IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 6 Ver. V (Nov. - Dec. 2016), PP 149-157
www.iosrjournals.org

Studies on Design Modification of Forging die for Improvement of Life.

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Abstract: *Forging is a process where a shape of a component is manufactured by heating raw material in a furnace and applying compressive forces on the die. Though it's a hot forging process, there will be die wear and plastic deformation. Due to these deformations often replacement of die is required, which causes an increase in production cost and there is loss of productive plan. It also changes the dimensions of required component. The paper discusses how to increase the die life. The effort made to increase die life is to increase number of operations on the die that lead to reduce the drop force. This process is being done by two ways. One way to analytical model and the other way is to establishing experimental setup. As the cost of experimental setup is high compare to analytical solution. The paper attempted the solution using cae software. In this paper, die is modelled with inputs of existing model and then model is modified by increasing the operation on the die. The contact analysis and the fatigue analysis is elaborated in this to show the modified design yielding higher life. This paper is also extends to transient analysis of die for transient loading. Nx-cad software is used for modelling and ansys software is used for analysis of die.*
Keywords: *Modeling, Die life, CAE software, Optimization.*

I. Introduction

Forging is a process where a shape of a component is manufactured by heating raw material in a furnace and applying compressive forces on the die. The desired shape is obtained in one or more stages. There are two types of forgings die 1.open die forging: In this is process the forging are made with the help of repeated blows in open die. 2. closed die forging: In this process two are brought together ,squeezing the metal causing it to fill the die impression. In this paper analysis of forging die life is increased by modifying the existing die by introducing the roller operation. Earlier die has two operations namely blocker, finisher. Modified die will be compared with the existing die by using contact analysis, fatigue analysis and transient analysis. This paper is organised in the following manner section 2 gives the details of the geometry of the die. Section 3 include the modelling of the die. Section 4 discusses the contact, fatigue and transient analysis. Section 5 discusses the results and section 6 shows about the conclusions.

II. Geometry of the die

The geometry of the die is shown in fig 2.1. This consists of various operations on the die as follows. They are roller, blocker and finisher. Both the die has the same impression and dimensions.

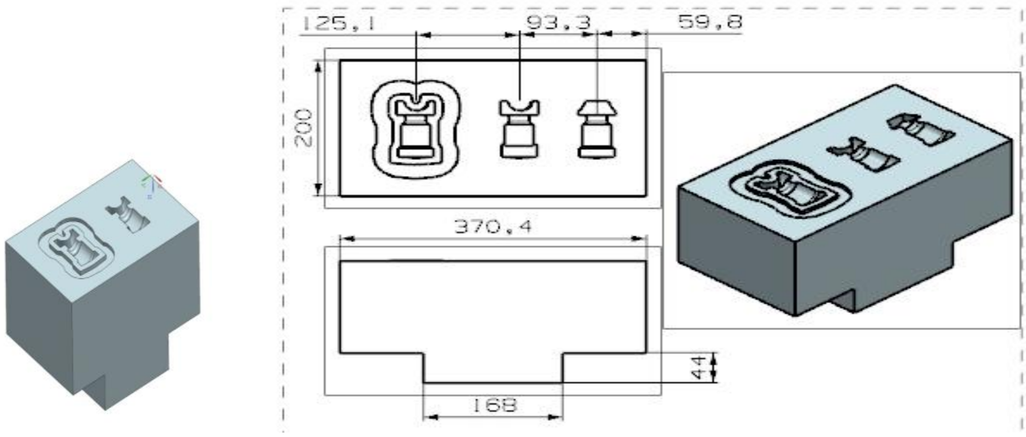

Figure 2.1: the geometry of die.

III. Modelling of die

The modelling of die is done by using Nx 7.5.

Modelling of component.

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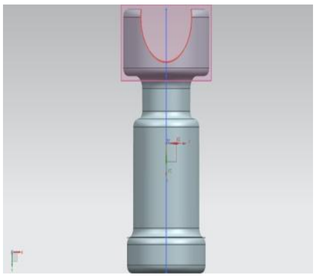


Fig 3.1 component model.

