ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

IARJSET

International Advanced Research Journal in Science, Engineering and Technology

2nd International Conference on Advances in Mechanical Engineering(ICAME-2016)

Amrutvahini College of Engineering, Sangamner

Vol. 3, Special Issue 1, March 2016

Die Design for Camshaft

Mr. D. J. Sangale[1], Prof. P. N. Nagare [2]

PG student, Department of Mechanical Engineering, Amrutvahini College of Engineering, Sangamner, India[1]

Assoc. Professor, Department of Mechanical Engineering, Amrutvahini College of Engineering, Sangamner, India[2]

Abstract: Forging is the manufacturing process which can formed desired metal of pieces with the help of pressure and forging equipments. Forging industry is the main partner of automotive sector. Aim of the forging parts are forming a metal, Maintain product quality, Reduce development cycle time and minimize production cost of the forging parts.Faster the production rate of complex shapes with least wastage of material are some of the other benefits of forging process. In this work used various types of methodological tools such as Press machine, Induction heater, Ingot, Die and Simufact software. In current design of die, camshaft yield percentage is 58.5%. An investigation is undertaken to optimize the process design of die for camshaft and control camshaft yield percentage. As well as the input weight for forging of camshaft is to be minimized using forging die design improvement, which will result in increasing the production rate and decrease in the cost of the part. This will lead to reduce overall cost of the process and camshaft.

Keyword: Camshaft, Die, Forging, yield, Warm.

I. INTRODUCTION

In recent days, it is very important forging companies to develop the ability to design and produce a variety of high quality products within short time with customer satisfaction. Quick release of new product in the market place, ahead of any competitors is an important factor to capture a higher percentage of the market share and increase profit margin. As a result of the consumer desire for Variety, batch production, this has resulted in the need for manufacturers to develop flexible manufacturing process to achieve a rapid turnaround in product development. In the past design of die and forging process is mainly based on trial and error basis. Several points such as temperature, friction, die material, design of die, geometry of the part and other influencing parameters in the forging process [6]. No big more research on the field of forging die simulation and forging die design as per the design standard. So in this paper highlighted on forging die design for camshaft and its simulation in SIMUFAT software.

Faeket al. illustrate the metal simulation flow. It also studied the die design methodology using the CAD software [1].T. Altanet. alexplain the procedure of impression die forging. The design of any forging process begins with the geometry of the finished part.Nikolai et al. studied the development of forging simulation software has initiated the problem of its cost effective implementation in a forging company [2]. A.Cherouatet. al studied the numerical methodology developed in order to improve the cold 3D forging process with respect to the ductile damage occurrence [3]. Aktakkaet. alin this study analyse the warm forging process, this process is strongly affected by the process temperature. In hot forging process, a wide range of materials can be used and even complex geometries can be formed [4]. M. Sedighiet. alstudied thegeometrical design of perform in forging process of complex parts has great effects on the forging load and material wastes [5].Sukhwinder**,** analysed the wear analysis of a closed die used in hammer forging has been done. Also studied the simulation of forging process for the die and the work piece was carried out by finite volume method [6]. P. Poddar**,** relates to principles of metal working process, virtually all ductile metals may be forged by first preheating the work piece to a forging temperature.

The work piece can be a billet, a wrought bar, a cast or sintered ingot etc [7]. S. Z. Qamar**,** studied the followingH11material properties, H11 is a special high-alloy tool steel, belonging to the hot-work chromium tool-steel category [8]. Ranjit, studieda method for optimal selection of parting direction and parting line has been presented. Factors affecting selection of parting direction and parting line have been discussed and proposed [9].Taylanet. al required the selection of the die material, hardness and coating is critical for increasing die life in precision forging [10]. Xinghuiet. althe purpose of this paper is to reveal the complicated friction behaviours in cold rotary forging. For this purpose, the relationship between stable forming conditions and friction coefficient is first obtained by the static analysis of cold rotary forging [11].Zdeneket.al the paper presents the results of calculations, stress distribution fields in the frames of both proposals of mechanical forging presses with working force 25 MN [12].G. Shaiket. alstudied the project work emphasizes on the design and development of forging die. Before going to the die design principle, a detailed study is conducted on forging processes, forging equipments, forging dies and materials [13].Chandan, in this work, an automotive driveline component (Flange Yoke) is taken as a reference sample, to study the metal forming behaviour during closed die forging [14]. N. R. Harrison et.alstudied how to design warm forming dies for high-volume production. The challenges that arise when transferring this technology from the laboratory to production are generally focused on the attainment of thermal stability within the die [15].

