INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Forging Die Design of a Connecting Rod

G. Shaik Usmansha
Assistant professor, Department of Automobile Engineering, NCERC, Trissur, India
M. Mohammed Safeeque
Assistant professor, Department of Automobile Engineering, NCERC, Trissur, India
A. Athisaya Sagaya Rajan
Assistant professor, Department of Automobile Engineering, NCERC, Trissur, India

Abstract:
Forging is a process in which to transform the shape of metal using heat and localized compressive forces.die is the shaping part of the forging process. 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. After studying the various aspects involved in the die design, die design for connecting rod is made. Here in the design of forging die, the product is made most accurately so as to get the forged product free from all defects and as per the requirements given in the product drawing. In industrial view the forging die for connecting rod helps for the mass production of product without any defects of the material after forging. For the analysis of die defects all the required data are collected and based on this study the suitable actions should be suggested for reducing the die failures and for increasing the die life for connecting rod. The product thus obtained by forging is at good strength and free from any defects.

Key words: *forging die, connecting rod, design*

1. Introduction

Forging is one of the past known metalworking process. Usually, forging was done by a smith using hammer and anvil. In the design of forging die, the product is made most accurately so as to get the forged product free from all defects and as per the requirements given in the product drawing. In industrial view the forging die for connecting rod helps in the mass production of product without any defects of the material after forging. For the analysis of die defects all the required data are collected and based on this study the suitable actions should be suggested for reducing the die failures and for increasing the die life for connecting rod.
The objective of Forging Die Design of a Connecting rod is to give a quality die product to the customers as per their drawings and specifications. A detailed study is done about the forging processes, forging dies and materials, die manufacturing methods and die design considerations for making the die that are free from any defects. Thereby reducing the die failures and increasing the die life. The analysis is going to do using ANSYS software

2. Experimental Procedure

2.1. Forging Dies Design for a Typical Product

The forging die for that product should be designed in such a way that the product should be economic. Material of connecting rod: AISI E 86B45VD.

ELEMENTS	PERCENTAGE (%)
Iron	96.46 - 97.67
Manganese	0.75 - 1.00
Carbon	0.43 – 0.48
Chromium	0.4 - 0.7
Nickel	0.4 – 03
Silicon	0.2 - 0.35
Molybdenum	0.15 - 0.25

Table 1: Chemical composition of Connecting Rod

Property	Din 1.2714	AISI E86 B45 VD
Density (kg/m^3)	7860	7850
Elastic modulus (GPa)	190-210	80-140
Poisson's ratio	0.27	0.3
Tensile strength (MPa)	1250	1000
Yield strength (MPa)	900	850
Elongation (%)	15	17
Hardness (BHN)	383	348

Table 2: Material properties of connecting rod and die

2.1.1. Suggested Temperature

- Normalizing : 870˚C
- Hardening : 850˚C
- Tempering : 600˚C
- Unspecified draft angle : 5˚
- Unspecified Radius : R4
- Fillet : R6
- Die closure : 2

2.2. Design and Development

2.2.1. Number of Forging Process Required

After studying product drawing it was found that in order to get the connecting rod forged three forging processes are required

- Fullering
- Blocking
- Finishing

The impressions for fullering, blocking and finishing can be made on a single die block.

2.3. Detection of Parting Line

Since the connecting rod is symmetrical, the parting line is selected as that line which divides the connecting rod into two symmetrical sections. Thus the parting plane is that plane which passes through the centre portion of the production such that the cross section at that parting line of the product will be same as shown in the product drawing.

2.4. Fuller Design

The length of connecting rod is 814.3 mm. considering all the dimensions of connecting rod, the fuller is designed. Thus the length of fuller is taken as 814.3mm, width as 460mm and it is tapered as shown in product drawing. The fillet radius is given as 6mm.

2.5. Blocker Design

For the finishing impression of the die, the dimensions are given such that it is equal to 1.015 times the dimension of the product (that is the dimension given in the product drawings). The change in dimension is given in order to compensate for the shrinkage of the product during cooling. At the check portions dimensions are slightly increased.

2.6. Finisher Design

For the finisher the dimension are that they are 1.015 times that of the product in order to compensate for the shrinkage of the product during cooling product drawing for finisher design.

2.7. Die Block Selection

Thus the design of fuller, blocker and finisher is completed. The next step is to determine the size of the die block. Since the size of connecting rod is smaller we can accommodate the fuller, blocker and finisher in a single die block. The width of the connecting rod at the paring line is 224mm. The width of flash and gutter is 260mm thus total maximum width required for both blocker and finisher is 224+260+260+(2x55) that is 924 mm taken as 950mm.The length of connecting rod is 640+(3x180)mm that is 1180mm taken as 1200mm. Considering all the dimensions mentioned above the standard die block of dimension 1200x950x500mm^3 is selected. Die block material is DIN 2714.