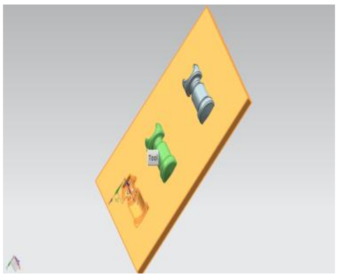


Fig 3.2 the similar shapes

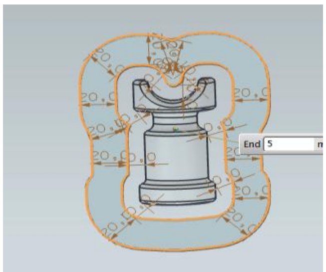


Fig3.3 shows finisher operation

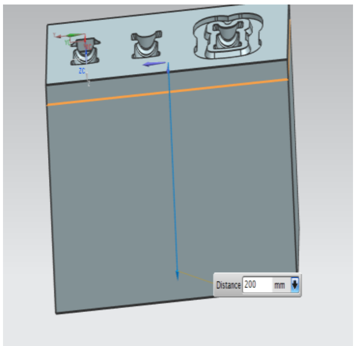


Fig 3.4 die block

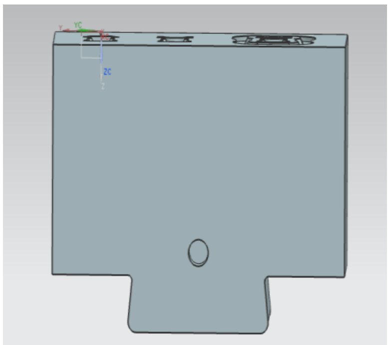


Fig 3.5 full die with dovetail.

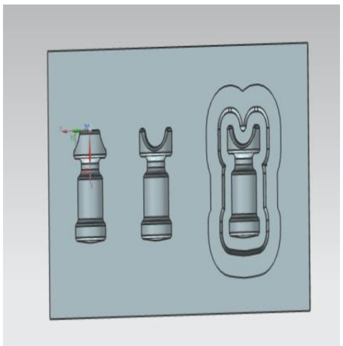


Fig 3.6 die with operation

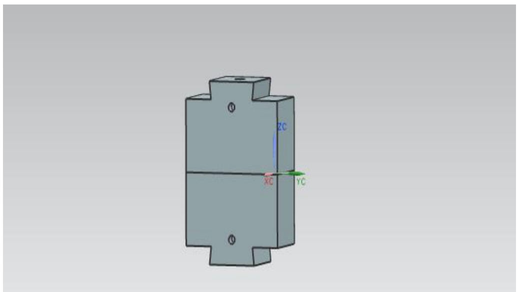


Fig 3.7 Assembly of die.

IV. Analysis

Analysis of die: The die is imported from uni graphics to ANSYS 11.0 in parasolid format for further analysis. In this contact , fatigue and transient analysis are carried out for die.

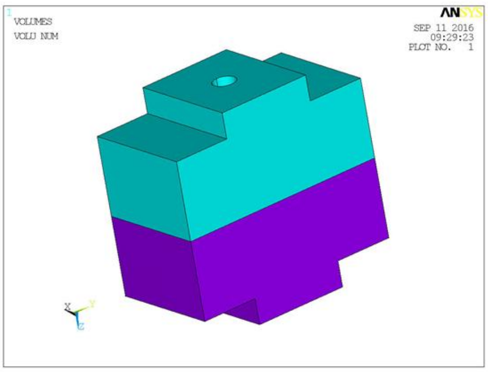


Fig 4.1 : imported file from ug.

Contact analysis: This analysis is carried out whether to check the applied force is sufficient for contact of die. In this analysis three different forces are taken according to check the applied load is sufficient or not.

