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Preform design for near net shape close die gear forging using simulation technique

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ABSTRACT

In this study, attempts have been made to design preform for near net shape upsetting of gear forging using simulation techniques which is based on the filling of the material during closed die forging. Four types of preforms were tried. Using this parametric study, best die and process parameters are suggested for near net shape gear forging. In present scenario when there are a lot of emphases on accurate design in short span of time. Such study has a lot of industrial value.

Key-words: Preform; Forging; Simulation; Stress; Metal forming.

INTRODUCTION

In metal forming process, net shape forging can be defined as the process of forging components to final dimensions with no post forging machining necessary. Near-net shape forged components, on the other hand, are forged as close as possible to the final dimensions of the desired part, with little machining or only grinding after forging and heat treatment. Automotive industry is the main customer of net shape forging companies. Today's market is characterized by requirements for short delivery times, low costs and high quality. The supplier is confronted with smaller production and delivery batch sizes and an increasing type variation of part types. Automobile producers are more and more interested in parts which need minimal machining or are ready to assemble. Net shape cold forging parts can fulfill these requirements [1]. The preform design used in net shape forging processes is an important aspect for improving product quality and decreasing production cost. In the past, preform design was accomplished by empirical design, approximate analysis and trial-and-error. This task is now supported by the finite-element method and the backward tracing scheme [2]. Preform is material part that has undergone preliminary shaping but is not yet in its final form. In preform all process parameter and part geometry is defined in advance by which near net shape is easily found. Through the use of simulation technique, reasonably accurate and inexpensive computer software is available for simulating metal flow throughout a forging operation. Thus, forging "experiments" can be run on a computer by simulating the finish forging that would result from an "assumed" or "select" blocker design. The result can be displayed on graphics. If the simulation indicates that the selected blocker design would not fill the finisher die or that too much material would be wasted, then another blocker design can be selected and the computer simulation, can be repeated. This computer –aided simulation will reduce the required number of expensive die tryouts [3].

In the past various researches have worked on net shape forging by using simulation technique suc Guoqun Zhao et. al. [4] used the rigid viscoplastic finite element method for preform die shape design in net shape forging process. Guoqun Zhao et. al. [2] used the finite-element-based inverse die contact tracking method to design the preform die shapes of a generic turbine-disk forging process. Victor Vazquez et. al. [5] dealt with the preform design for flashless forging of a connecting rod and introduced a new tooling concept for forging of complex parts with a controlled amount of flash. Chitkara et al [6] presented a few salient results of an experimental investigation made into the quasi-static progressive incremental closed-die forging of crown gear forms starting initially from both solid and hollow circular cylindrical specimens made of tellurium lead as the model material. Ou et. al. [7] achieved the net shape forging of aerofoil components. Domblesky Joseph et al [8] gave results of an investigation using friction-welded preforms for bulk forming. Behrens et. al. [9] presented precision forging technologies for a gear wheel and a crankshaft consist of multistage processes including preforming operations and a final forging. Lu et. al. [10] reported on work in developing a finite element based die shape optimisation for net-shape forging of 3D aerofoil blades for aeroengine applications.

On the basis of these research papers on net shape forging and simulation technique, it is observed that they deal with different component such as air foil, helical shape gear, warm gear. The purpose of this research is to design the preform to find out the near net shape of gear which has internal and external teeth with collar to be manufactured in single step. For this, computer simulation of gear forging have been attempted parametrical and best preform is selected.

Problem description

In this study, close die forging of a gear has been carried out. Various views of the gear is shown in Fig: 1, 2 and 3. This selected gear component has internal and external teeth with collar. The aim of this study is find out preform near net shape of gear component . To achived this goal following four type of preforms are considered.:

Case 1: Equal top and bottom length preform
Case 2: Incresed bottom length preform
Case 3: Flared shape preform
Case 4: Collar shape preform

CAD Modelling of die and punch

CAD Models of die and punch has been made with help of mearge and cutout feature in assembly modelling on ProE software [11]. The die and punch is shown in Fig. 4, 5 &6. In cut section of the die, die cavity is shown in Fig.5. For net shape upsetting of gear it is necessary that the die cavity should be completely filled. After making the CAD model of die and punch, the different preforms are made and assembled in between of die and punch. Assembled model is shown in Fig: 7.This assembled model is sent to Simufact software [12] for forging simulation.

Material and processing parameters

Material for preform and die are adopted from library of Simufact software. Following material and their properties are considered.

