Design optimisation of Hydraulic press structure

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Abstract- The hydraulic pressing machine for 800 tones load is modelled using Ansys parametric design language using scalar parameters. Due to symmetry only quarter section is built. The boundary conditions are applied and problem is solved in static domain. The results shows maximum vonmises stress of around 71.851 N/mm2 and displacement of around 0.7077mm.The structure is optimised for weight using design optimiser which is based on size optimisation. The design and state variables are set and weight is set as objective function. A total of 13 feasible sets are obtained and best set weight is observed to be around 4625.7 kg for quarter section and 18502 kgs for full structure. The optimised structure vonmises stress is around 136 N/mm2 and deflection of around 1.67mm. Graphs are represented for variation of geometry (Weight), vonmises and deflection with reference to number of iterations. The graphs shows drop of weight with reference to increased number of iterations. Also stress and deflection can be observed in the structure. But finally around 23% weight reduction can be observed at the end of size optimisation.

Keywords – **Optimisation, Hydraulic press, Vonmises Stress, deformation.**

I. INTRODUCTION

Optimization is a popular subject in finite element analysis, and is becoming more important goal in the product development process analysis. This trend is facilitated by the ever-increasing computing power used to solve analysis problems. For the design engineer, it is often the real end goal.

A. Basic concept of optimisation –

Optimization is quite an interesting aspect of engineering practice that cuts across all branches of engineering. In the production sector, for example, the reduction of material (Figure 1) used in manufacturing is possible when optimization is incorporated beforehand.

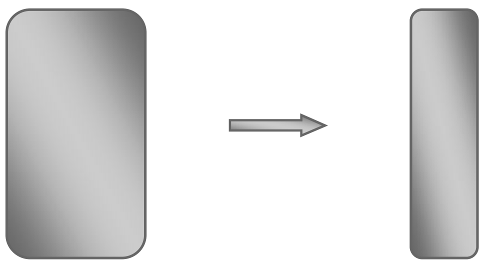

Figure. 1 Material reduction

B. Defination of Optimisation –

Optimization can be defined as the process of finding the conditions that give maximum or minimum value of a ‘function’. Where effort required or benefit desired for a given practical situation is expressed as a ‘function’ of certain design variables. This is illustrated in the Figure 1

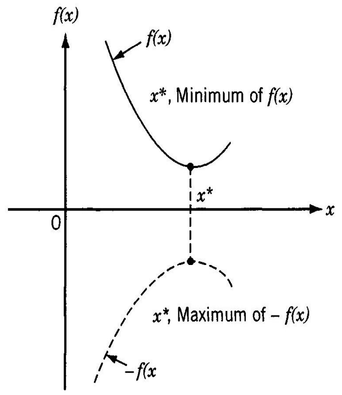

Figure. 2: Minimum or Maximum Value of an expression

II. PROBLEM DEFINATION AND FINITE ELEMENT MODEL DEVELOPMENT

A. Defination –

Study of usage of design optimisation in reducing the weight of structure within the functional requirements (displacement and stress) of the problem.

B. Problem Requirement –

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C. Main Objective-

Modelling of the problem for the given dimensions Representation of the problem using APD Iterating the problem for the best design sets.

III. PROBLEM DEFINATION AND FINITE ELEMENT MODEL DEVELOPMENT

Material: Structural Steel

Allowable stress =180 N/mm^2

Poison's ratio=0.3

Weight density=7800kg/m^3

IV. PROBLEM DEFINATION AND FINITE ELEMENT MODEL DEVELOPMENT

Maximum deformation allowed =3 mm
Allowable stress =180 N/m m^2

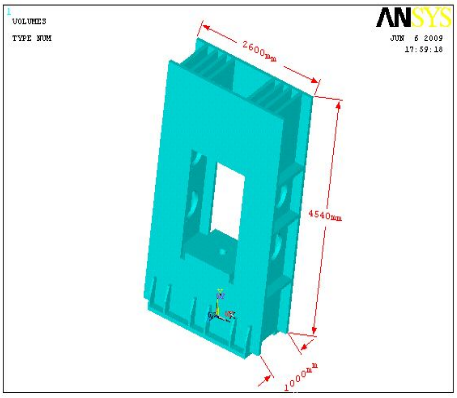

Figure.3: 800 tone press structure for forge welding

The above structure shows Hydraulic pressing machine. The machine structure is having a total height of 4540mm, 2640mm width and 1000mm breadth. The machine is mainly made of mild steel plates and ribs. Cut outs are created to reduce the weight of the structure. The above picture represents meshed plot of the problem. Also boundary conditions are shown in the problem. The base frame of 100 mm height is supported where the table is placed for forging operation. The hydraulic cylinders are mounted on