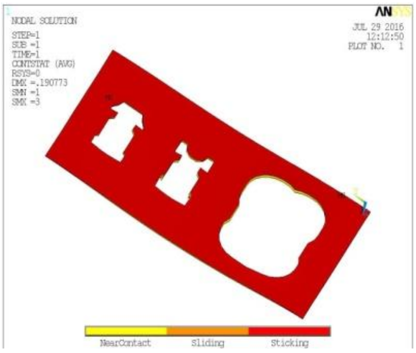


Fig 4.2 contact status for die assembly for case -1

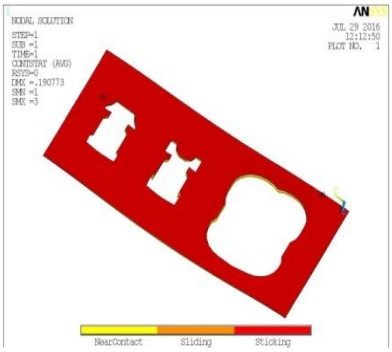


Fig 4.3 contact status for die assembly for case-2

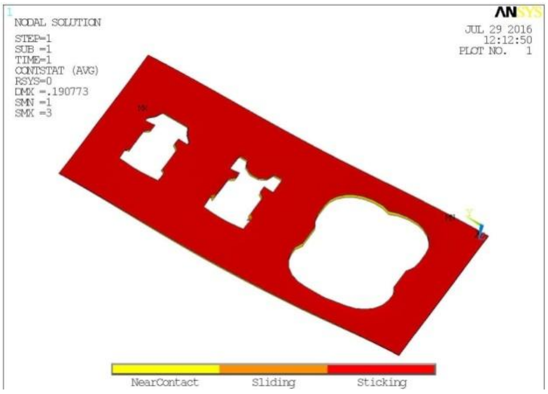


Fig 4.4 contact status for die assembly for case 3

Fatigue analysis : The maximum and minimum principle stress obtained from the contact analysis is given as input in the Goodman diagram tool . The material properties like maximum principal stress and minimum principle stress. The values given for the three load cases are shown

By using the goodman diagram life of the die is shown.

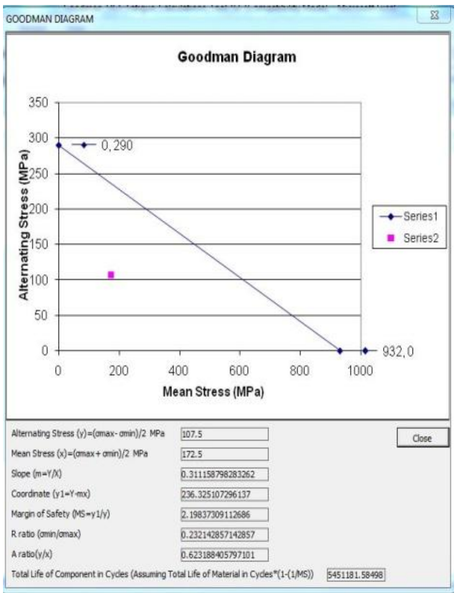


Fig 4.5 for case 1 die life.

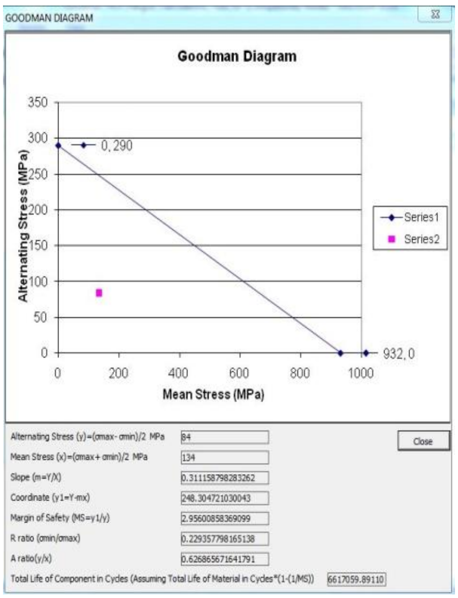


Fig 4.6 for case 2

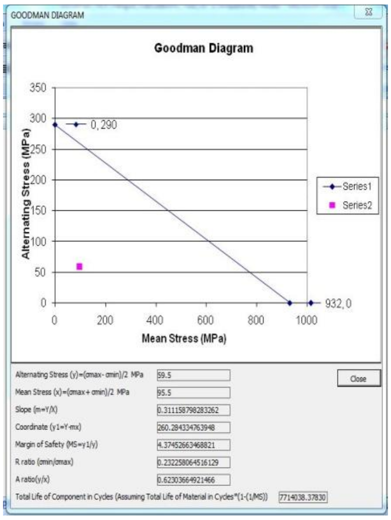


Fig 4.7 case 3

Transient analysis: The die structure is subjected to load per 2 seconds. The below analysis is carried out for a 2 seconds. The whole load acting is considered as one load step and the load step is divided into 50 sub steps for better convergence.