(a) Material of preform=DBAA_2024

Elastic young modulus = 7.24×10^4 MPa

Passion ratio = 0.33

Density =2780kg/m^3

Minimun yield stress =188 MPa

Yield canstant = 38.68 MPa

Strain hard exp (n) = 0.154

Yield stress v/s strain plot for work pice is shown in Fig.8.

(b) Material of die=DBH13

Young modulus = 2.1×10^5 MPa

Passion ratio = 0.33

Density = 7800kg/m^3

Yield stress v/s strain rate plot for die material is shown in Fig.9.

The press is of hydraulic press. Punch stroke is 0.43 m and punch velocity is 5mm/s.

RESULTS AND DISCUSSION

Simulation result for four type of preforms are describe below:

Case 1

This preform has step length of 20mm each. Outer radius of preform is 50 mm and internal hole radius for making internal teeth is 20mm (Fig.10). After simulation it has been found that maximum effective strain act on the disc is 0.646. It acts mostly at the center of the billet. At outer side of the billet the strain acts in between 0.168 and 0.258. Maximum effective stress is 362 MPa, and most of the portion lie in between of stress 217.2 and 362.0 MPa. For this perform, load stroke plot is shown in Fig.11. Maximum force has been found as 6.175MN. The transparent view after the simulation is shown in Fig.12. It can be observed that material does not enter in the die cavity due to this collar of the gear has not formed. Hence this perform is not suitable for net shape forging.

Case 2

This preform has 18 mm length of upper portion and 22 mm length of lower portion. Outer radius of preforms is 50 mm and internal hole radius for making internal teeth is 20mm. This preform is shown in Fig.13. After simulation it has been found that maximum plastic strain is 5.568 which is quite high. It acts mostly at the center and bottom of the gear billet. At the outer portion of the gear strain is in between 0.616 to 1.856. Maximum effective stress is 508.1MPa and most of the portions have stress in between 169.4 to 338.7 MPa. Load stroke plot is shown is shown in Fig.14. Maximum force is 5.455MN. The transparent view after the simulation is shown in Fig.15. It can be observed that material has not entered in the die cavity due to which collar of the gear has not formed. Hence this perform is not suitable for net shape forging.

Case 3

This preform has 22 mm length of lower portion with conical shape and 18 mm length of upper portion. Outer radius of preform is 50 mm and internal hole radius for making the internal teeth is 18 mm. This preform is shown in Fig.16. After simulation, it is found that max plastic strain is 2.192 and it act at the bottom of the billet and most of outer portion of the billet have the strain in between 0.285 to 0.132. Max stress act on the disk is 436 MPa and most of the portions lie in the stress range of 436.8-231.5 MPa. Maximum force has been found as 3.61 MN. The transparent view after the simulation is shown in Fig.18. The material has tried to enter in the die cavity and some improved result has been found but die cavity is not completely filled yet. Hence this perform is not suitable for net shape forging.

Case 4

This preform has 22 mm length of lower portion with 5 mm collar shape in the horizontal direction and 18mm length of upper portion. Outer radius of preform is 50 mm and internal hole radius for making the internal teeth is 16mm (Fig.19). After simulation it has been found that maximum plastic strain in the billet is 1.206. Outer portion of the preform have strain in the range of 0.072 to 0.157. Maximum effective stress in the preform is 398.4 MPa. Most of the portion has stress in the range of 239.0 to 398.4 MPa. The load stroke plot is shown in Fig.20. Maximum force is 2.043 MN. The transparent view after the simulation is shown in Fig.21. Die cavity is completely filled hence near net shape of gear has been achieved.

