Abhay Anil, et. al. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 10, Issue 8, (Series-I) August 2020, pp. 10-16

RESEARCH ARTICLE OPEN ACCESS

Influence of Sliding Velocity on AISI H13 using DEFORM 3D

Abhay Anil*, Akshay V M*, Allen Mathews Chandy*, Bharat Nair*,
Sam Joshy**
** Student (Department of Mechanical Engineering, SCMS School of Engineering and Technology, Kochi, Kerala, India*
***Assistant Professor (Department of Mechanical Engineering, SCMS School of Engineering and Technology, Kochi, Kerala, India*

ABSTRACT
Forging is classified as a manufacturing process for shaping metals using compressive forces through methods like hammering or rolling. Forging provides a consistent delivery of quality which is essential in a manufacturing process. A good forging is defined by aligned grain flow pattern and a sound metal flow. Even though high-quality products are obtained through the process of forging, there are some defects likely to happen if not done with at most care. Forging as a process is vulnerable to various manufacturing anomalies such as variation in billet geometry, billet temperature, material properties, Sliding velocity, work piece and forging equipment positional error. The effect of important machining variables on performance characteristics and the influence of initial die temperature on die stress in hot forging process are focused mainly in this work. ONSHAPE was used to prepare the 3D model of the die. The die stress analysis is done on the finite element software Deform 3D. There are a lot of imperfections that can be considered as defects in a forging process right from the starting materials to the ones due to the forging processes or by post forging operations. The die stress analysis helps us detect most of the defects and eliminate them. The results obtained will be useful in understanding the material properties better and thus reduce the defects which are generally seen during the process.

***Keywords* -** DEFORM 3D, Die Stress, ONSHAPE, Sliding Velocity.

Date of Submission: 18-07-2020 Date of Acceptance: 02-08-2020

I. INTRODUCTION

Forging has got a prominent position among various manufacturing technologies. Forging is a metal forming process which the required shape is obtained by the action of compressive force through the use of hammering, pressing or rolling. The art of forging dates back to at least 4000 BC, and earlier. The hot forging of metals all began in the land of Mesopotamia, between the Tigris and the Euphrates. However, the very first recorded metal, forged by fire and employed by humans was Gold and rock was used as forging hammer. In 21st century forging operation is done with hammers powered by hydraulics, compressed air, electricity. Some examples of parts produced by forging process are Crane hook, connecting rod of an IC engine, crown wheel, pinion etc. Forging process usually produces parts with superior mechanical properties and metallurgical properties with minimum wastage of material. In hot forging process, forging is carried out at a temperature above the recrystallization temperature of the billet as a result material can be deformed easily. In hot forging, die failure can be a significant portion of the overall production cost. The dies that fail must be either repaired or replaced. Forging is an expensive process where the cost of die along account to about 15%-20% of total production cost and this can go upto 30% in case of catastrophic failure[1]. In order to achieve both accuracy and complexity in a forged part, the dies must be produced with higher accuracy and tighter tolerances than the part to be forged. As a result manufacturing time and cost of die increases [2]. In hot forging operations, the die surface is subjected to sudden changes in temperature. These changes are mainly due to contact with the hot workpiece and the cooling and lubrication practices. The high pressures and sliding velocities as well as the sudden changes in temperature may induce die failure due to several mechanisms. When a die failure occurs, the die has to be repaired or replaced which can result in increase in production cost.

Some of the forging parameters such as temperature, sliding velocity, coefficient of friction, number of forging steps, geometry of raw material and die are effective in reducing production cost and increasing part quality. Various other parameters that affect the forging operation are the material characteristics like material strength, ductility, deformation rate, temperature sensitivity, frictional characteristics of the work piece, perform design, die design and die material. Almost 80% of the automobile components are made by forging and therefore there is a large competition in the forging industry. So it is important to avoid any error which can occur during the forging process. Thus it is necessary to model hot forging process to help engineers improve forging quality, avoid overlaps and internal defects, reduce forging loads, reducing the time needed to design precision forged parts and dies from machined parts, minimizing the cost and subsequent machining. Compared with trial and errors in real experiments, physical modeling is low in cost, high in efficiency and easy in operation and analyzing results. Finite Element Analysis (FEA) is a simulation of any given physical phenomenon using the Finite Element Method (FEM) numeric technique. This is used by engineers to minimize the number of physical prototypes and tests, and to refine components in their design process to produce better, faster products. The resulting stresses and temperatures are then put into a material model to predict the component's "design life". The simulations used in FEA are generated using a mesh of millions of smaller elements that combine to shape the structure being evaluated.

