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Designing a Forging Die for connecting rod

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Abstract— The life of a forging die and the amount of flash produced in forging are the main issues of concern in all forging operations together with material wastage, overall cost and post process trimming costs. While proper control of the flash is essential to ensure die filling, the service life of hot forging die depends mainly on thermal, mechanical and combined stresses. Geometrical design of the pre-form has significant relationship with the forging load and flash amount in forging complex parts. 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.
Keywords: forging, flash, die design, preform, die design.

I. 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. Hot forging, which is also referred to as drop forging, it is a process that used in producing a wide variety of parts of most metals. It is a near net shape process. The principles and practices of hot forging are well established and the basic procedure for hot forging is relatively straightforward. Several improvements have been made over the years in equipment, lubricants, and the ability to process the 'more difficult to forge' materials. Computer aided design and analysis is being increasingly made use in the recent years to increase die life and productivity. The proposed work relates to development of a flash less die using CAD to control the amount flash produced in forging operations.

II. IMPORTANCE OF A FLASH IN THE PROCESS FORGING

The amount of flash produced in a forging operation increases with the complexity of the part If material is to be forced to move into the extremities of the die cavity, this sideways material flow must be restricted. Provision of a narrow flash land around the split line of the dies restricts the sideways flow of the material. A typical arrangement for the flash land and the flash gutter on a forging is shown in Fig. The gutter must be large enough to accommodate the flash produced. The choice of the appropriate width and thickness of the flash land is an important part of the forging process design. If the geometry is wrong, the dies may not fill completely or the forging loads may become excessive.

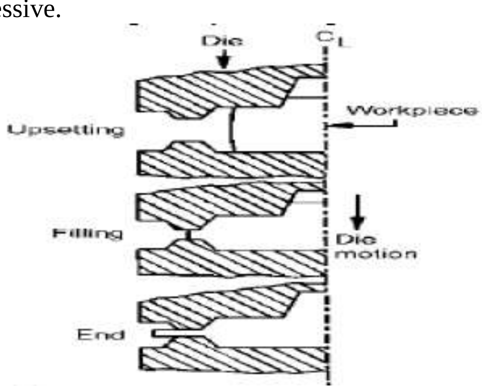


TABLE 1.
EMPIRICAL RELATIONS USED TRADITIONALLY FOR DESIGNING FLASH

Reference	Flash thickness, T_f (mm)	Flash land ratio, W_f/T_f
Brachanov and Rebelskii [3]	$0.015A_p^{0.5}$	—
Voiglander [4]	$0.016D + 0.018A_p^{0.5}$	$63D^{0.5}$
Vierrege [5]	$0.017D + 1/(D+5)^{0.5}$	$30/[D(1 + 2D^2/(h(2r + D))]^{0.33}$
Neuberger and Mockel [6]	$1.13 + 0.89W^{0.5} - 0.017W$	$3 + 1.2e^{-1.09W}$
Teterein and Tarnowski [7]	$2W^{0.33} - 0.01W - 0.09$	$0.0038ZD/T_f + 4.93/W^{0.2} - 0.2$

A_p, forging projected area (mm^2); W, forging weight (kg); D, forging diameter (mm); Z, forging complexity factor.

III. FLASH CONTROL TECHNIQUES

Flow material depends on the following [8]:

1. Geometry of the cavity.
2. Geometry of the flash opening.
3. Initial and intermediate billet geometry.
4. Percentage of flash.
5. Heat transfer between the tooling and the billet.

The first method to make a coarse preform from a non-porous billet and hitting in a press until the final shape get. This methods outcome is 20±40% material waste in the form of flash. Advantage of closed-die forging with flash is, preform volume can vary within a wider range than that of flashless forging, but a trimming process is required to remove the flash.

Requirements to perform a successful flash less forging process are : The volume must be same for initial preform and cavity at the end of the process. There is neither volume excess nor shortage, so the positioning of the preform and mass distribution is exact. If there is a compensation space in the dies, the real cavity must be filled first.