Fig.1: Front view of selected gear

Fig.2: Back view view of selected gear

Fig.3: Oblique view of selected gear component

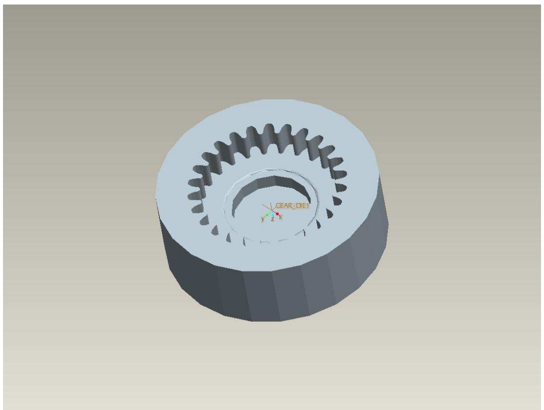

Fig.4: CAD model of Die

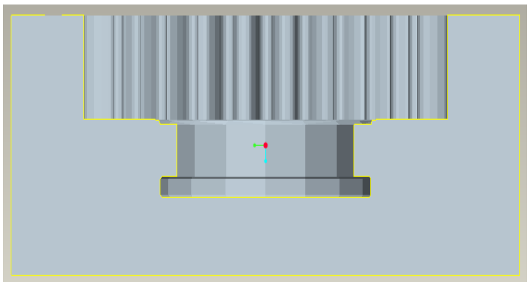

Fig.5: CAD model of half cross-section of die

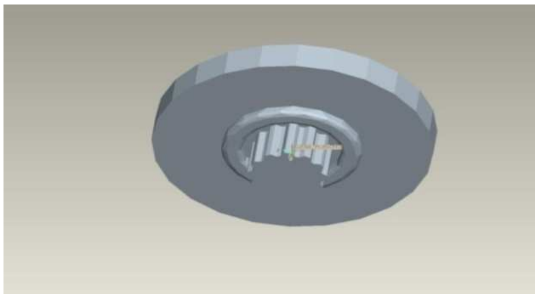

Fig.6: CAD model of punch

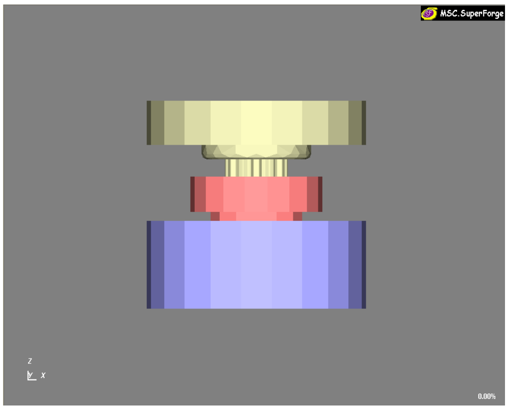

Fig.7: Assembled model die, punch and workpiece .

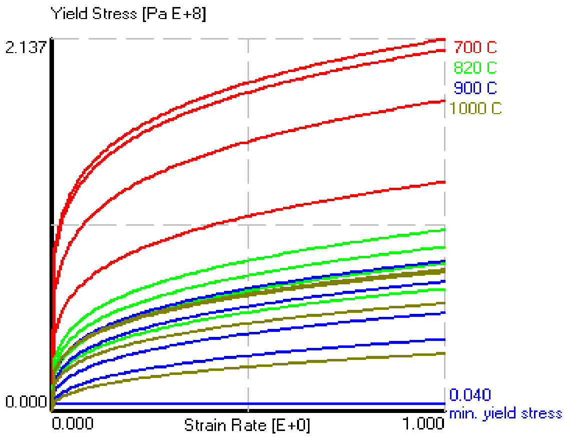

Fig.8: Graph between the yield stress and strain rate of die material

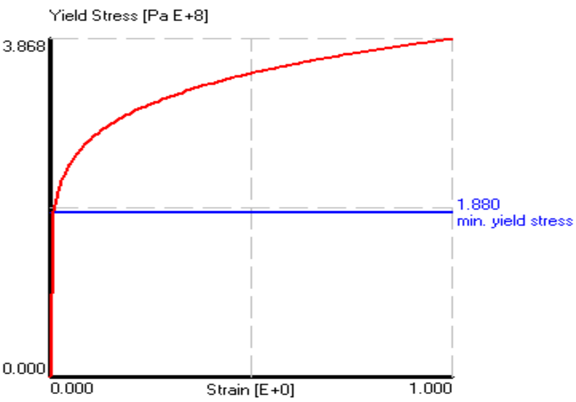

Fig.9: Graph between the yield stress

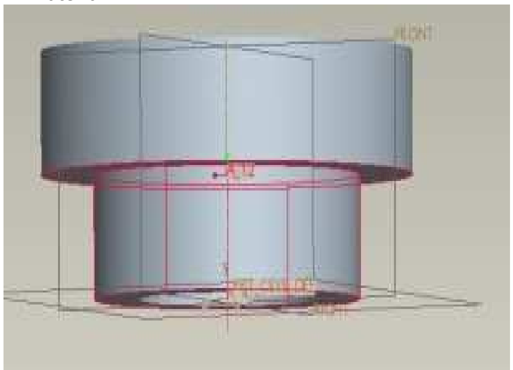

Fig.10: Preform-Case 1 and strain of workpiece material

Comparisons of the result

After finding the near net shape of the gear component, the results of all four performs have been compared. In case 1, effective plastic strain and effective stress is minimum. And in the case 2, effective plastic strain and effective stress is maximum. These are shown in Figs. 22 and 23 respectively. In case1, maximum and in case 4 minimum forces are required. This is shown in Fig. 24

