooms and billets, which are subsequently rolled to other products like plates, sheets etc. Rolling is the plastic deformation of materials caused by compressive force applied through a set of rolls. The cross section of the work piece is reduced by the process. The material gets squeezed between a pair of rolls, as a result of which the thickness gets reduced and the length gets increased. Mostly, rolling is done at high temperature, called hot rolling because of requirement of large deformations. Hot rolling results in residual stress-free product. However, scaling is a major problem, due to which dimensional accuracy is not maintained. Cold rolling of sheets, foils etc. are gaining importance, due to high accuracy and lack of oxide scaling. Cold rolling also strengthens the product due to work hardening (Zeng, Wu and Zhang, 2011; Poláková and Zemko, 2012). DEFORM-3D is a finite element methods (FEM) software based on process simulation, specifically designed to analyze three-dimensional (3D) metal flows in metal deforming process, to provide valuable process analysis data, and to analyze materials flow and temperature distribution related in the forming process. In this paper, to utilize finite element software, DEFORM-3D, aluminum coconut shell ash composite hot strip rolling model was established(Ahmad *et al.*, 2018; Hemanth, Arunkumar and Srinath., 2018).

II. ABOUT THE MATERIAL

CSA contains carbon particles/fibers which possess outstanding properties. They have high specific modulus which outweighs that of the steel(Siva Sankara Raju *et al.*, 2017; Sankara Raju *et al.*, 2019; Siva Sankara Raju, Srinivasa Rao and Samantra, 2019). Their thermal and electrical conductivities are excellent in comparison with those of competing materials such as ceramics and polymers. It is hard and possesses high strength due to the presence of carbon. Coconut-shell ash is agricultural waste. The waste is produced in abundance globally and poses risk to health as well as environment(Siva Sankar Raju, Srinivasa Rao and Muralidhara rao, 2015; Sankara Raju *et al.*, 2018; Thimothy, Ch. and Siva Sankara Raju, 2018; Rallabandi and Srinivasa Rao, 2019). Hence, coconut shell ash is used as a low cost reinforcement in Metal Matrix Composites (MMCs). .As aluminium is a lighter metal, it is best suited for automotive but it lacks strength. Therefore to increase the strength of this metal, the aluminum-CSA (MMC) is used.

III. RESULTS

Using the post-processor in Deform 3D extracted data are:

3.1 Variation of damage with respect to time:

Damage is a physical discontinuity in the object or material. It can be introduced either during manufacturing or service stage. The damage can impair usefulness or normal functioning of the object or material. Damage characterizes the state of the object or material. Quantitative evaluation of damage location, shape, size, evolution and effect can be performed based on experimental, analytical and numerical techniques. The Figure 1 and Figure 2 shows the variations in damage recorded at five variant points at which the simulations of the rolling process were performed at step 50 and 100. The maximum damage value recorded during the process is 0.0628. There is a clear view that up to sometime damage is constant but after some time the damage valve increase with increases in time and again it become constant. Here we can see the graphical variation of damage at variant point with respect to time at step 50 and 100.

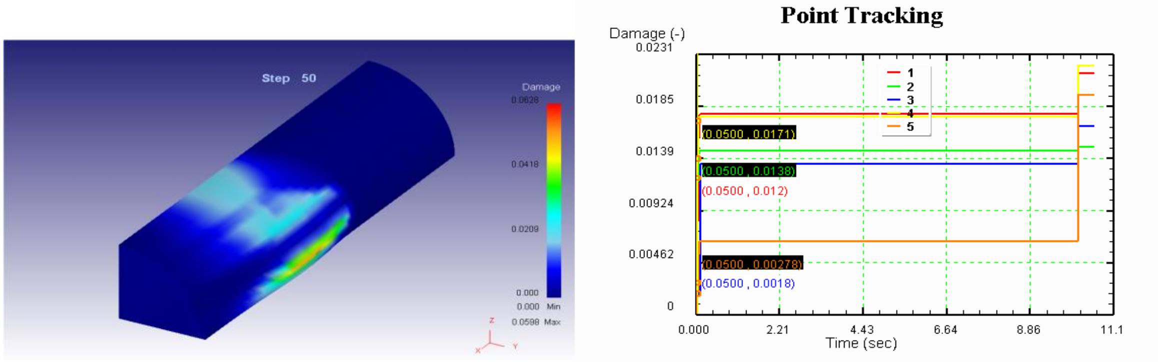

Figure 1: Variation of damage with respect to time at step 50.