II. LITERATURE REVIEW

Various studies associated to simulation of forging have been published some of them related to our study is been discussed. Usage of AISI-1045 medium carbon steel has increased due to various properties like wear resistance, excellent weldability, etc. Mohanraj Murugesan, Dong Won Jung [3] studied that it has better forgeablity at a temperature of 850℃-1250℃. They evaluated and formulated the flow behavior of AISI 1045 at different temperatures and strain rates (0.05-1.0 s^{-1}) by conducting isothermal uniaxial tensile experiment. Taylan Altan, Gracious Ngaile, Gangshu Shen [4] identified the die temperature in conventional forging process ranges from 200℃-425℃. Rachapol, Iamtanomchai, Sasithon Bland[5] studied the influence of process parameters like billet temperature, friction on die wear using Finite element model of hot forging process. It was identified that the die wear was minimum at increased initial billet temperature and reduced friction. Siamak Abachi, Metin Akkok, Mustafa Ilhan Gokler[6] conducted simulation of closed die forging based on finite volume method to determine the die wear with a constant wear coefficient. Shiyuan Luo, Dahu Zhu, Dongsheng Qian, Lin Hua, Sijie Yan, Jiajun Zhang [7] studied the influence of sliding velocity in forging of TI-6AL-4V turbine blade by using IFUM friction model and also compared its effect on material flow with shear friction model and orwan friction model. The frictional stress between workpiece and the die stress drops at higher sliding velocity. Sam Joshy, K R Jayadevan, A Ramesh , D Mahipal [8] studied and compared the wear and plastic deformation by conducting forging experiments on new and remanufactured forging dies without lubrication. Wear and plastic deformation rate was found higher in remanufacturing dies compared to new one. This was due to lower core hardness in remanufacturing dies.

III. METHODLOGY

The finite element method (FEM) is the most widely used method to solve engineering problems and mathematical models. It is also referred to as finite element analysis (FEA).To solve the problem by finite element analysis; it first subdivides a large problem into smaller, simpler parts that are called finite elements. In our present study Finite element analysis software DEFORM 3D is used to analysis the forging process. DEFORM 3D software is a widely used commercial FEM program, employed both in the academia and the industry; it provides validated, detailed information about heat flow, temperatures, stresses, tool life, and surface characteristics for machining processes. DEFORM 3D is a powerful simulation software designed to analyze the three dimensional flow in the complex metal foaming process and metal cutting problems. DEFORM 3D mainly consists of three processes

- Pre-processor-input process parameters are given in pre-processor.
- Simulation engines- according to input parameters numerical calculations are performed for analysis.
- Post processor – used to view and extract the results.

3.1 OBJECT DESCRIPTION

Top die, workpiece and bottom die has been modeled by a 3D modeling software ONSHAPE and these solid model are then saved in .stl format. The material selected for the workpiece is AISI 1045 medium steel billet with diameter 40 mm and height of 20mm and the properties of AISI 1045 medium steel available in software database was made to use and the material selected for top and bottom die is AISI H-13 with diameter 40 mm and height 70 mm and the properties of AISI H-13 available in software database was made into use.