Fig.11:Graph between force and stroke (Case 1)

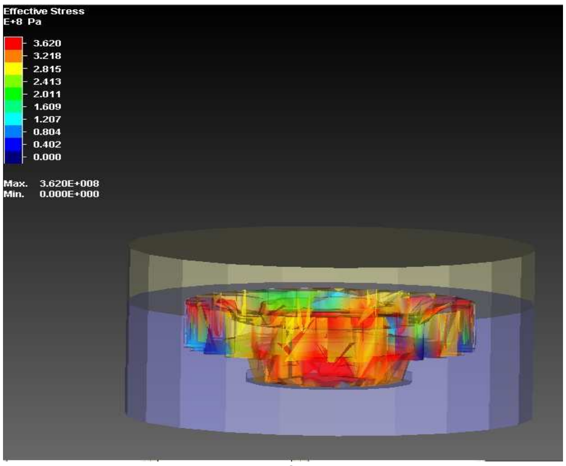

Fig.12: Transparent view after simulation (Case 1)

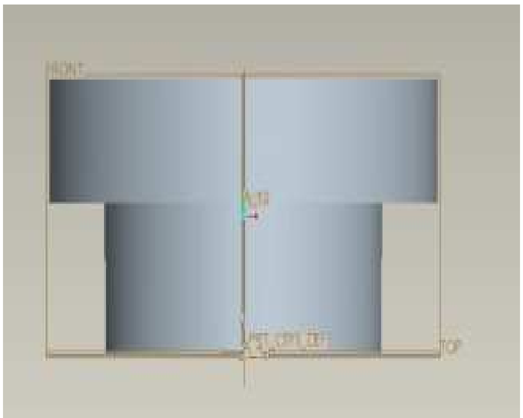

Fig.13: Preform- Case 2

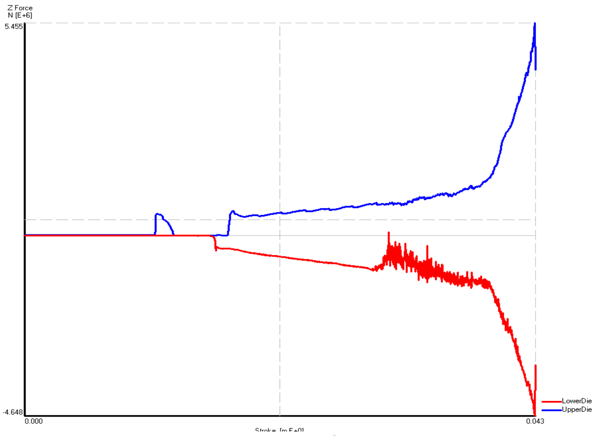

Fig:14 Graph between force and stroke (Case 2)

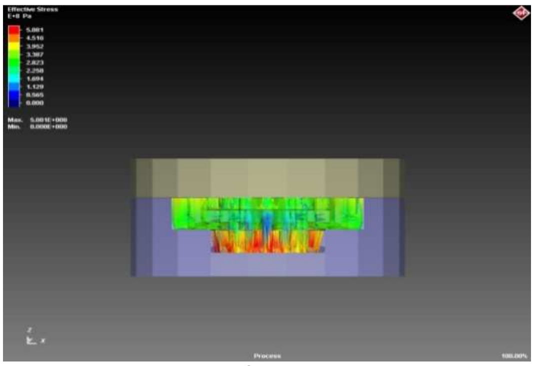

Fig.15: Transparent view after simulation (Case 2)