2.8. Die Layout

The next step is to locate the position of these impressions on the proper laying of the center lines for fullering, blocking and finishing impressions at suitable place on the die block dimensions. The finisher is located at the side of the finisher at some distance away from it. Fuller is located at one suitable corner of die block. The location of fuller, blocker and finisher is shown in the product drawing.

2.9. Locking Arrangements

Referred product drawing for locking arrangement, female blocks are made on the bottom die, but reverse is the case with impression. Four locks are arranged, each at the corner at the die block.

2.10. Results of Design

The product obtained after forging was free from all defect except that lap was formed at the parting plane of check portion of the connecting rod. It was not a major defect the lap was removed by grinding. The dimensions of the product were also accurate. About 100 connecting rods were forged and dies did not find any fault.

3. Results and Discussion

3.1. Numerical results

Ultimate Tensile Strength	=125 kg/mm^2
	=1226.25 MPa
Factor of Safety	=4
Working Stress	=Ultimate Tensile Strength/Factor of Safety
	=1226.5/4
	=306.5N/mm^2
	=306.5MPa
Energy	= Pressure × Volume
We know, Energy	=277102 Nm
Volume	=1200×950×500 mm^3
	=0.57m^3
So, Pressure	=Energy/Volume
	= 277102/0.57
	=486143.86 Pa
	=0.486MPa

Table 3

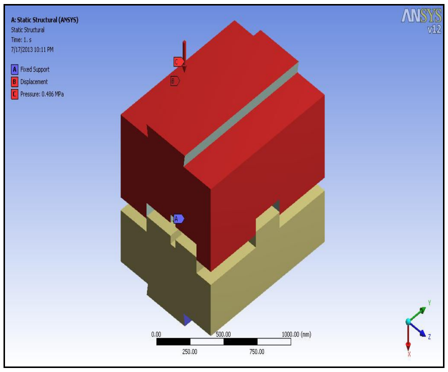
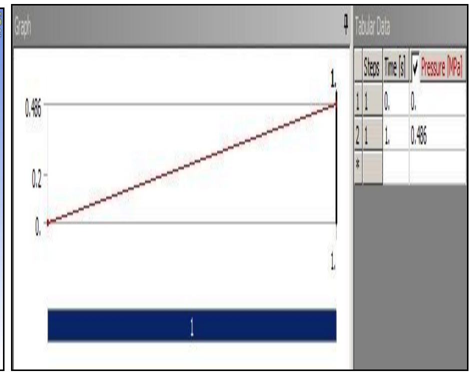

Figure 1: Top and Bottom Dies at pressure 0 .486 MPa
Figure 2: Pressure Time Relation at pressure .486 MPa

We can compare the total deformation occurs in this case.

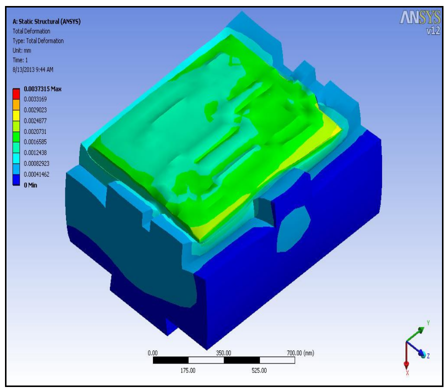

Figure 3: Total Deformation occurring in the Dies at Pressure .486MPa

From the result files we can see that the maximum deformation occurring is 0.0037 mm which is infinitely small value.
From the Analysis, we can find that equivalent stress corresponding to pressure 0.486 MPa = 5.27 MPa

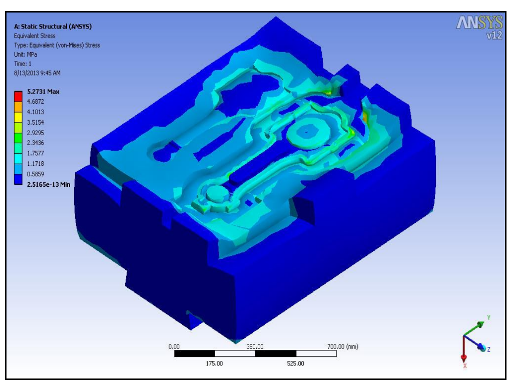

Figure 4: Equivalent Stress corresponding to pressure .486MPa

This value is comparatively very small to the working stress that we have calculated above.
Allowable ratio of stress =working stress / equivalent stress =306.5/5.27=58.15 MPa
From this we assumed that the pressure can be increased by 58.15 times than the pressure we had applied before.
Allowable pressure =0.486×58.15 =28.26MPa
Now we can consider the second case with increased pressure of 28.26 MPa.