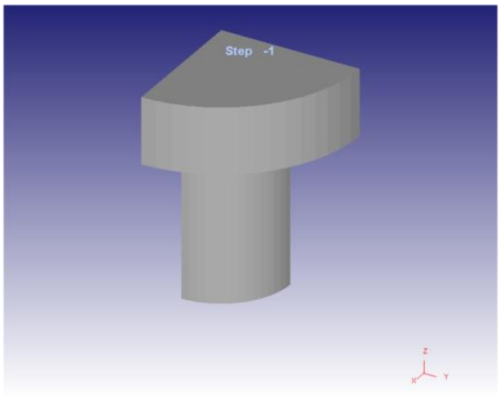

Fig.1. Top Die

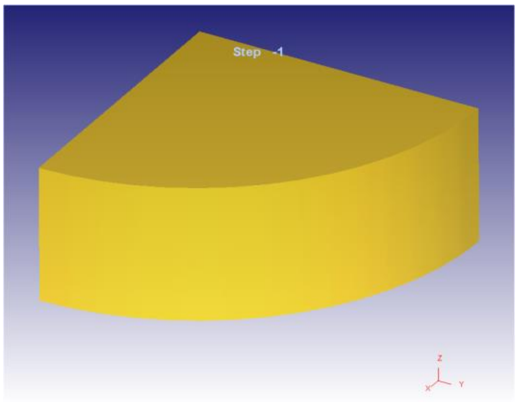

Fig.2. Workpiece

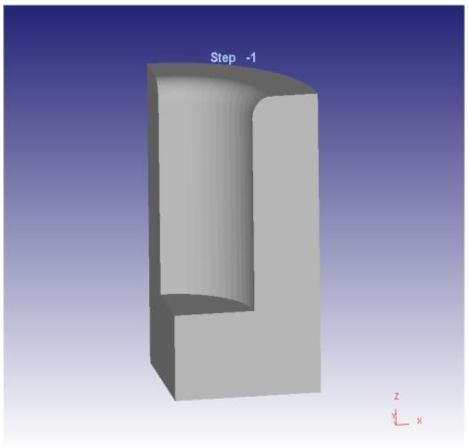

Fig.3. Bottom Die

TABLE.1. Process Parameters

Billet length	20mm
Billet diameter	40 mm
Billet temperature	1200℃
Die temperature	150℃
Die speed	0.2mm/s,0.5mm/s,1mm/s,1mm/s.5mm/s,2mm/s
Friction	0.7
No. of mesh element	17720
Average strain rate	$1s^{-1}$

1.2 PRE-PROCESSOR

In pre-processor is used to input various process parameters like temperature of billet and die, sliding velocity, boundary conditions, simulation control, inter-object relations etc. Modeling of top die, bottom die and workpiece was done by the 3D modeling software ONSHAPE and these solid models are imported to DEFORM 3D in .stl format for analysis. The workpiece is chosen as plastic and the top and bottom die were chosen as rigid object. 17720 tetrahedron elements and 3490 nodes internal mesh were generated for billet.

1.2.1 PROCESS PARAMETERS

Analysis was carried out for five different sliding velocity 0.2mm/sec, 0.5mm/sec, 1mm/sec, 1.5mm/sec, 2mm/sec and the temperature of top die was kept at 150℃and that of workpiece was kept constant at 1200℃ at a constant strain rate of 1 s^{-1}. Most of the conventional forging process takes place at this temperature .Inter object relations have been defined where the top die is defined as master die and workpiece is defined as slave object .In our study coefficient of friction between die and workpiece was selected as 0.7.The movement of top die was restricted only in –Y direction. There was no movement of bottom die and workpiece and a total of 10 forging steps were chosen and the stopping distance between top and bottom die is 10mm.

1.3 SIMULATION ENGINE

The simulation engine performs various numerical calculations which are required to analyze the process and modify the database files. The simulation engine first reads the database file coming from pre-processor and performs the various numerical calculations to solve the problem. Simulation engine will run until it satisfies the stopping criteria which are given in preprocessor are met. Postprocessor is used to extract the results after completing simulation.

1.4 POST-PROCESSOR

The post processor is used to display and extract data from the results of the simulation in the Database file. All results steps that were saved by the simulation engine are available in the postprocessor. We can obtain stress, strain, final geometry of the object from the post processor and Graphs of the different parameters and steps in the process of forming. Data's available from the post processor includes:

- In vector plots displacement and velocity vectors indicate magnitude and direction of displacement or velocity for every node at each step throughout the process.
- Graphs of key variables, such as press key pads, volumes, and point tracked state variables.
- Deformed geometry, including tool movements and deformed mesh at each saved step Point tracking to show how material moves and plots of state variables at these points.