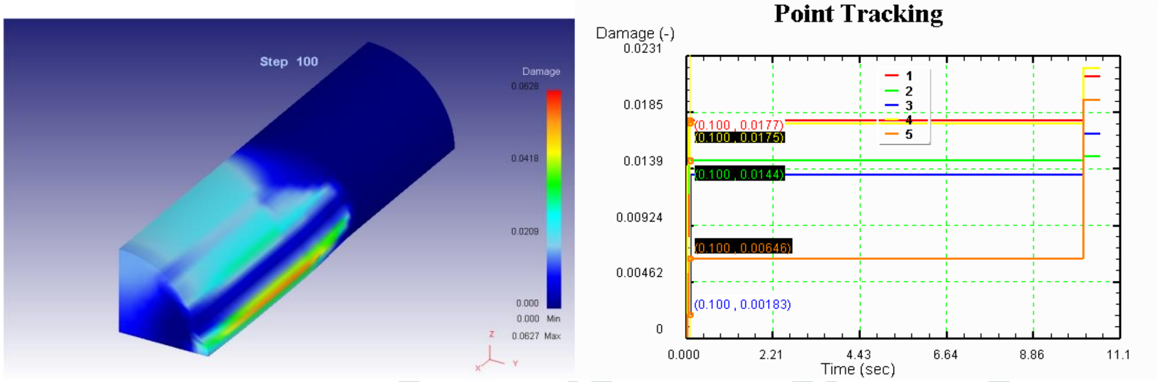

Figure 2: Variation of damage with respect to time at step 100

3.2. Variation of strain effective with respect to time:

Effective stress is defined as that stress which when reaches critical value, yielding can commence. The corresponding strain is defined as effective strain. The Figure 3 and Figure 4 shows the variations in strain effective recorded at five variant points at which the simulations of the rolling process were performed at step 50 and 100.

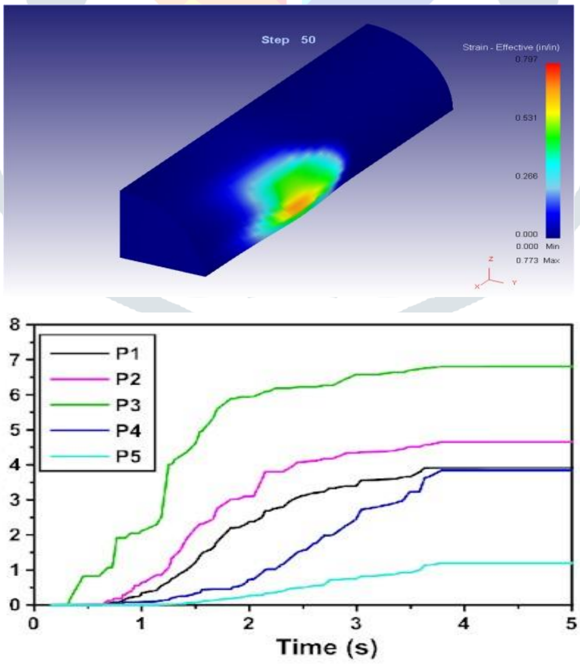

Figure 3: Variation of strain effective with respect to time at step 50

We can clearly observe that the varition of strain effective is proportion at varient points and the maximum strain rate effective value recorded is 0.773 at step 50 and 0.797 at step 100.
it concluded that the effective stress increases with increase in roller diameter and speed.