The boundary conditions are applied for the transient analysis are as follows.

- The Force will be different for three load cases distributed on the upper side surface of the die.
- The bottom surface of the die is constrained in all DOF for all the cases.
-

Transient loading for existing die

Loadstep-1	**Displacement**	**Von misses stress**	**Factor of safety**
Substep-1	0.0039	15.4	42.5
Substep-5	0.0196	77.1	8.5
Substep-10	0.0393	154.2	4.2
Substep-15	0.0589	231.3	2.8
Substep-20	0.0786	308.4	2.1
Substep-25	0.0982	385.5	1.7
Substep-30	0.1179	462.6	1.4
Substep-35	0.1375	539.7	1.2
Substep-40	0.1572	616.8	1.06
Substep-45	0.1768	635.5	1.03

Table 4.1

Transient loading for modified die

Loadstep-2	**Displacement**	**Von misses stress**	**Factor of safety**
Substep-1	0.0020	8.21	79.9
Substep-5	0.0103	41.0	16
Substep-10	0.0206	82.1	7.9
Substep-15	0.0310	123.2	5.3
Substep-20	0.0413	164.2	3.9
Substep-25	0.0516	205.3	3.1
Substep-30	0.0620	246.4	2.6
Substep-35	0.0723	287.4	2.2
Substep-40	0.0826	328.5	1.9

Table 4.2

V. Results

For load case 1: The height of the weight falling on the die is 900 mm. The force calculated for the case-1 condition is shown below.

F= P/ t

P= mv

= 1300x4.2

= 5460 kg m/sec

F= 2730N

Contact analysis:

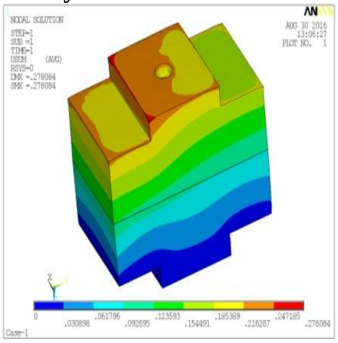


Fig 5.1 total delfection

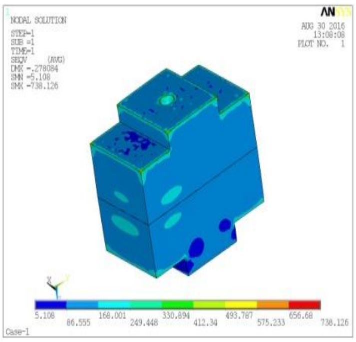


Fig 5.2 von mises **stress**

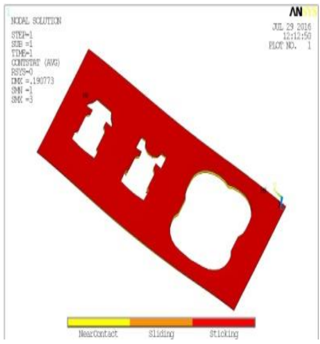


Fig 5.3 contact status

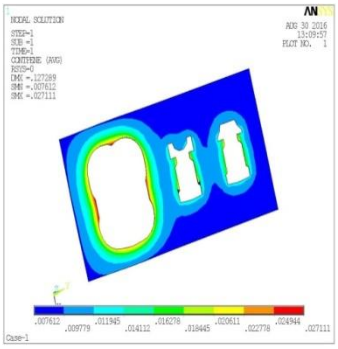


Fig 5.4 contact pentration

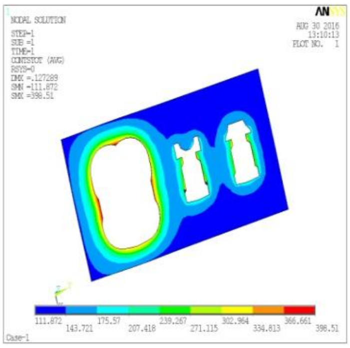


Fig 5.5 contact stress

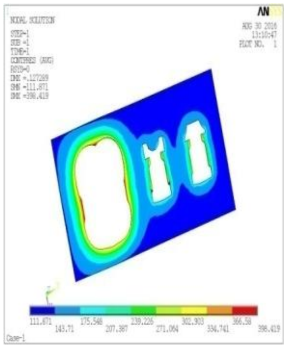


Fig 5.6 contact pressure

S.no	Item	Case-1
1	Total Deflection (mm)	0.27
2	Von Mises Stress (N/	330
3	Contact status	Sticking
4	Contact Penetration (mm)	0.027
5	Contact Stress(N/mm2)	398
6	Contact Pressure(N/mm2)	398