1.5 DIE STRESS ANALYSIS

Die stress analysis of the generated database was done for step 10 by keeping the work piece as rigid and the top and bottom dies as elastic and the material chosen for dies were AISI H13 and a new database for die stress analysis was generated and it was made to run. After that the post processor is used to view and extract data like stress-effective, stress mean, at different points on dies were analyzed. This is done for 5 different sliding velocities (0.2mm/sec, 0.5mm/sec, 1mm/sec, 1.5mm/sec and 2mm/sec) of die and the corresponding die stress is analyzed.

IV. RESULT AND DISCUSSION

The simulation results of finite element analysis are obtained from the DEFORM 3D post-processor. The change in stress distribution during the forging process for 5 sliding velocities can be illustrated by taking four points on the deformed top die as shown in Fig. 4 to Fig. 8**.** From this analysis, it has been shown that the deformation was not uniformly distributed across the die, with the edge surface experiencing higher deformations and high stress as shown in fig 4- fig 8.

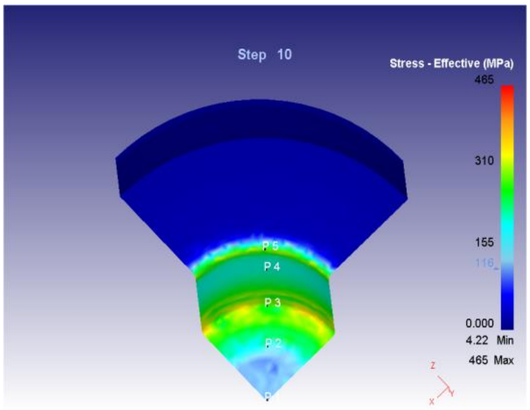

Fig.4. Effective stress at sliding velocity 0.2mm/sec.

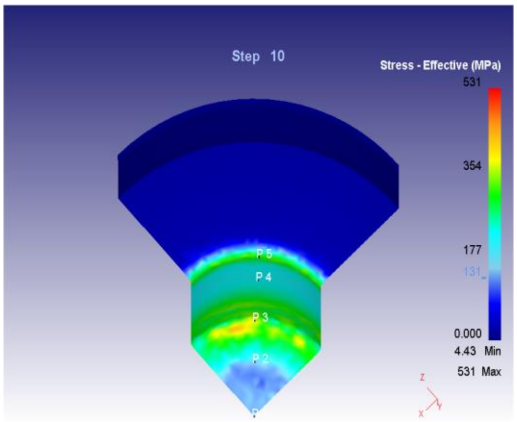

Fig.5. Effective stress at sliding velocity at 0.5mm/sec.

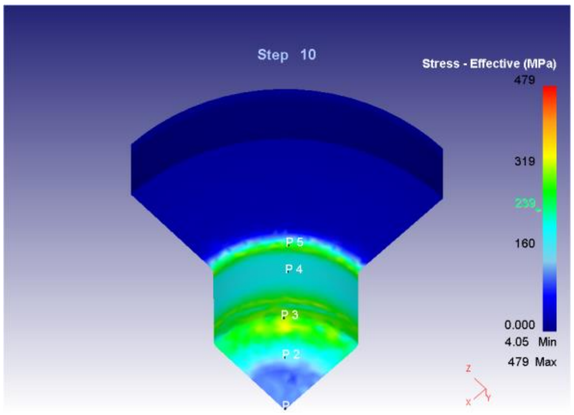

Fig. 6. Effective stress at sliding velocity 1mm/sec.

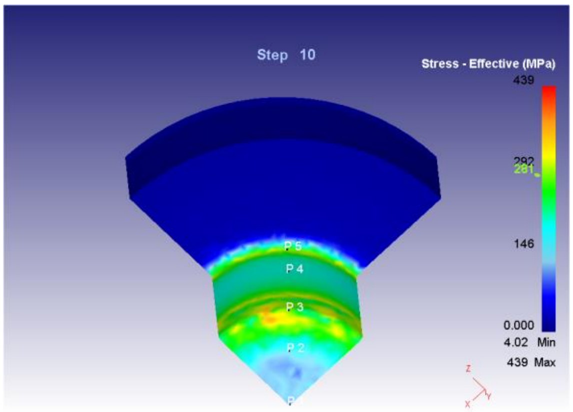

Fig.7. Effective stress at sliding velocity 1.5mm/sec.