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

IARJSET

International Advanced Research Journal in Science, Engineering and Technology

2nd International Conference on Advances in Mechanical Engineering(ICAME-2016)

Amrutvahini College of Engineering, Sangamner

Vol. 3, Special Issue 1, March 2016

II. PROBLEM DEFINITION

In current design of die, camshaft yield percentage is low. An investigation is undertaken to optimize the process design of die for camshaft and control camshaft yield percentage. As well as the input weight for forging of camshaft is to be minimized using forging die design improvement, which will result in increasing the production rate and decrease in cost of the part. This will lead to reduce overall cost of the process and camshaft.

III. JUSTIFICATION OF PROBLEM SELECTION

A. Horizontal Forging Process

Table 1: Horizontal Forging Process Parameters

Sr. No	Parameter	Ingot 1	Ingot 2	Ingot 3
1	Ingot Weight	0.400 kg	0.450 kg	0.500 kg
2	Ingot Diameter	38 mm	38 mm	38 mm
3	Ingot Area	1134.11 mm^2	1134.11 mm^2	1134.11 mm^2
4	Ingot Length	44.8 mm	50.48 mm	56.09 mm
5	Ingot Volume	50887.5 m^3	57249.87 m^3	63612.22 m^3
6	Ingot Temperature	1200 – 1250^{0}C	1200 – 1250^{0}C	1200 – 1250^{0}C
7	Press Load	250- 260 ton	250- 260 ton	250- 260 ton
8	Die Contact	Under filling	Under filling	Filling

As per the above considerations different types of ingots simulated on SIMUFACT software then following results were obtained. Following simulation is based on changing the weight of the ingot. When different types of ingot are selected on weight basis then ingot radius, diameter, volume andlengths are changes with ingot to ingot. So following simulation is carried out as per the above parameters.

B. Simulation of Ingot 1 for 38 mm Diameter

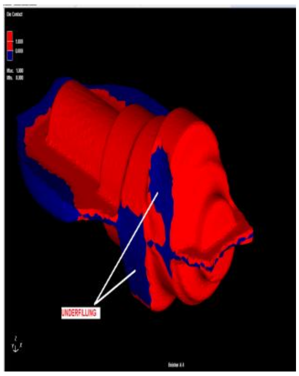

Fig.1. Under filling of Horizontal Die Forging Process of Camshaft for 0.400 kg

In above Fig.1 red color indicates the ingot contact with die and blue color indicates the under filling material in the die. Here select 0.400 kg ingot and simulated in SIMUFACT software then software give the under filling result of the ingot. Therefore, ingot 0.400 kg is not 100% contact with die or die cavity is not filled up completely with the material. Hence 0.400 kg ingot is not suitable for horizontal die forging process of camshaft. Thus 0.400 kg ingot was not selected for horizontal die forging process.In current forging process (horizontal forging process) yield % is the ratio of net weight to gross weight. [15]

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

Net weight = 0.31 kg

Gross weight = Cut weight × 1.06

= 0.4×1.06

=0.424 kg

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

$$\text{Yield\%}=\frac{0.31}{0.43}\times 100$$

Yield % = 72%

As per the simulation of the ingot 0.400 kg yield percentage is 72%. But final result is under filling of the die cavity. Here due to under filling cavity of die thus this ingot is not suitable for this process.