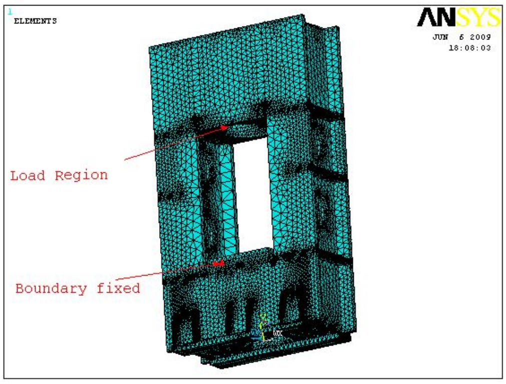

Figure.4: Meshed plot with boundary conditions.

The above picture represents meshed plot of the problem. Also boundary conditions are shown in the problem. The base frame of 100 mm height is supported where the table is placed for forging operation. The hydraulic cylinders are mounted on the top and load will be applied on the top of the plate where forging components are placed.

V. ASSUMPTIONS

Material is assumed to isotropic and homogenous All FEM approximations are applied to analysis Reaction load is considered for analysis. Ansys Design optimiser is used for analysis10 noded tetrahedral element is used for meshing and analysis

VI. ELEMENTS USED

8 noded solid 45 :

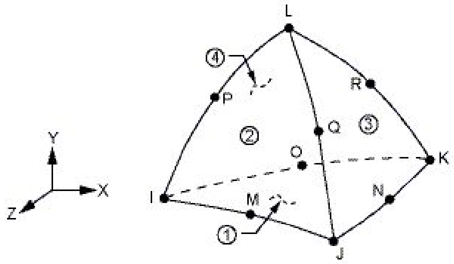

Figure.5: Solid45 element

SOLID92 is used for the 3-D meshing of solid structures. The element is defined by 10 nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. The element is defined by ten nodes and the orthotropic material properties. Orthotropic material directions correspond to the element coordinate directions. Pressures may be input as surface loads on the element faces as shown by the circled numbers.

VII. Results and Discussions

A. Results for design Optimization –

The machine structure has been analysed with 3 different design approaches. Initially design optimiser results are presented.

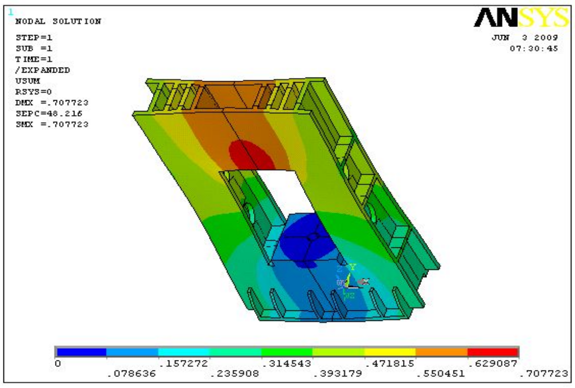

Figure.6: Displacement plot of the problem

The above picture shows displacement in the structure. Maximum displacement value is around 0.7077 mm shown with red colour. Exactly at the centre of the loading platform more displacement can be observed. Different color patterns represent distributed displacement on the structure.

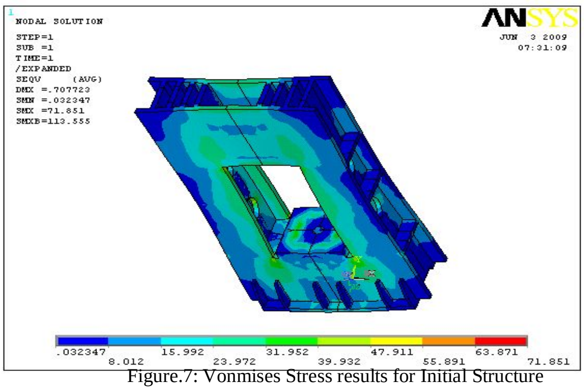

Figure.7: Vonmises Stress results for Initial Structure

The above structure shows vonmises stress distribution in the structure. Maximum vonmises stress is around 71.851 N/mm^2 which is less compared to the allowable stress of 180 N/mm^2. The stress is a localised, so more chances for material saving. The structure is having initial weight of 28.5 tons. Design optimisation process is carried out with the design requirements of allowable stress of 180 N/mm^2 and maximum displacement of 1.25mm. The design results are as follows.