IV. CONNECTING ROD DIE DESIGN METHODOLOGY

Experimental Procedure

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:

ELEMENTS PERCENTAGE (%)

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

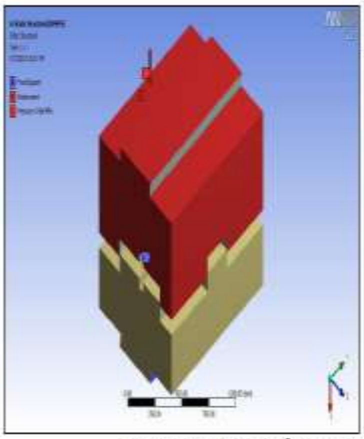
Table 2: Material properties of connecting rod and die

Suggested Temperature
- Normalizing : 870˚C
- Hardening : 850˚C
- Tempering : 600˚C
- Unspecified draft angle : 5˚
- Unspecified Radius : R4
- Fillet : R6

Design and Development
1) Number of Forging Process Required
   - Fullering
   - Blocking
   - Finishing
2) Detection of Parting Line
3) Fuller Design
4) Blocker Design
5) Finisher Design
6) Die Block Selection
7) Die Layout
8) Locking Arrangements
9) Results of Design

3. Results and Discussion
Numerical results

Ultimate Tensile Strength	$=125\ kg/mm^2$
	$=1226.25$ MPa
Factor of Safety	$=4$
Working Stress	=Ultimate Tensile Strength/Factor of Safety
	$=1226.5/4$
	$=306.5N/mm^2$
	$=306.5$MPa
Energy	= Pressure × Volume
We know, Energy	=277102 Nm
Volume	$=1200\times950\times500\ mm^3$
	$=0.57m^3$
So, Pressure	=Energy/Volume
	= 277102/0.57
	=486143.86 Pa
	=0.486MPa



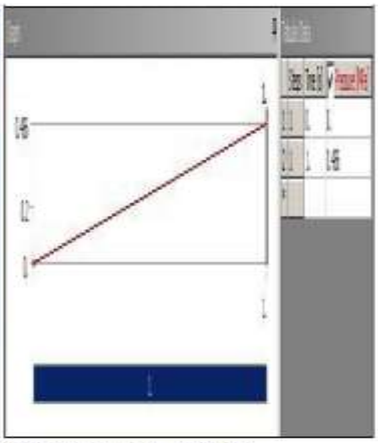
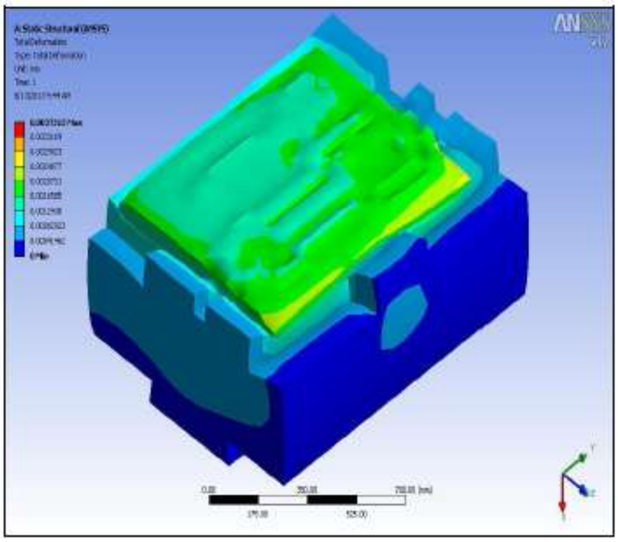
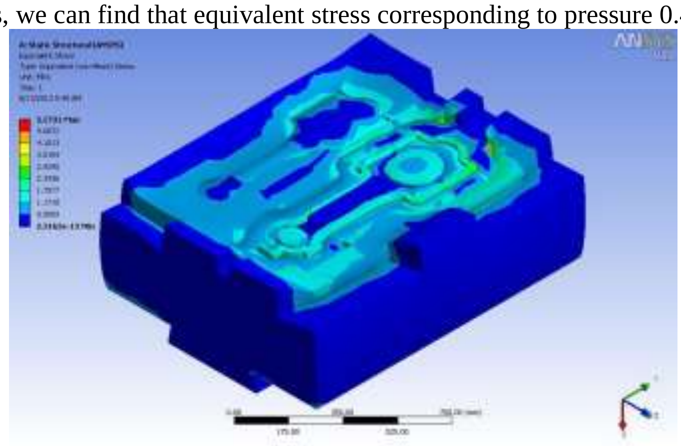