C. Simulation of Ingot 2 for 38 mm Diameter

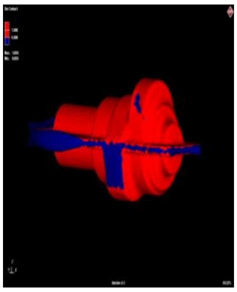

Fig.2.Under filling of Horizontal Die Forging Process of Camshaft for 0.450 kg

In above Fig.2 also red color indicates the ingot contact with die and blue color indicates the under filling material in the die. Here select 0.450 kg ingot and simulated in SIMUFACT software then software give the under filling result of the ingot. Therefore ingot 0.450 kg is not 100% contact with die or die cavity not fill up completely with ingot material. As compare to the first ingot the die contact of the second ingot is more. But under filling is also available in the 0.450 kg ingot. Hence also 0.450 kg ingot is not suitable for horizontal die forging process of camshaft. Thus 0.450 kg ingot was not selects for horizontal die forging process.In existing forging process (horizontal forging process) yield % is the ratio of net weight to gross weight.

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

Net weight = 0.31 kg

Gross weight = Cut weight × 1.06

= 0.45×1.06

=0.477 kg.

$$\text{Yield\%}=\frac{0.31}{0.477}\times 100$$

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

Yield % = 64.98%

As per the simulation of the ingot 0.450 kg yield percentage is 64.98%. But final result is under filling of the die cavity. Here due to under filling cavity of die thus this ingot is not suitable for this process.

D. Simulation of Ingot 3 for 38 mm Diameter

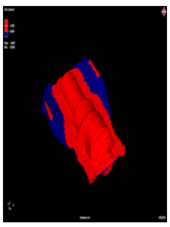

Fig.3. Horizontal Die Forging Process of Camshaft for 0.500 kg

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

IARJSET

International Advanced Research Journal in Science, Engineering and Technology

2nd International Conference on Advances in Mechanical Engineering(ICAME-2016)

Amrutvahini College of Engineering, Sangamner

Vol. 3, Special Issue 1, March 2016

In above Fig.3 red color indicates the ingot contact with die and blue color indicates the under filling material in the die. Here select 0.500 kg ingot and simulated in SIMUFACT software then software gives the complete filling result of the ingot. Therefore ingot 0.500 kg is 100% in contact with die or die cavity completely fill up with material. But by making comparison of third ingot with the first and second ingot then third ingot is completely filled up with die. Hence 0.500 kg ingot is suitable for horizontal die forging process of camshaft. Then select the 0.500 kg ingot for horizontal die forging process.

In existing forging process (horizontal forging process) yield % is the ratio of net weight to gross weight.

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Net weight = 0.31 kg

Gross weight = Cut weight × 1.06

= 0.5×1.06

=0.530 kg.

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

$$\text{Yield\%} = \frac{0.50}{0.53} \times 100$$

Yield % = 58.5%

As per the simulation of the ingot 0.500 kg yield percentage is 58.5%. But final result is filling of the die cavity. Comparing this result with other results then thus ingot is suitable for this process.

E. Comparison of Yield Percentage

Table 2: Comparison of Horizontal Forging Yield Percentage

Sr. No.	Ingot Type	Yield Percentage (%)	Results
1	0.400 kg	72	Under filling
2	0.450 kg	64.98	Under filling
3	0.500 kg	58.5	Filling

IV. OBJECTIVE

Input weight of camshaft will be reduced by changing the die design. Forging die design for camshaft for the purposes of fulfilling the following objectives,

1) To design a vertical forging die for improving the yield percentage of the forging process.
2) To reduce forging defects such as input forging weight and parting line selection.
3) To increase production rate with minimizing the forging stages.
4) To minimize the trimming press load for trimming operation.
5) To minimize the overall cost of camshaft.

V. DISCUSSION OF SIMUFACT RESULTS

A. Vertical Forging

Table 3: Vertical Forging Process Parameters with 38 mm Ingot Diameter

Sr. No.	Parameter	Ingot 1
1	Ingot Weight	0.500 kg
2	Ingot Diameter	38 mm
3	Ingot Area	1134.11 mm^2
4	Ingot Length	56.09 mm
5	Ingot Volume	63612.22 m^3
6	Ingot Temperature	1200 – 1250^{0}C
7	Press Load	250 – 260 ton
8	Die Contact	Filling

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
2nd International Conference on Advances in Mechanical Engineering(ICAME-2016)
Amrutvahini College of Engineering, Sangamner
Vol. 3, Special Issue 1, March 2016

As per the above considerations ingot 0.500 kg is simulated on SIMUFACT software then following results were obtained. Following simulation is based on same weight which is used in horizontal forging process. Only changes in the die design by horizontal forging process to vertical forging process. So following simulation is carried out as per the above input parameters.