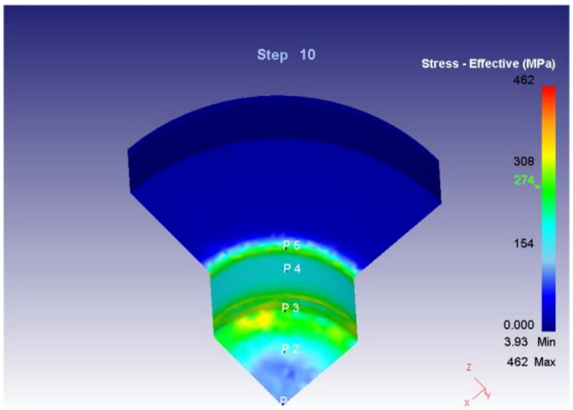

Fig. 8. Effective stress at sliding velocity 2mm/sec.

The graph between effective stress vs sliding velocity for 0.2 mm/sec, 0.5 mm/sec , 1 mm/sec, 1.5 mm/sec, 2 mm/sec is shown in fig.7 – fig.11.

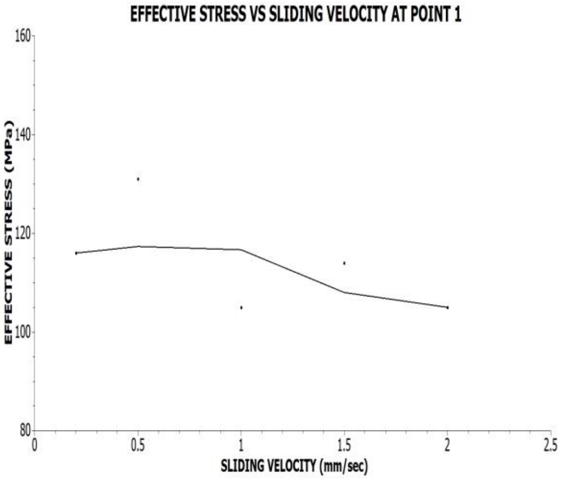

Fig. 9. Effective stress vs sliding velocity at Point 1

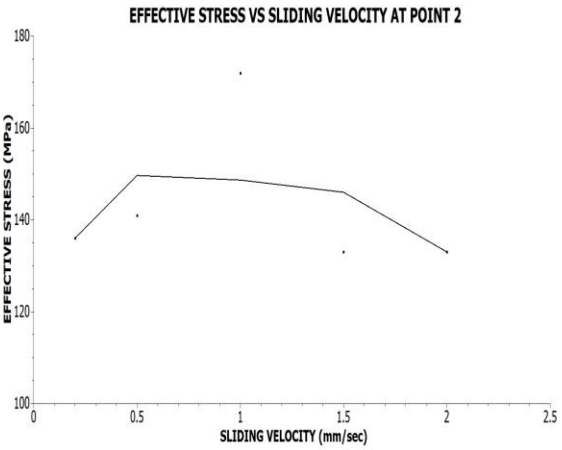

Fig.10.Effective stress vs sliding velocity at point 2

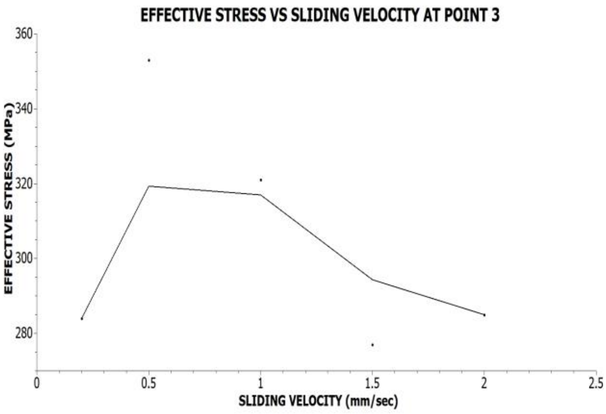

Fig.11. Effective stress vs sliding velocity at point 3

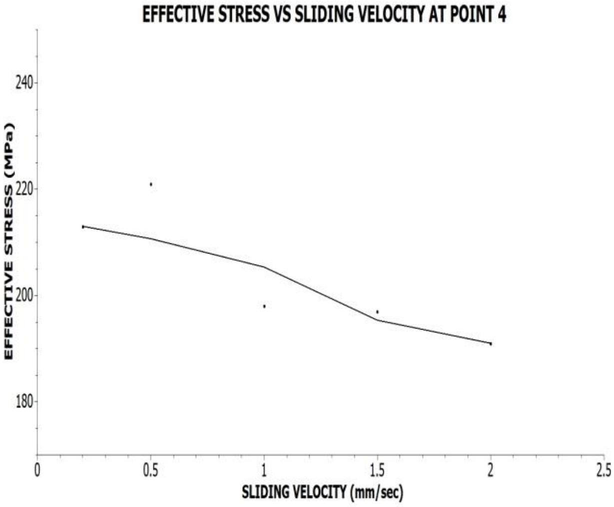

Fig.12. Effective stress vs sliding velocity at point 4

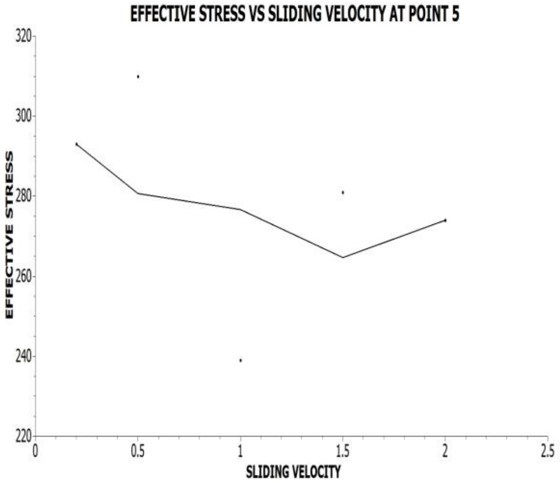

Fig.13.Effective stress vs sliding velocity at point 5

The temperature used to analyze the variations of effective stress with respect to sliding velocity is taken as 150℃ since it is the lowest temperature we considered and it is very much close to the optimum temperature. Here we have taken 5 sliding velocities ranging from 0.2mm/sec to 2mm/sec.

At point 1, we can see that at lower sliding velocity, that is 0.2mm/sec, the effective stress is high and when the sliding velocity is increased to 1mm/sec, we can see only a slight variation but when the sliding is increased to 1.5mm/sec, we can see a decrease in the effective stress value and it again decreases when the sliding velocity is increased to 2mm/sec. The most sudden change in the change in the effective stress value is seen when the sliding velocity value is varied from 1mm/sec to 1.5mm/sec. At point 1, the least effective stress value is developed at sliding velocity 2mm/sec.