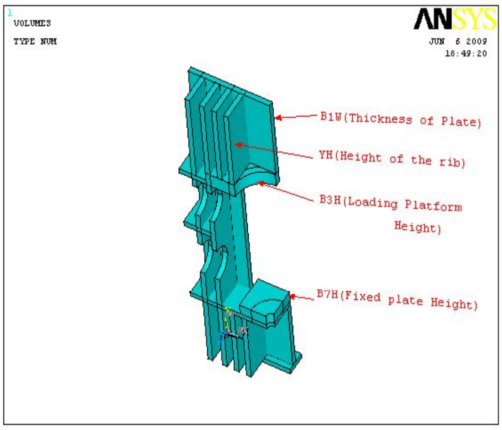

Fig.8 Optimization parameters

The above picture represents optimisation parameters. Totally 4 design parameters are used to represent the problem or to reduce the weight. B1W, YH, B3H & B7H representing the thickness of strengthening and support plates are used for optimisation.

B. Optimised Structure Results –

	SET 1	SET 2	SET 3	SET 4
MAX DISP	0.7877 9	0.9656 7	0.9895 2	0.9332 0
MAXS	88.733	90.503	92.425	89.526
B1W	71.179	63.439	61.727	67.379
B3H	145.72	161.79	132.03	107.00
YH	310.88	678.40	634.35	278.35
B7H	134.62	100.17	129.11	105.62
WT	6406.8	5517.4	5436.4	6041.2
	SET 5	SET 6	SET 7	SET 8
MAXDIS P	0.8874 0	1.2563	1.2566	1.2609
MAXS	88.498	103.09	103.23	106.93
B1W	63.244	53.287	52.107	52.270
B3H	198.95	108.33	110.08	110.04
YH	505.63	757.73	787.16	795.71
B7H	107.54	115.66	140.61	141.18
WT	5742.3	4698.0	4648.4	4654.1
	SET 9	SET 10	*SET 11*	SET 12
MAXDIS P	1.2496	1.2415	1.2533	1.2539
MAXS	105.28	108.14	108.93	109.88
B1W	51.533	50.428	50.153	50.071

B3H	110.60	109.48	105.72	103.99
YH	740.50	659.31	624.86	601.32
B7H	140.99	141.93	142.45	143.08
WT	4645.3	4627.3	4625.7	4634.2
	SET 13			
MAXDISP	1.2502			
MAXS	109.46			
B1W	50.073			
B3H	104.49			
YH	601.54			
B7H	143.13			
WT	4635.3			

Table -1: Optimization table for bottom frame

The above table represents optimisation results. The bottom structure has been optimised for the design constraints and best set shown with'*" mark in the above table. Totally 13feasible sets are obtained for four design variables. The optimised weight is shown as 4625.7 Kg. The best design set is shown by '*' mark in the table.

Figure.9: Final Optimized Structure

The above picture shows optimised model for the bottom frame. The parameters for optimisation, 'B1W', 'B3H','YH' and 'B7H' are also shown. Initial values of 75, 200, 1300,150 mm are reduced to 50.153, 105.72, 624.86, 142.45 mm respectively.

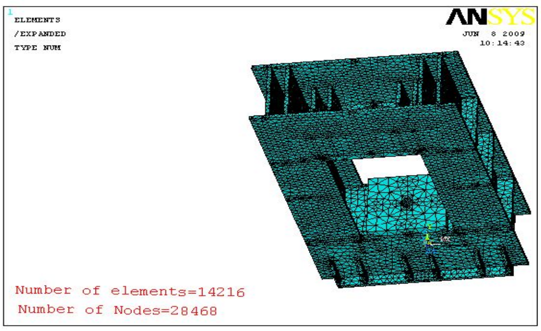

Figure.10: Final Geometry element plot

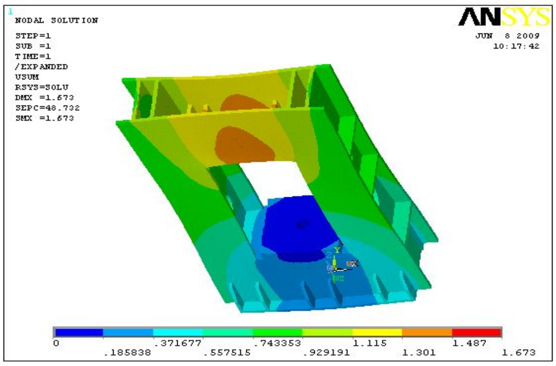

Figure.11: Final Displacement plot of the problem

The above picture represents final displacement in the structure. The maximum value is around 1.673 mm.