B. Simulation of Ingot 1 for 38 mm Diameter

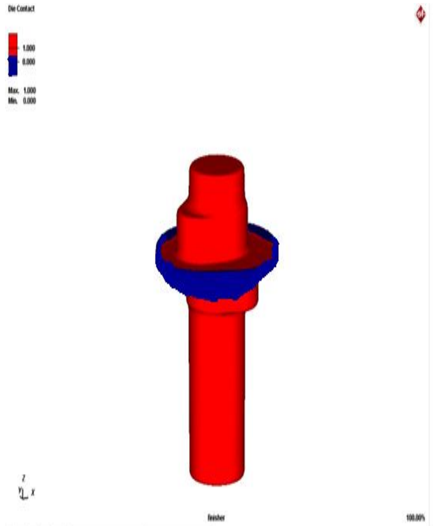

Fig.4. Vertical Die Forging Process of Camshaft for 0.500 kg with Excess Flash

In above Fig.4 red color indicates the ingot in contact with die and blue color indicates the under filling material in the die. When select the 0.500 kg ingot and simulated in SIMUFACT software then software gives the complete filling result of the ingot with excess flash pattern. Here same weight is used for horizontal forging. Only changes in the die design for horizontal forging to vertical forging process. After the change the die design ingot filling is 100 percentages with excess flash of the material. Therefore material wastage of this ingot is high thus rejecting this ingot and selecting another ingot. Following method describes the changes in weight and temperature of the process.

C. Trials Taken on Reducing Cross Section and Temperatures
The different type of ingots was simulated on SIMUFACT software then following comparison is obtained,

Table 4: Vertical Forging Process Parameters

Sr. No.	Parameter	Ingot 1	Ingot 2	Ingot 3
1	Ingot Weight	0.300 kg	0.350 kg	0.400 kg
2	Ingot Diameter	24 mm	24 mm	24 mm
3	Ingot Area	452.38 mm^2	452.38 mm^2	452.38 mm^2
4	Ingot Length	84.36 mm	98.43 mm	112.36 mm
5	Ingot Volume	38162.77 m^3	44527.76 m^3	50888.22 m^3
6	Ingot Temperature	700 – 750 ^{0}C	700 – 750 ^{0}C	700 – 750 ^{0}C
7	Press Load	250 - 260 ton	250 - 260 ton	250 - 260 ton
8	Die Contact	Under filling	Under filling	Filling

As per the above considerations different types of ingots are simulated on SIMUFACT software then following results were obtained. Following simulation is based on changing the weight of the ingot. When different types of ingot are selected on weight basis then ingot radius, diameter, volume and length are changed from ingot to ingot. So following simulation is carried out as per the above parameters.

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

D. Simulation of Ingot 1 for 24 mm Diameter

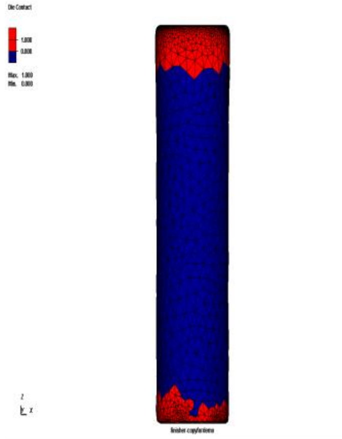

Fig.5. Under filling of Vertical Die Forging Process of Camshaft for 0.300 kg

In the above Fig.5 red color indicates the ingot material in contact with die and blue color indicates the under filling material in the die. Here select the 0.300 kg ingot and simulated in SIMUFACT software then software gives the under filling result of the ingot. Therefore ingot 0.300 kg is not 100% in contact with die or die cavity not filled up completely with material. Hence 0.300 kg ingot is not suitable for vertical die forging process of camshaft. Thus 0.300 kg ingot was not selected for vertical die forging process. In improved forging process (vertical process) yield % is the ratio of net weight to gross weight [15]