At point 2, we came across more variations to the effective stress value with change in sliding velocity. The value of effective stress is seen to be the lowest at sliding velocity 0.2mm/sec and effective stress showed an increasing nature upto a sliding velocity value of 0.5mm/sec. The value of effective stress remained almost the same when the sliding velocity value was increased upto 1.5mm/sec. But the value of effective stress showed a sudden decrease when the sliding velocity was increased from 0.5mm/sec to 2mm/sec. From the graph, we concluded that the optimum value of sliding velocity for point 2 was 0.2mm/sec.

At point 3, we are able to see drastic changes in the values of effective stress with change in sliding velocity. The value of effective stress is very less at lower a sliding velocity, which is 0.2mm/sec. As the sliding velocity value increases upto 0.5mm/sec, we can see a sudden increase in the value of effective stress. Then the sliding velocity value almost remains the same upto sliding velocity of 1mm/sec. The value of effective stress shows a sudden dip in its value when the sliding velocity is increased to 1.5mm/sec. Then also we can see a decreasing nature when the sliding velocity is increased upto 2mm/sec. The large variations in the effective stress value at point 3 is because this point is one of the corners and therefore more stress is induced at this point and therefore stress variations also occur. From the graph, we concluded that the optimum value of sliding velocity for this point is 0.2mm/sec which is very much clear from the lower effective stress value shown in the graph.