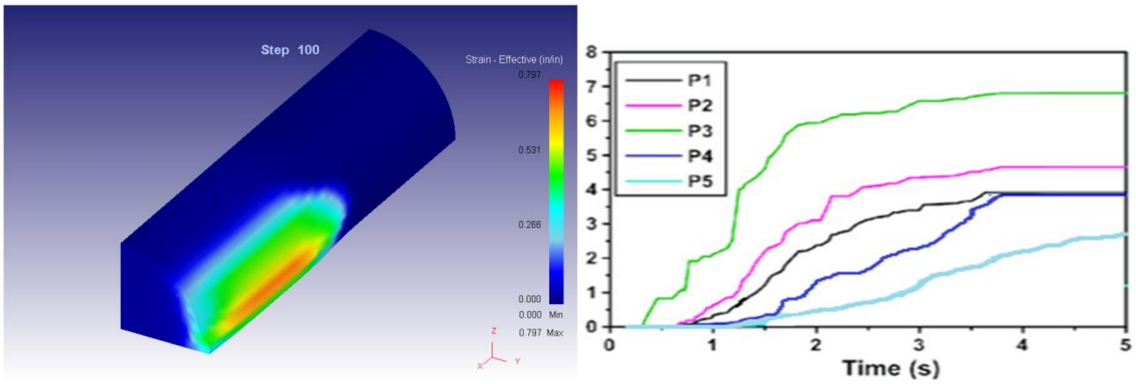

Figure 4: Variation of strain effective with respect to time at step 100

Above (Figure 4) can observed the graphical variation of strain effective at variant point with respect to time at step 50 and 100.

3.3. Variation of strain rate effective with respect to time:

Strain rate is the change in strain (deformation) of a material with respect to time. The strain rate at some point within the material measures the rate at which the distances of adjacent parcels of the material change with time in the neighborhood of that point. The effective strain rate in an element is dependent not only on the rate of loading but also such factors as the shape and dimensions of your specimen.

The Figure 5 and Figure 6 shows the variations in strain rate effective recorded at five variant points at which the simulations of the rolling process were performed at step 50 and 100. The maximum strain rate effective value recorded is 42.2 at step 50 and 41.1 at step 100. Another conclusion is that effective rate stress increases with increase in roller diameter.

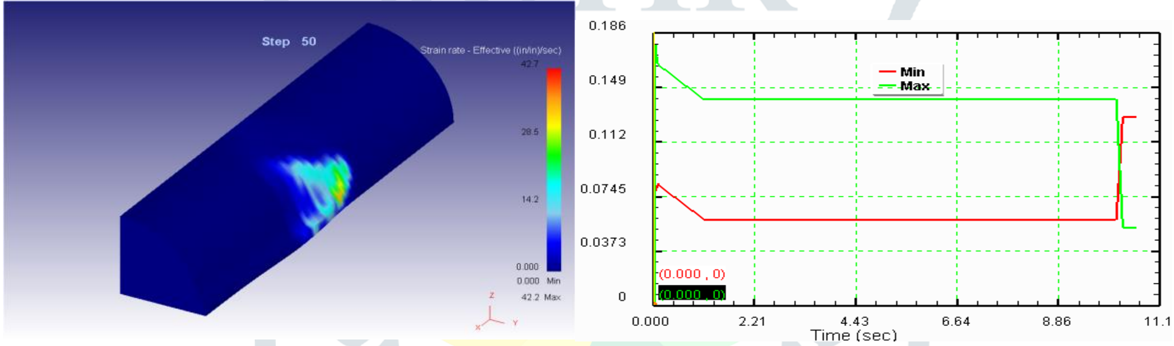

Figure 5: Variation of strain rate effective with respect to time at step 50

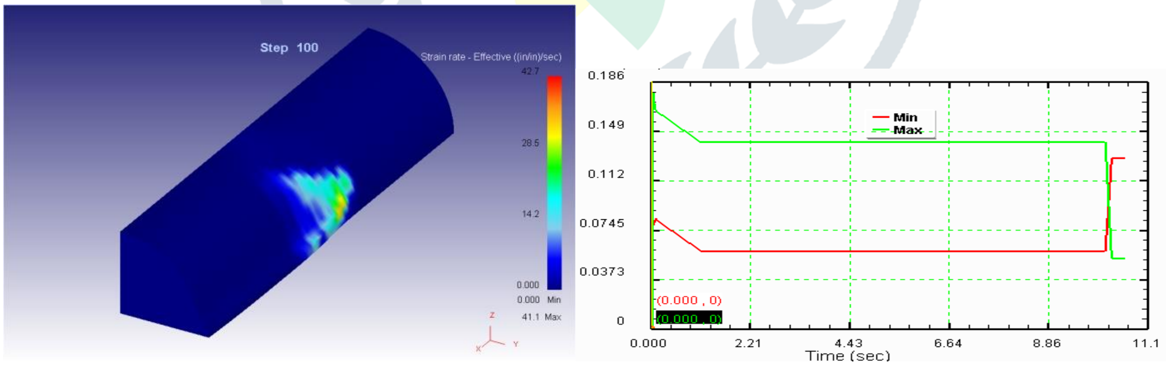

Figure 6: Variation of strain rate effective with respect to time at step 100

Above we can see the graphical variation of strain rate effective at variant point with respect to time at step 50 and 100.