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

Net weight = 0.36 kg

Gross weight = Cut weight × 1.06

= 0.3× 1.06

= 0.43 kg

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

$$\text{Yield\%}=\frac{0.36}{0.31}\times 100$$

Yield % = 116.12%

As per the simulation of the ingot 0.300 kg yield percentage is 116.12%. But final result is under filling of the die cavity. Comparing this result with other results then thus ingot is not suitable for this process.

E. Simulation of Ingot 2 for 24 mm Diameter

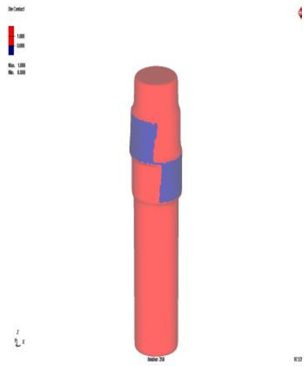

Fig.6. Under filling of Vertical Die Forging Process of Camshaft for 0.350 kg

In above Fig.6 also red color indicates the ingot in contact with die and blue color indicates the under filling material in the die. When select the 0.350 kg ingot and simulated in SIMUFACT software then software gives the under filling result of the ingot. Therefore ingot 0.350 kg is not 100% in contact with die or die cavity not filled up completely with ingot material. As compare to the first ingot die contact of the second ingot is more. But under filling is also available in the 0.350 kg ingot. Hence also 0.350 kg ingot is not suitable for vertical die forging process of camshaft. Thus 0.350 kg ingot was not selected for vertical die forging process.In improved forging process (vertical process) yield % is the ratio of net weight to gross weight

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

Net weight = 0.36 kg

Gross weight = Cut weight × 1.06

= 0.35× 1.06

= 0.37 kg

.

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

$$\text{Yield\%}=\frac{0.35}{0.37}\times 100$$

Yield % = 94.33%

As per the simulation of the ingot 0.350 kg yield percentage is 94.33%. But final result is under filling of the die cavity. Comparing this result with other results then thus ingot is not suitable for this process.

F. Simulation of Ingot 3 for 24 mm Diameter

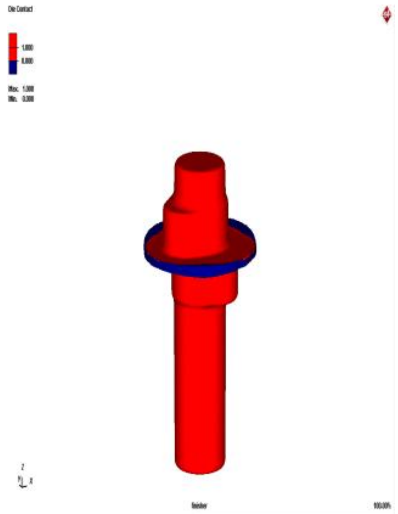

Fig.7. Vertical Die Forging Process of Camshaft for 0.400 kg

In above Fig.7 red color indicates the ingot in contact with die and blue color indicates the under filling material in the die. When select the 0.400 kg ingot and simulated in SIMUFACT software then software gives the complete filling result of the ingot. Therefore ingot 0.400 kg is 100% contact with die or die cavity completely filled up with material. But comparison of third ingot with first and second then third ingot is completely filled up in die. Hence, 0.400 kg ingot is suitable for vertical die forging process of camshaft. Thus accept the 0.400 kg ingot for vertical die forging process.In improved forging process (vertical process) yield % is the ratio of net weight to gross weight.

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

Net weight = 0.36 kg

Gross weight = Cut weight × 1.06

= 0.4× 1.06

= 0.43 kg

$$\text{Yield\%}=\frac{\text{Net Wt.}}{\text{Gross Wt.}}\times 100$$

$$\text{Yield\%}=\frac{0.36}{0.43}\times 100$$

Yield % = 83.72%

As per the simulation of the ingot 0.400 kg yield percentage is 83.72. But final result is filling of the die cavity. Comparing this result with other results then thus ingot is suitable for this process.