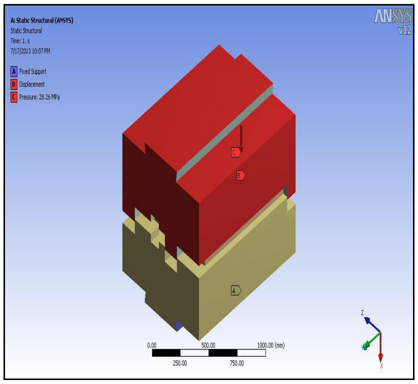
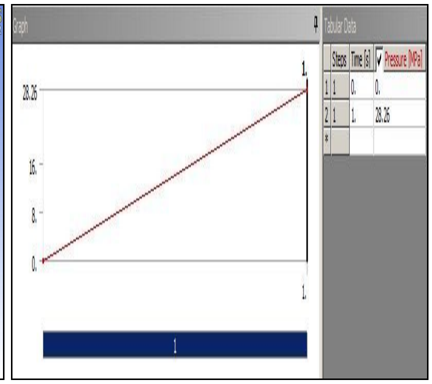

Figure 5: Top and Bottom Dies at pressure 28.26 MPa
Figure 6: Pressure Time Relation at pressure 28.26 MPa

To consider the safety in deformation we need to check total deformation during the increased pressure.

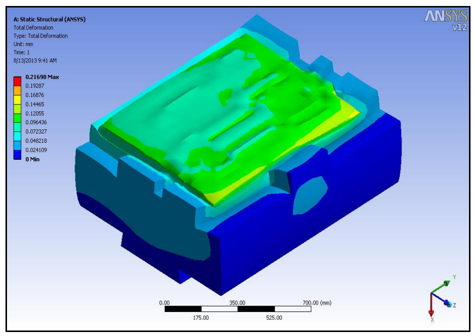

Figure 7: Total Deformation occurring in the Dies at Pressure 28.26MPa

Here also we can have a look on the total deformation and the value is only 0.22mm. These results of total deformation are the values of the dies. From this final analysis we can find that equivalent stress =306.62MPa

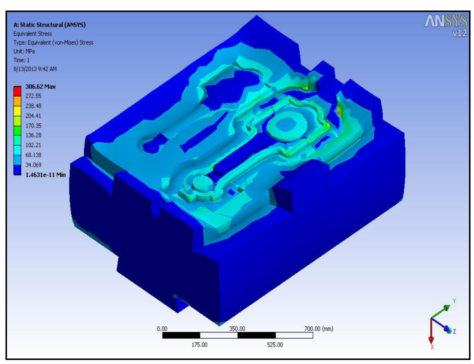

Figure 8: Equivalent Stress corresponding to pressure 28.26MPa

This value is almost matching with the calculated working stress. Since, the equivalent stress obtained from the final analysis is within the yield strength of the material and obeying the factor of safety, the design is safe, so our analyzed design is safe in the point of view of both maximum stress and total deformation.

4. Conclusion

During the first phase of the project a detailed study of Forging processes, Forging die and materials, Design considerations was done.DIN 2714 tool steel is using for the die block of a connecting rod. With these data die design of a connecting rod was done. The analysis of die design is done with ANSYS software during the final phase of the project and presented in this thesis.

Now the die material by conducting material property tests and calculations before using it for production. The analysis helps to see the stress concentration at various portions of the die and we can estimate the die failures before using it for production..Through analysis it is observed that equivalent stress is more on one sharp corner of the die as shown in figure 19.It can be reduced by filleting that portion. If the fillet radius is changed from R6 to R8, We can reduce the stress concentration in that portion. Thus we can improve the die life. The calculation of die life prediction can estimate the quantity of products forged before reworking or resinking and the die failures such as profile bulging, surface cracks etc due to the heat transfer from the billet to the dies can be sparingly reduced. This project's finding can be used by the company for their future products.

5. References

1. Dieter, G.E., Mechanical metallurgy, SI metric edition, McGraw-Hill, (1998).
2. Edwards, L. and Endean, M., Manufacturing with materials, Butterworth Heinemann, (1990).
3. Beddoes, J. and Bibbly M.J., Principles of metal manufacturing process, Arnold, (1999).
4. Lange, K., Handbook of metal forming, McGraw-Hill Book company,(1919).
5. O.P Khanna and M.Lal 'Production Technology', Dhanpat rai Publications, Vol 2, pp. 428-442, (1999)
6. P C Sharma 'A Text book of Production Engineering's Chand and company Ltd, vol 3, pp132-157, (1996).
7. "ASM Metals Handbook-Forging and Forming"Vol.14, 9th Edition, ASM Handbook committee, USA, (1988)