Figure 1: Top and Bottom Dies at pressure 0 .486 MPa
Figure 2: Pressure Time Relation at pressure .486 MPa

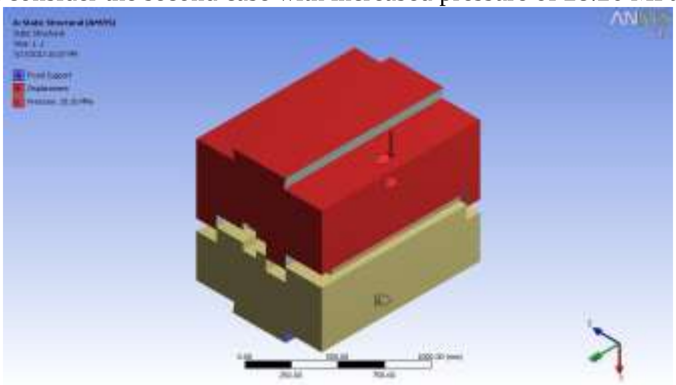


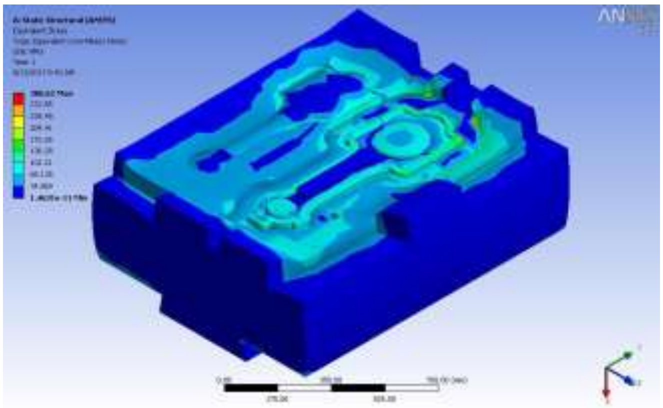
Total Deformation occurring in the Dies at Pressure 486MPa
From the result files we can see that the maximum deformation occurring is 0.0037 mm which is infinitely small value.From the Analysis, we can find that equivalent stress corresponding to pressure 0.486 MPa =5.27MPa

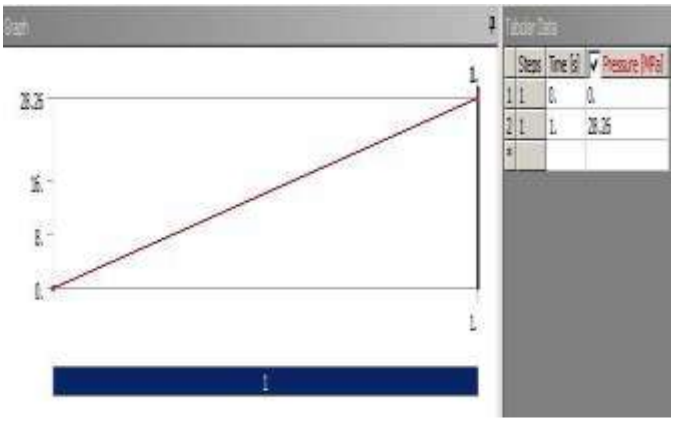


Equivalent Stress corresponding to pressure .486MPa

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.

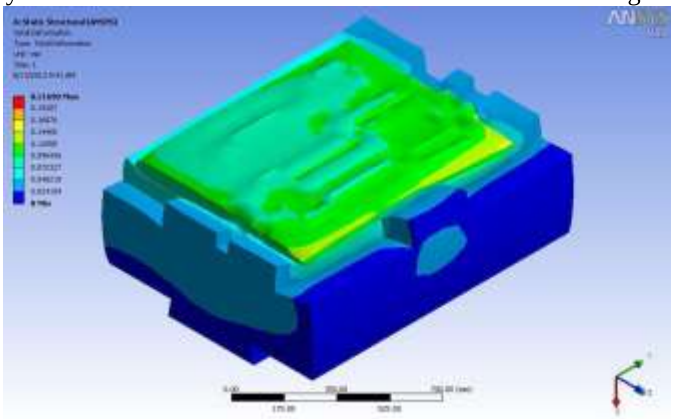






Top and Bottom Dies at pressure 28.26 MPa Pressure Time Relation at pressure 28.26 MPa

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



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 =306.6 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.

V. 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.

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