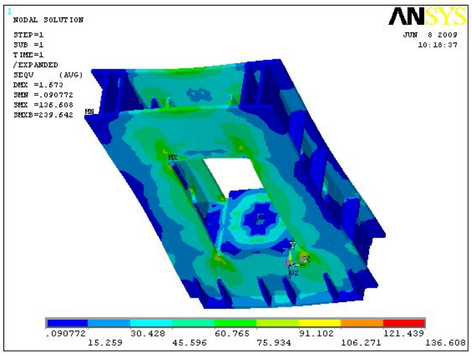

Fig.12: Vonmises Stress results

The above picture shows vonmises stress in the structure. Maximum vonmises is around 136.608 N/mm^2 concentrating around the ribs and support zones. The symbol ‘MX’ shows maximum stress region in the problem.

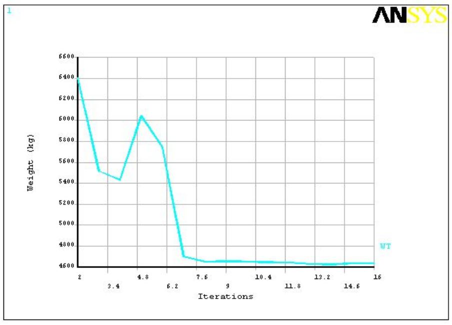

Figure.13: Iteration vs Weight

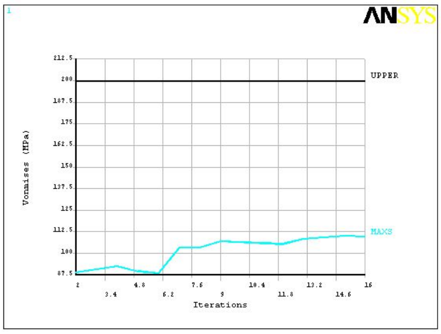

Figure -14: Iteration Vs Maximum Stress

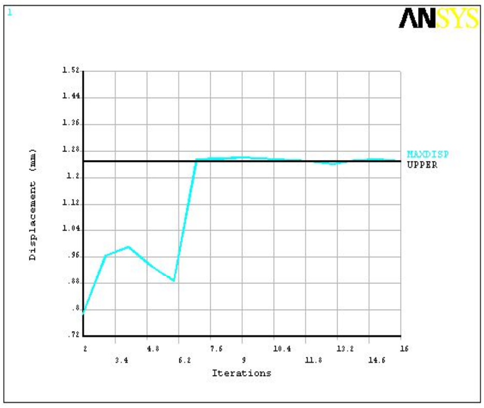

Figure -15: Iteration vs Displacement

The above graphical picture obtained from design optimiser tool shows; drop in weight with reference to increased number of iterations. But at the same time stress and deformations are increasing in the structure. In all the graphs, slope is more pronounced in the beginning and later slopes are not much varying excepting for deformation. The term 'upper' represents the top margin or state variable constraint for the particular criteria like displacement, stress etc.

VIII. CONCLUSIONS

The hydraulic pressing structure used for forging operation is optimised using design optimisation, technique. The conclusions is as follows.The hydraulic pressing machine for 800 tones load is modelled using Ansys parametric design language using scalar parameters. Due to symmetry only quarter section is built. The boundary conditions are applied and problem is solved in static domain. The results shows maximum vonmises stress of around 71.851 N/mm2 and displacement of around 0.7077mm.The structure is optimised for weight using design optimiser which is based on size optimisation. The design and state variables are set and weight is set as objective function. A total of 13 feasible sets are obtained and best set weight is observed to be around 4625.7 kg for quarter section and 18502 kgs for full structure. The optimised structure vonmises stress is around 136 N/mm2 and deflection of around 1.67mm. Graphs are represented for variation of geometry (Weight), vonmises and deflection with reference to number of iterations. The graphs shows drop of weight with reference to increased number of iterations. Also stress and deflection can be observed in the structure. But finally around 23% weight reduction can be observed at the end of size.

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