3.4. Variation of temperature with respect to time:

The Figure 7 and Figure 8 shows the variations in temperature recorded at five variant points at which the simulations of the rolling process were performed at step 50 and 100. The minimum temperature recorded is 165 F and maximum temperature is 499 F at step 50 and the minimum and maximum temperature at step 100 is recorded as 170 and 505 respectively. Here we can see the graphical variation of temperature at variant point with respect to time at step 50 and 100.

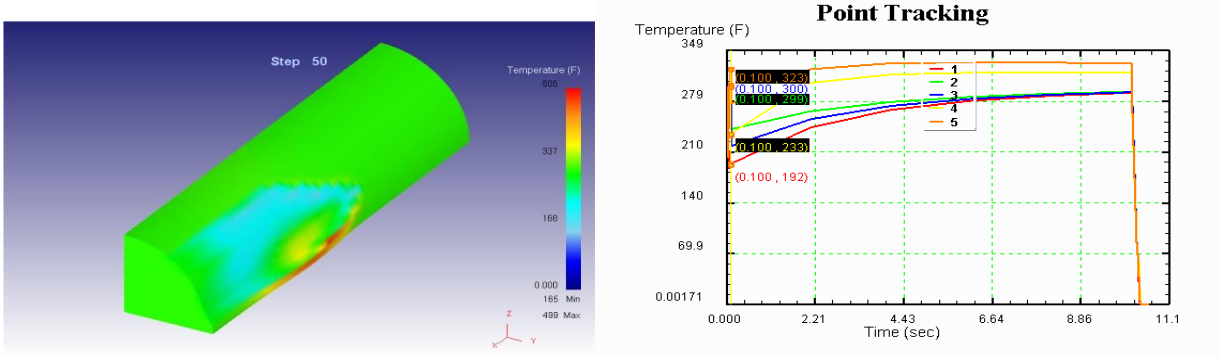

Figure 7: Variation of temperature with respect to time at step 50

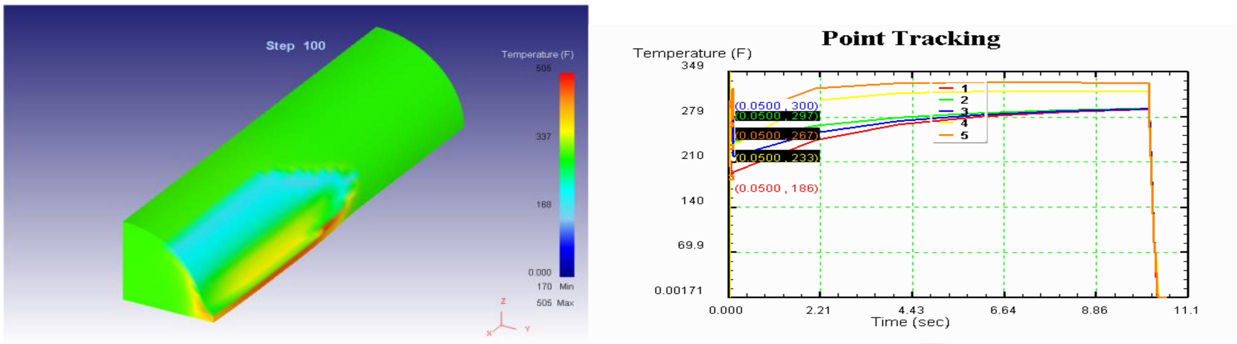

Figure8: Variation of temperature with respect to time at step 100

3.5. Variation of stress effective with respect to time:

Effective stress is defined as that stress which when reaches critical value, yielding can commence.

The Figure 9 and 10 shows the variations stress effective recorded at five points at which the simulations of the rolling process were performed at step 50 and 100. The maximum stress effective value recorded at step 50 and 100 are 140 and 139 respectively. There is a conclusion too as effective stress increases with increase in roller diameter and speed. Here we can see the graphical variation of stress effective at variant point with respect to time at step 50 and 100.