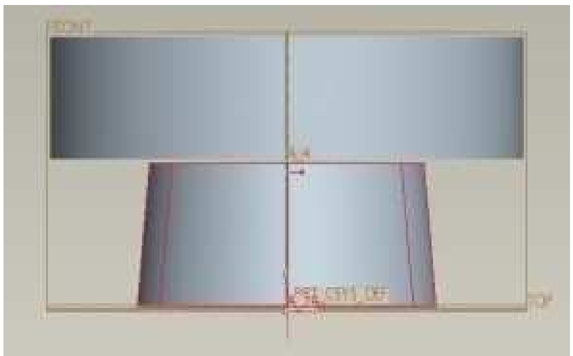

Fig.16: Preform-Case 3

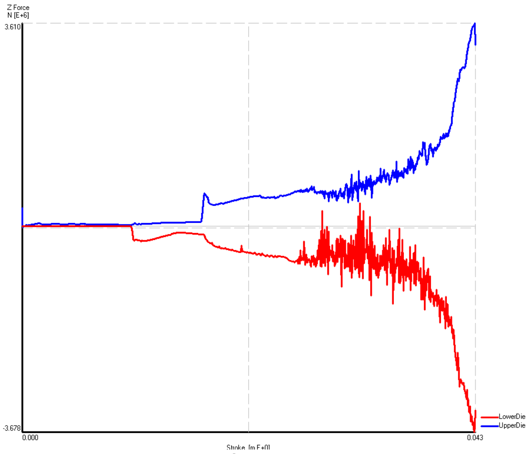

Fig.17: Graph between force and stroke (Case 3)

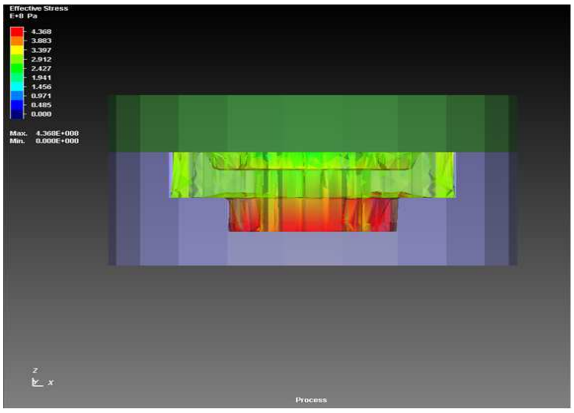

Fig.18: Transparent view after simulation (Case 3)

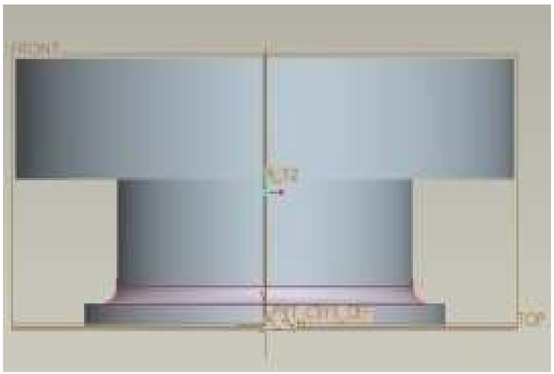

Fig. 19: Preform (Case 4)

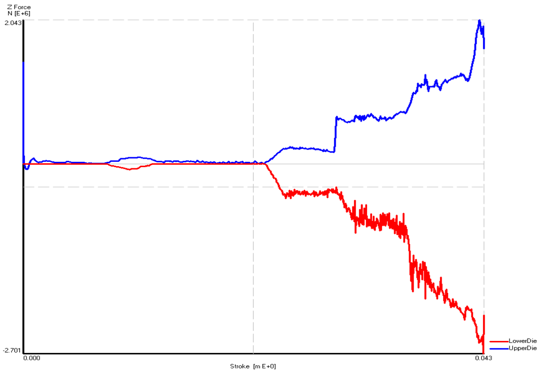

Fig.20: Graph between force and stroke (Case 4)

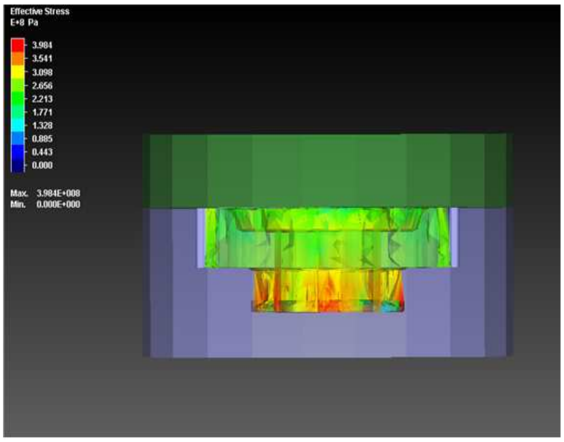

Fig.21: Transparent view after simulation (Case 4)