At point 4, we are able to see completely a decreasing value of effective stress with increase in sliding velocity. When the sliding velocity is increased from 0.2mm/sec to 1mm/sec, we can see a slight decrease in the value of effective stress. When the sliding again is increased upto 1.5mm/sec, the rate in which effective stress decreased increased. Furthermore increase in the value of sliding velocity yet again showed a decrease in the effective stress but in a slower rate. From the graph we concluded that sliding velocity 2mm/sec is the optimum sliding velocity for this point since it showed the lowest effective stress developed.

At point 5, the pattern in which effective stress varies with change in sliding velocity varies from other points. Upto sliding velocity of 0.5mm/sec, we can see a decrease in the value of effective stress. As the sliding velocity is again increased upto 1mm/sec, we can see that the effective stress almost remains the same. Then the effective stress again shows a decreasing nature when the sliding velocity is increased to 2mm/sec. But the nature in which the effective stress value varies with change in sliding velocity varies when the sliding velocity is increased to 2.5mm/sec, as the effective stress also shows an increasing trend which is clear from the graph. Point 5 is also a corner point and therefore a lot of effective stress is produced and therefore a lot of stress variations also occur. From the graph it was also concluded that the effective stress showed the least value for sliding velocity of 1.5mm/sec and therefore it was identified as the optimum sliding velocity for point 5.

From all the graphs, we came to a general conclusion by considering different factors that the effective stress shows an optimum value when the sliding velocity is 0.2mm/sec.

V. CONCLUSION

We were able to conclude our project by finding an optimum sliding velocity value from a range of sliding velocities By taking optimum sliding velocity value we were able to reduce the effective stress developed to some extent. From all the graphs, we found that the effective stress shows an optimum value when the sliding velocity is 0.2mm/sec.

REFERENCES

[1]. Podgrajsek M, Glodez S and Ren Z: Failure Analysis of forging die insert protected with diffusion layer and PVD coating. Surf. Coat. Technol. 276 521–8(2015) .
[2]. Dahl, C., Vazquez, V., Altan, T.: Effect of Process Parameters on Die Life and Die Failure in Precision Forging. Engineering Research Center for Net Shape Manufacturing, PF/ERC/NSM-98-R-15 (1998).
[3]. Mohanraj Murugesan, Dong WonJung: Two Flow stress models for describing hot deformation behavior of AISI-1045 medium carbon steel at elevated temperatures. Heliyon Volume 5, Issue 4,E01347,(2019).
[4]. Taylan Altan , Gracious Ngaile, Gangshu Shen: Cold and Hot Forging: Fundamentals and Applications, Volume 1, ASM international, ohio (2005).
[5]. Rachapol Iamtanomchai, Sasithon Bland: Study of Wear and Life Enhancement of Hot Forging Dies Using Finite Element Analysis, Proceedings of the World Congress on Engineering 2015 Vol II WCE 2015, July 1 - 3, 2015, London, U.K.
[6]. Siamak Abachi, Metin Akkok,Mustafa Ilhan Gokler: Wear analysis of hot forging dies, Tribology International 43, 467–473 (2010)
[7]. Shiyuan Luo, Dahu Zhu, Dongsheng Qian, Lin Hua,Sijie Yan Jiajun Zhang: Effects of friction model on forging process of Ti-6Al-4V turbine blade considering the influence of sliding velocity, The International Journal of Advanced Manufacturing Technology (82) (2016).
[8]. Sam Joshy, K R Jayadevan, A Ramesh , D Mahipal:Influence of in-service thermal softening on wear and plastic deformation in remanufactured hot forging dies, Eng. Res. Express 1 (2019).

Abhay Anil, et. al. “Influence of Sliding Velocity on AISI H13 using DEFORM 3D.” *International Journal of Engineering Research and Applications (IJERA)*, vol.10 (08), 2020, pp 10-16.