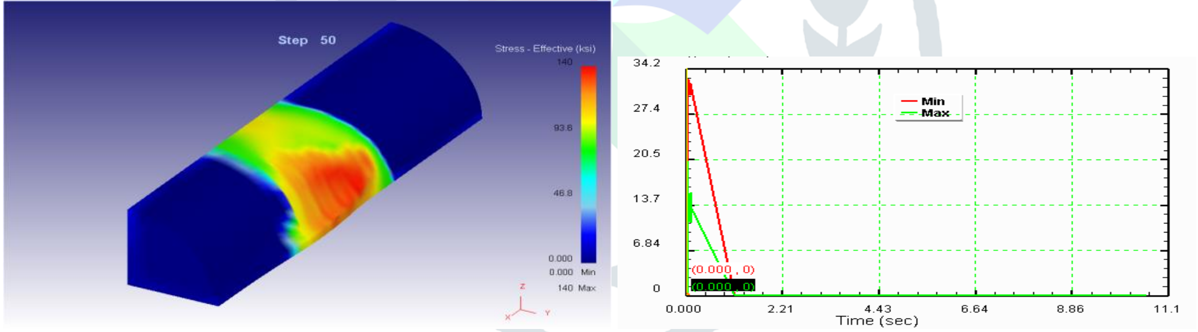

Figure 9: Variation of stress effective with respect to time at step 50

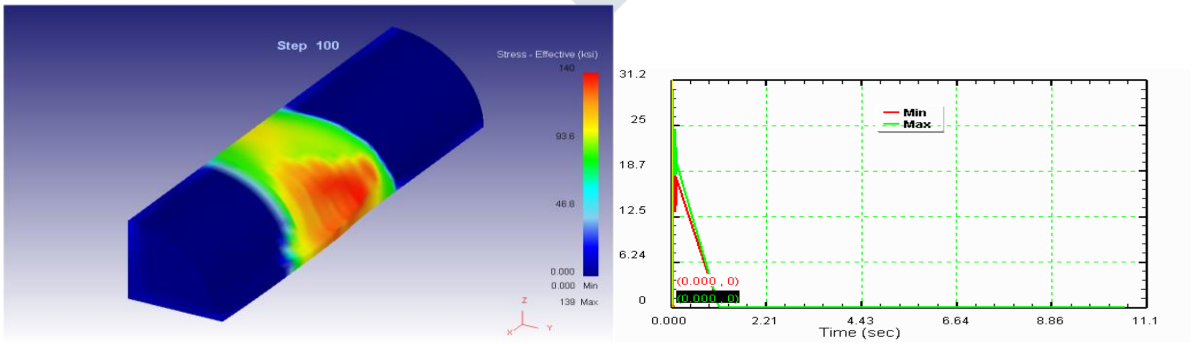

Figure 10: Variation of stress effective with respect to time at step 100

3.6. Variation of stress-max principal with respect to time:

The maximum value of normal stress is known as major principal stress and minimum value of normal stress is known as minor principal stress. The Figure 11 and Figure 12 shows the variations stress-max principal recorded at five variant points at which the simulations of the rolling process were performed at step 50 and 100. The maximum stress-max principal value recorded at step 50 and 100 is 178.Here we can see the graphical variation of stress-max principal at variant point with respect to time at step 50 and 100. Here we can see the graphical variation of stress-max principal at variant point with respect to time at step 50 and 100.