Fatigue analysis for load case -1

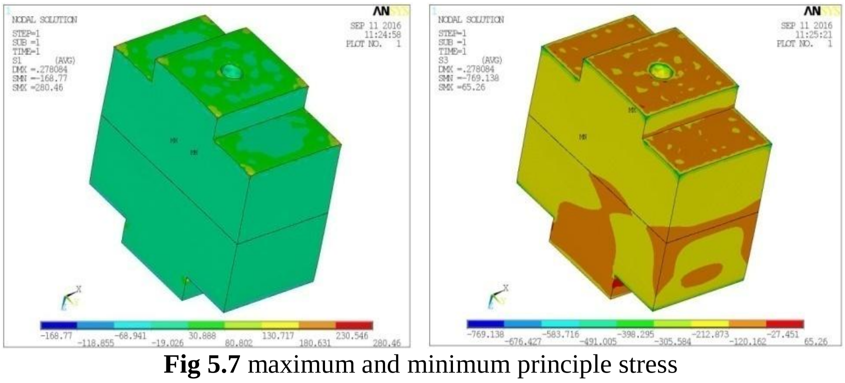


Fig 5.7 maximum and minimum principle stress

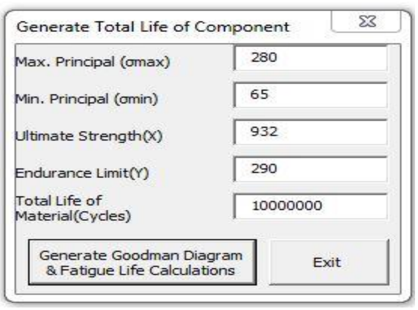
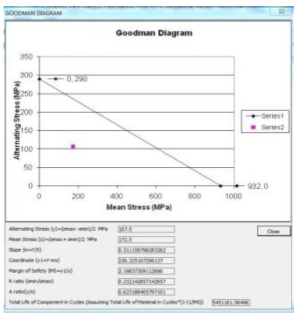


Table 5.1 shows goodman tool



Graph 5.1 shows life of die for case 1

It is observed that the Goodman point falls within the limits of Goodman line. From this it can be said that the total life of die assembly is 5451181 cycles.

Load case -2

For case-2 the height of the weight falling on the die is 700 mm. The force calculated for the case-2 condition is shown below.

F= P/ t

P= mv

= 1300x3.70

= 4816.5 kg m/sec

F= 2408N

Contact analysis

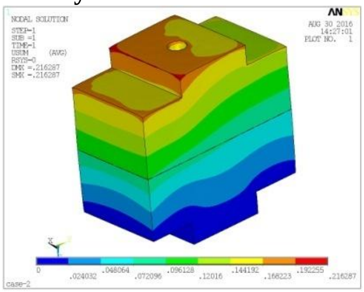


Fig 5.8 displacement

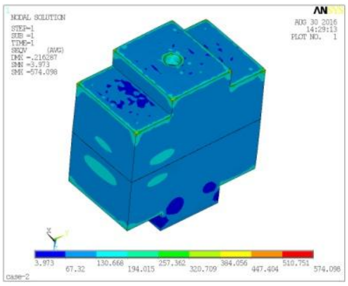


Fig 5.9 von moises stress

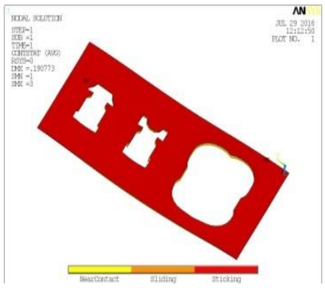


Fig 5.10 status

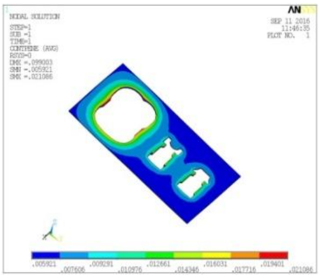


Fig 5.11 conatct pentration.