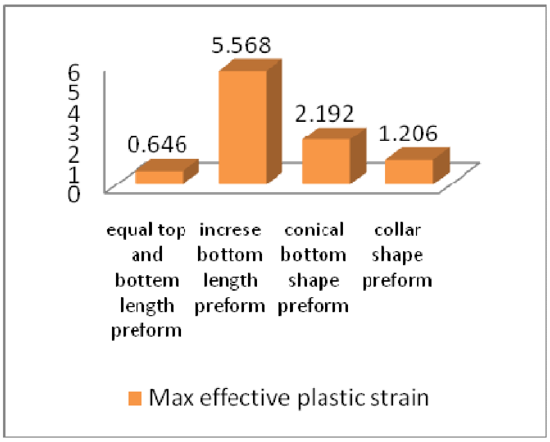

Fig.22: Comparison of max effective plastic strain

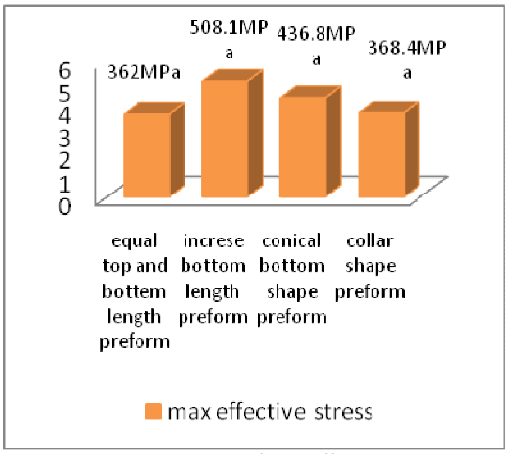

Fig.23: Comparison of max effective stress

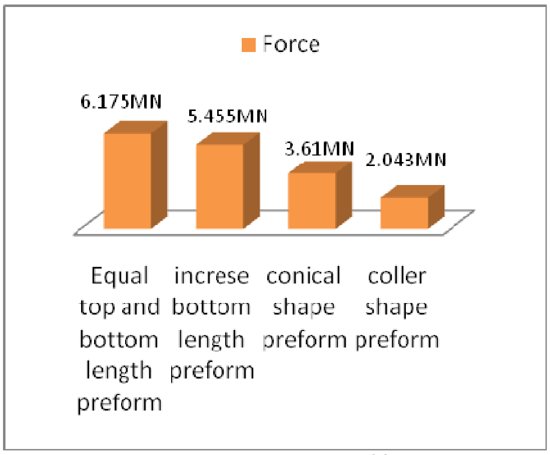

Fig. 24: Comparison of force.

CONCLUSION

In this study, computer simulation of gear forging has been carried out considering four types of preform. It is observed that out of four, only one preform could result in near net shape forging. Such application of simulation techniques will help achieve optimum utilization of resources which will result in economical manufacturing of components.

REFERENCES

[1] Meidert. M, Hansel. M, *Journal of Materials Processing Technology*,98, 150-154, (**2000**).
[2] Guoqun Zhao, Zhenduo Zhao, Tonghai Wang, Ramana V. Grandhi, *Journal of Materials Processing Technology*,84,193–201,(**1998**).
[3] Altan taylan, Metal Forming Fundamental and Application, ASM International, 180-181(**1983**).
[4] Guoqun Zhao, Wright Ed and Ramana V.Grandhi, *Int. J. Mach. Tools Manufact*.v 37 ,1251-1271, (**1996**).
[5] Victor Vazquez, Altan Taylan, *Journal of Materials Processing Technology*, 98,81-89,(**2000**).
[6] Chitkara Naunit R, Young J. Kim, *International Journal of Machine Tools & Manufacture*, 41, 225-246, (**2001**).
[7] Ou H, Lan J., Armstrong C.G, Price M.A, *Journal of Materials Processing Technology*,151,208–216,(**2004**).
[8] Domblesky Joseph, Frank Kraft, Benjamin Druecke, Bart Sims, *Journal of Materials Processing Technology*, 171, 141–149, (**2006**).
[9] Bramley A.N., Manors D.J., *Materials and Design* .21, 279-286, (**2000**).
[10] Lu B., Ou H., Armstrong C.G, Rennie. A, *Materials and Design*, 30, 2490–2500, (**2009**).
[11] User's manual ProE PTC U.S (**2000**)
[12] User's manual, Simufact software, Simufact (**2010**)