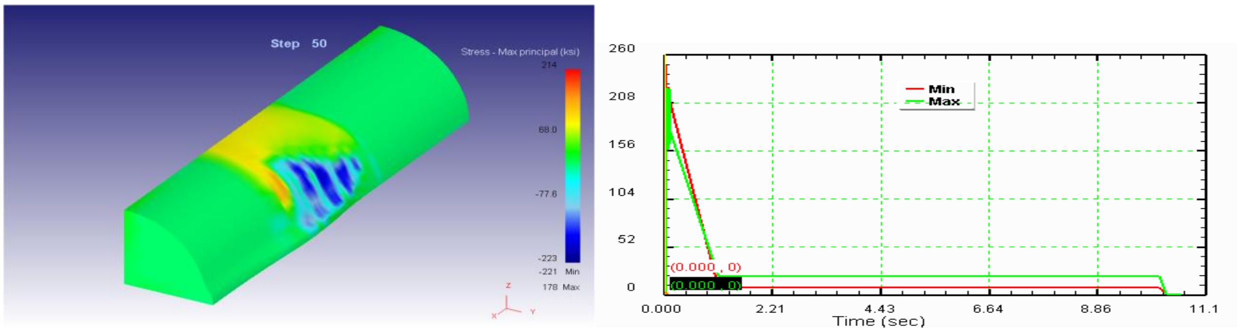

Figure 11: Variation stress-max principal with respect to time at step 50

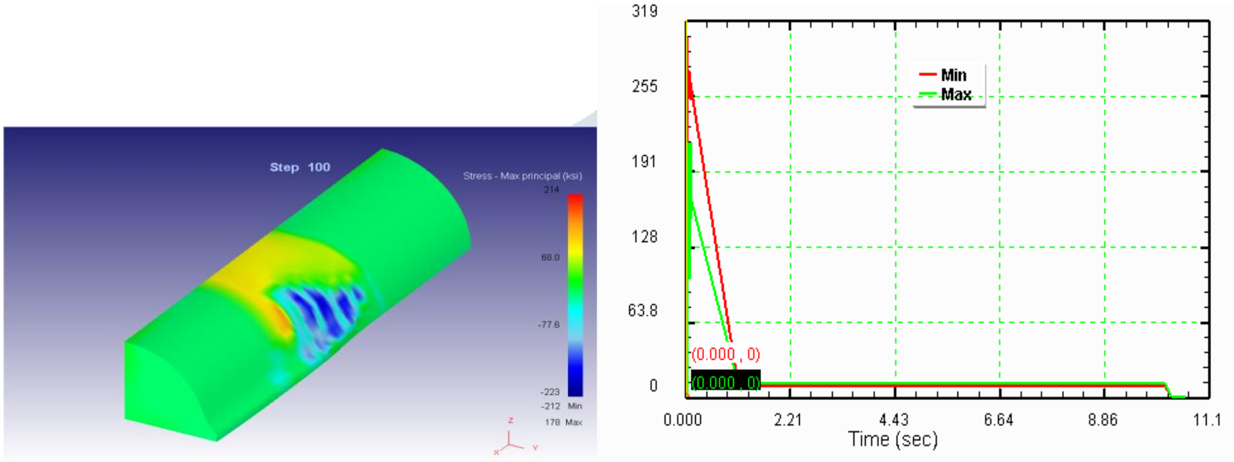

Figure 12: Variation stress-max principal with respect to time at step 100

3.7. Microstructure:

Microstructures form through a variety of different processes. Microstructures are almost always generated when a material undergoes a phase transformation brought about by changing temperature and/or pressure (e.g. a melt crystallizing to a solid on cooling). Microstructures can be created through deformation or processing of the material (i.e. rolling). Finally, microstructures can be created artificially by combining different materials to form a composite material. Here we examined microstructures through the Deform 3D software. Figure 13 shows the microstructure of workpiece while rolling operation performed with position of grain boundary and Figure 14 shows the grain orientation during operation.

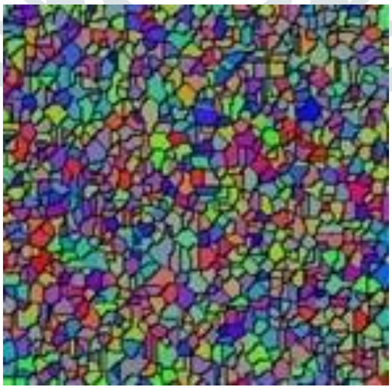

Figure 13: Grain orientation

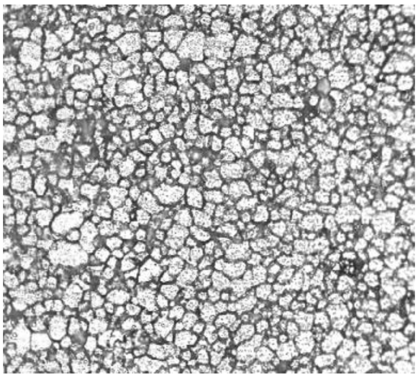

Figure 14: Grain boundary

IV.CONCLUSION

In this study, Coconut shell ash (CSA) is an agricultural waste and is produced in abundance globally, poses risk to health as well as environment. Hence we have taken Aluminium (Al) - coconut shell ash (CSA) in which CSA acts as a low cost reinforcement in Aluminium Metal Matrix Composites (MMCs). We have performed rolling operation using DEFORM 3D software to know the behavior of materials at elevated conditions. The Al- Coconut shell ash (CSA) composites have been subjected to rolling is analyzed in this software to know phase transformation and Microstructural changes at ambient conditions. After the simulation of Al-CSA, we have observed that the strength of Al-CSA is more when compared to the Al metal as the damage value of Al-CSA is less in comparison to the Al metal. Hence this can be preferable for the automotive. Other parameters such as strain rate, effective strain, effective stress, etc. have also been observed in the post processor of the simulation process. We have even observed the microstructures of Al-CSA in rolling operation.