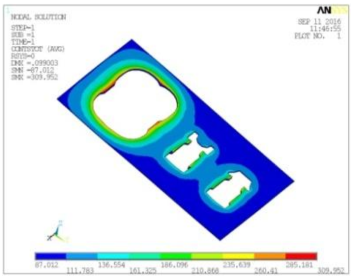


Fig 5.12 contact stress

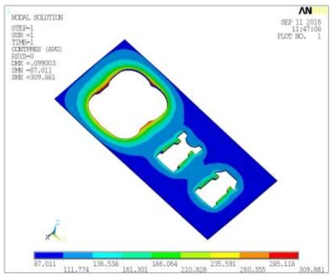


Fig 5.13 contact pressure.

S.no	Item	Case-1
1	Total Deflection (mm)	0.21
2	VonMisesStress(N/mm2)	320
3	Contact status	Sticking
4	Contact Penetration (mm)	0.021
5	Contact Stress (N/mm2)	309
6	ContactPressure(N/mm2)	309

Fatigue analysis for laod case 2

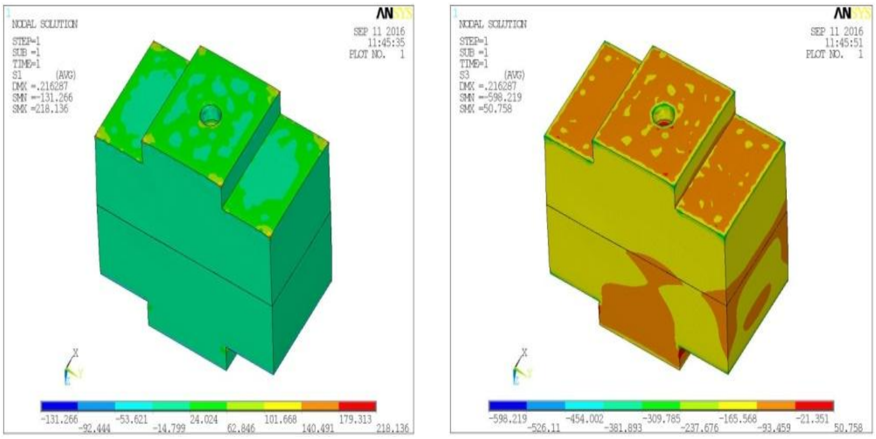
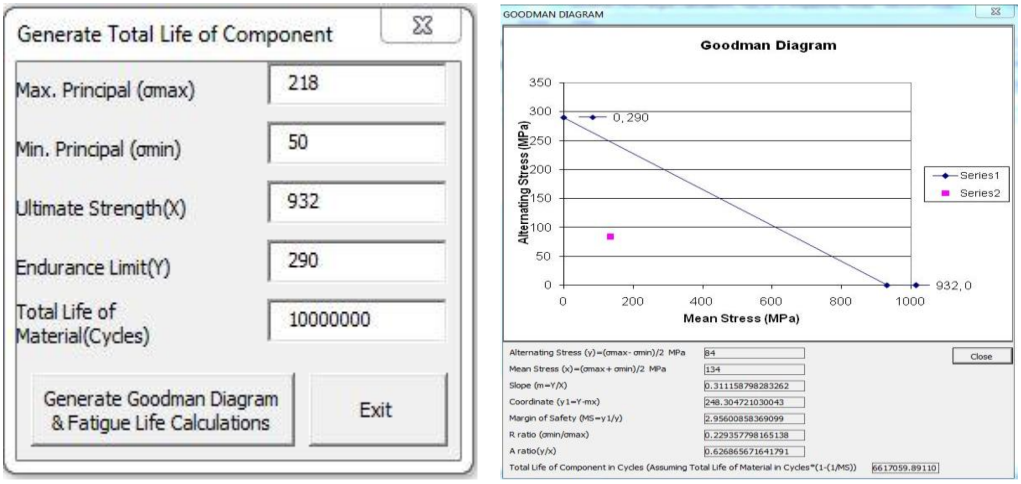


fig 5.14 maxmium and minimum principle stress



Graph 5.2 life for case 2

It is observed that the Goodman point falls within the limits of Goodman line. From this it can be said that the total life of die assembly is 6617059 cycles**.**

Load case 3

For case-3 the height of the weight falling on the die is 500 mm. The force calculated for the case-3 condition is shown below.