IARJSET

International Advanced Research Journal in Science, Engineering and Technology

2nd International Conference on Advances in Mechanical Engineering(ICAME-2016)

Amrutvahini College of Engineering, Sangamner

Vol. 3, Special Issue 1, March 2016

VI. CONCLUSIONS

Yield Improvement from 58.5% to 83.7% (25.2%). Because yield percentage is depends on the ratio of net weight to gross weight of the ingot. Hence we maximize the ratio and improve the yield percentage of the process.

1) Reduce input forging weight from 0.500 kg to 0.400 kg. For horizontal process raw material cross section is ϕ 38 and hence considering length requirement input gross weight is 0.500 kg. For vertical forging process raw material cross section is ϕ24 and hence considering length requirement, input gross weight is 0.400 kg.
2) Increase production rate. For horizontal forging process there are two stages for forging single component up i.e. setting and finisher. For vertical forging process there is only one stage for direct finisher and hence production cycle time is reduced.
3) Minimize the trimming press load.

ACKNOWLEDGMENT

The author would like to thank Principal, Dr. G. J. Vikhe -Patil, HOD, Prof. A. K. Mishra of Mechanical Engineering Department, AVCOE, Sangamner, for their valuable guidance and Prof. V. D. Wakchaure, Prof. V. S. Aher, for skilful assistance with the work.

REFERENCES

[1]. FaekDiko B eng, M Eng, Metal flow simulation and design of dies, Scientific studies and research center Damascus Syria, 237, pp. 1- 237, 1992.
[2]. T. Altan, M. Shirgaokar, Process design in impression dies forging, Technol, 98, pp. 1-12, 2000.
[3]. Nikolai Biba, Sergei Stebounov, Andrei Lishiny, Cost effective implementation of forging simulation, Material Processing Technology, 113, pp. 34-39, 2001.
[4]. A. Cherouat, k. Saanouni, Y. Hammi, Improvement of forging process of a 3D complex part with respect to damage occurrence, Material Processing Technology, 142, pp. 307- 317,2003.
[5]. GulgunAktakka, Analysis of warm forging process, Natural and applied sciences, 99, pp. 1-99,2006.
[6]. M. Sedighi, S. Tokmechi, A new approach to perform design in forging process of complex parts, Material processing Technology, 97, pp. 314-324, 2008.
[7]. Sukhwinder Singh Panesar, Evaluation of wear coefficient of hot forging dies in hammer forging, CAD/CAM and Robotics, 71, pp. 1-71, 2008.
[8]. P. Poddar, Principles of metal working processes, Special Metal Casting and Forming Processes, 14, pp. 64-77, 2008.
[9]. S.Z. Qamar, Effect of heat treatment of mechanical properties of H11 toll steel, Achievements in Materials and manufacturing Engineering, 6, pp. 1- 6, 2009.
[10]. Ranjitsingh, JatinderMadan, Optimal selection of parting line for die–casting, National Conference on Precision Manufacturing, 6, pp. 106-148, 2010.
[11]. TaylanAlatan, MayurDeshpande, Selection of die materials and surface treatments for increasing die life in hot and warm forging, Tech Conference, 32, pp. 1- 32, 2011.
[12]. Xinghui Han, Lin Hua, Friction behaviors in cold rotary forging of 20CrMnTi alloy, Tribology, 55, pp. 29-39, 2012.
[13]. ZdenekChval, Milan Cechura, Optimization of power transmission on mechanical forging presses, Procedia Engineering, 69, pp. 890-896, 2014.
[14]. G. ShaikUsmansha, M. Mohammed Safeeque, A. AthisayaSagayaRajan, Forging die design of a connecting rod, International Journal of Innovative Research and Development, 6, pp. 265- 270, 2014.
[15]. ChandanSamal, Study of process parameters towards improving efficiency of closed die hot forging process, Production Technology, 69, pp. 1-69, 2014.