V.REFERENCES

[1]. Ahmad, A., Lajis, M. A., Shamsudin, S. and Yusuf, N. K. (2018) ‘Conjectured the behaviour of a recycled metal matrix composite (MMC-AlR) developed through hot press forging by means of 3D FEM simulation’, *Materials*, 11(6). doi: 10.3390/ma11060958.

[2]. Hemanth, T. S., Arunkumar, Y. and Srinath., M. S. (2018) ‘Optimize the Rolling Process Parameters for Material AA1100 using Metal Forming Simulation’, *MATEC Web of Conferences*, 144, p. 03005. doi: 10.1051/matecconf/201714403005.

[3]. Poláková, I. and Zemko, M. (2012) ‘Fem Simulation of Strips Cold Rolling in Deform 3D’, *Recent Trends in Strctural Materials*, 21, pp. 1–6.

[4]. Rallabandi, S. R. and Srinivasa Rao, G. (2019) ‘Assessment of Tribological Performance of Al-Coconut Shell Ash Particulate—MMCs using Grey-Fuzzy Approach’, *Journal of The Institution of Engineers (India): Series C*. Springer India, 100(1), pp. 13–22. doi: 10.1007/s40032-017-0388-4.

[5]. Sankara Raju, R. S., Panigrahi, M. K., Ganguly, R. I. and Srinivasa Rao, G. (2018) ‘Optimization of tribological behaviour on Al- coconut shell ash composite at elevated temperature’, *IOP Conference Series: Materials Science and Engineering*, 314, p. 012009. doi: 10.1088/1757-899X/314/1/012009.

[6]. Sankara Raju, R. S., Panigrahi, M. K., Ganguly, R. I. and Srinivasa Rao, G. (2019) ‘Tribological behaviour of Al-1100-coconut shell ash (CSA) composite at elevated temperature’, *Tribology International*. Elsevier Ltd, 129, pp. 55–66. doi: 10.1016/j.triboint.2018.08.011.

[7]. Siva Sankar Raju, R., Srinivasa Rao, G. and Muralidhara rao, M. (2015) ‘Optimization of Machinability Properties on Aluminium Metal Matrix Composite Prepared By In- Situ Ceramic Mixture Using Coconut Shell Ash - Taguchi Approach’, *International Journal of Conceptions on Mechanical and Civil Engineering*, 3(2), pp. 17–21.

[8]. Siva Sankara Raju, R., Panigrahi, M. K., Ganguly, R. I. and Srinivasa Rao, G. (2017) ‘Investigation of Tribological Behavior of a Novel Hybrid Composite Prepared with Al-Coconut Shell Ash Mixed with Graphite’, *Metallurgical and Materials Transactions A*. Springer US, 48(8), pp. 3892–3903. doi: 10.1007/s11661-017-4139-1.

[9]. Siva Sankara Raju, Srinivasa Rao, G. and Samantra, C. (2019) ‘Wear behavioral assessment of Al-CSAp-MMCs using grey-fuzzy approach’, *Measurement*. Elsevier Ltd, 140, pp. 254–268. doi: 10.1016/j.measurement.2019.04.004.

[10]. Thimothy, P., Ch., R. and Siva Sankara Raju, R. (2018) ‘ASSESSMENT OF TRIBOLOGICAL PERFORMANCE OF AL/CSA COMPOSITES USING RSM’, *International Journal of Mechanical Engineering and Technology (IJMET)*, 9(13), pp. 442–451. Available at: http://www.iaeme.com/MasterAdmin/UploadFolder/IJMET_09_13_046/IJMET_09_13_046.pdf.

[11]. Zeng, B., Wu, J. and Zhang, H. H. (2011) ‘Numerical simulation of multi-pass rolling force and temperature field of plate steel during hot rolling’, *Journal of Shanghai Jiaotong University (Science)*, 16(2), pp. 141–144. doi: 10.1007/s12204-011-1109-4.