F= P/ t

P= mv

= 1300x3.132

= 4071.6 kg m/sec

F= 2035.8N

Contact analysis for load case 3

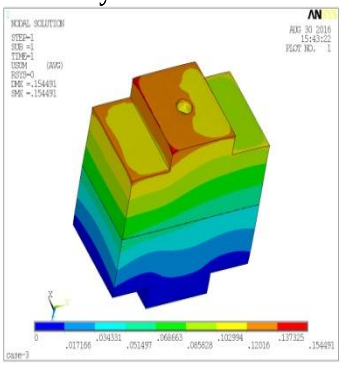


Fig 5.15 displacement

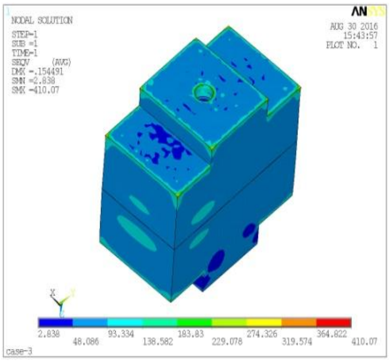


Fig 5.16 vonmoises stress

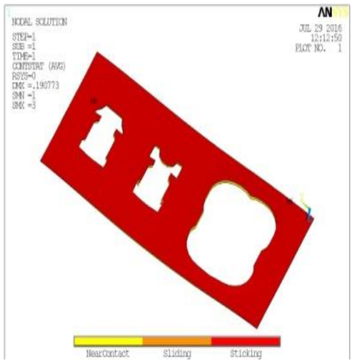


Fig 5.17 status

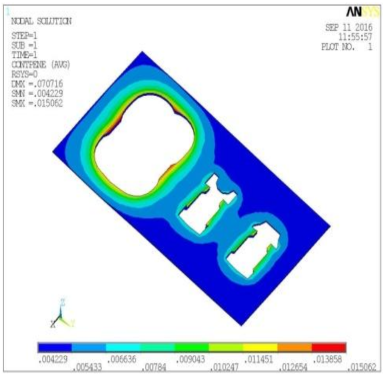


Fig 5.18 contact pentration

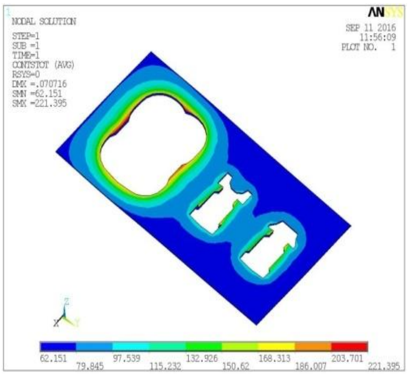


Fig 5.19 contact stress

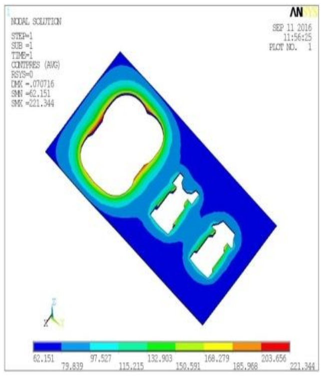


Fig 5.20 contact pentration

S.no	Item	Case-1
1	Total Deflection (mm)	0.15
2	VonMisesStress(N/mm2)	229
3	Contact status	Sticking
4	Contact Penetration (mm)	0.015
5	Contact Stress (N/mm2)	221
6	ContactPressure(N/mm2)	221

Fatigue analysis

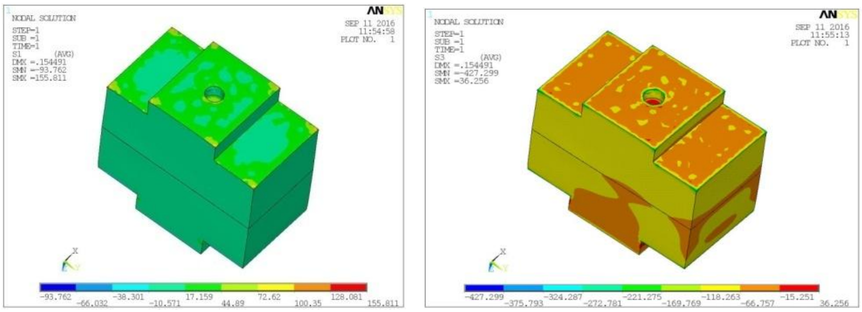
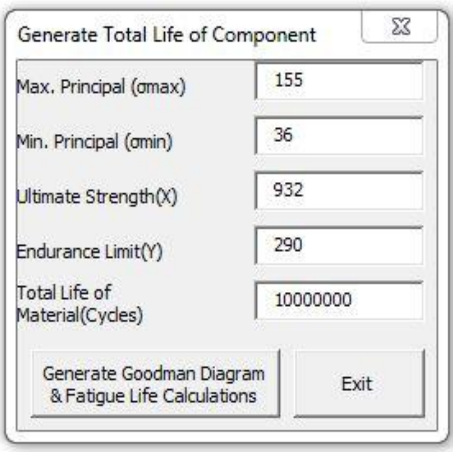
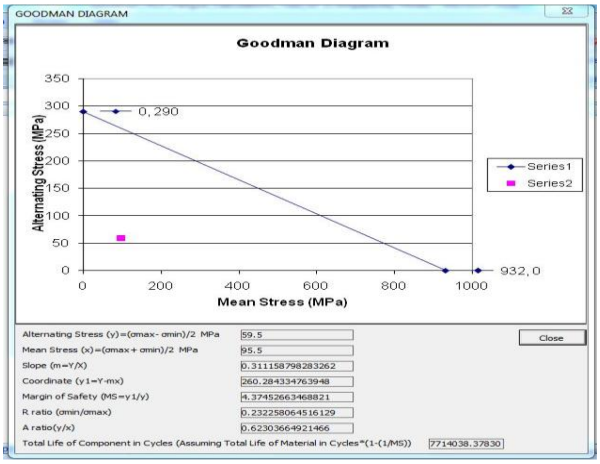


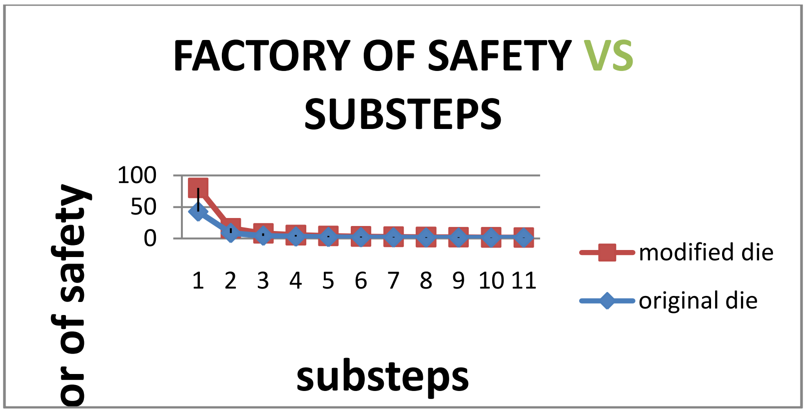
Fig 5.21 maxmium and minimum principle stress





Total life of die assembly is 7714038 cycles.

Transient analysis



Graph

VI. Conclusion

3d model of die was generated by using NX-CAD software. 3d model of die was modified by increasing an operation on the die.3d model of modified die was subjected to Contact analysis in ANSYS software for 3 load cases. Modified die assembly had perfect contact for 3 load cases and die assembly was safe for all load conditions. Fatigue analysis was done on the die assembly for 3 load conditions. For all the load cases, Die assembly has infinite cycles and die assembly was safe. Original Die and modified die were subjected to transient analysis to check the behaviour of die for transient loading. Both Original die and Modified die had Von misses stress less than the yield strength of the material at all sub steps of Load step-2.So, both dies were safe for transient loading. In all the sub steps, factor of safety of modified die was high compare to original die. From these, it was concluded life of the modified die is more compare to original die.

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[2] Preliminary research for the development of a hot forging die life prediction model by Thomas Grobaski.
[3] Finite element stress analysis of forging dies to improve their fatigue life by K. Dehghani, A. Jafari.