Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
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DAAAM Symposium

FEM ANALYSES OF CONNECTIONS FOR SEVERAL STRUCTURES OF A HYDRAULIC RADIAL FORGING MACHINE

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Abstract: The aim of this paper is stress-strain analyses of several structures of a hydraulic radial forging machine in order to find the most suitable frame. The structure consists of four hydraulic units and connection elements. The frame can be designed as one piece or as four hydraulic units and their connections. Three variants were judged according to radial deformation and stress distribution in the frame by FEM analysis.

Key words: hydraulic, forging, structure, FEM

1. INTRODUCTION

The machine for radial forging can be designed with two basic drive principles - hydraulic or mechanical. This kind of machine is mostly used for forging of straight long bars with a changes of the biggest disadvantage of the mechanical drive is, as for typical presses, the stroke is more complicated to adjust. Machines with a hydraulic drive and other necessary conditions like suitable design, sophisticated drive system, gauging devices and manipulators allow the working stroke to be adjusted during the forging process. This also allows greater production flexibility to be achieved. The machine is considered to be a part of a complex automated forging centre consisting of an induction heater, a manipulator for 3D manipulation with forgings and a hardening tank, and so on.

Fig. 1. Hydraulic unit

2. PROBLEM DESCRIPTION

The aim of this paper is to design a frame for a forging machine and to analyze how to connect four hydraulic units (Fig. 1), or to make a monoblock frame. The hydraulic forging machine with hydraulic drive enables each swage to be independently controlled. This method of forming enables forging of shaped bars and forging profiles with a strong directional axis. Forgings can be used as finished products or as ideal blocks for selected types of more complicated drop stampings. Development of the experimental equipment is planned for reducing semi-finished products with a maximum dimension of 150 mm to smooth or stepped.

The machine has exactly four ram, because of the most used shapes of forged bars. The bars can be with circular, rectangle or square cross section. The four rams should be in an x-shaped arrangement what means that the axes of rams are not in horizontal and vertical positions, but turned for 45 degrees. This brings us several advantages. The first one is that hammer scales can during the forging process fall down from the workplace and do not stay on the bottom ram.

3. PROBLEM SOLUTIONS

The first basic and most conventional method (Fig. 2) is to bore holes in one piece of material for the cylinders. The connection between hydraulic cylinders and frame is same as a connection between cylinders and body of hydraulic unit. In this case are gauging devices placed on the front side of the frame. The model for FEM analysis is load by nominal radial forces in places of hydraulic units covers. Covers are screwed into the frame. In these places is a thread transferring radial forces to the frame. On the bottom surface are not allowed displacements in all directions. In this place is supposed to be a connection with a stand. Such a closed frame has the highest rigidity but it also requires more material and it is obviously heavier.

The second approach to make a frame is to connect four hydraulic units using welded triangles as connecting elements. Connection between the units and the triangle welds is realized by preloaded bolts which are screwed into elements of the hydraulic units.

Fig. 2. Ilustration of the first variant and boundary conditions

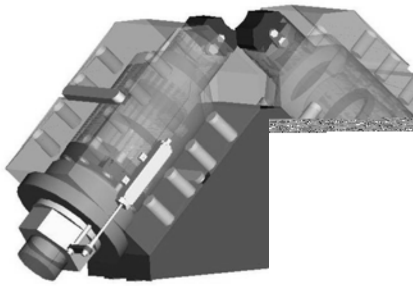

Fig. 3. Ilustration of the second variant

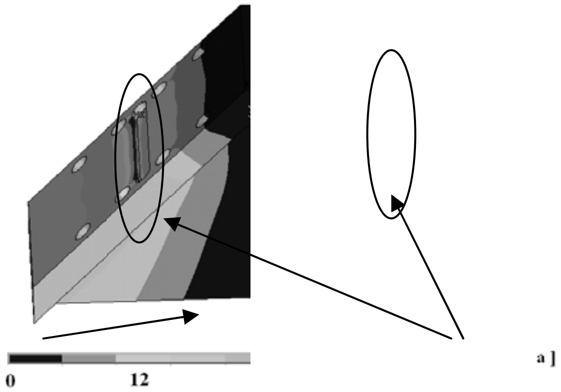

Fig. 4. Equivalent stress distribution welded triangle

Radial forces originating from the forging process are transferred by two opposing crosswise keys. In this variant was model for FEM analysis simplified to one fourth of the frame (Fig. 3). Radial forces were divided between nodes on area where a contact between keys and welds is. Displacements in axis Z were not allowed for all nodes because we were not counting with asymmetrical load of the frame. For nodes on contact surfaces with hydraulic units were displacements in direction towards hydraulic unit set u=0. In these directions is the weld leaned against the hydraulic unit's bodies. In this calculation we supposed hydraulic units as absolutely rigid.

The third way of connecting the hydraulic units uses plates from ultra high strength steel. On each side of the machine there are two layers of plates and each layer consists of four pieces of plate (Fig. 5). The plates are connected to the hydraulic units using preloaded bolts. The transfer of forging forces is ensured by circular keys which go through both layers of plates and part of hydraulic unit. For the support of plates are between hydraulic units placed brace struts. In this variant was model for FEM analysis simplified to one layer of plates (Fig. 5). Four plates in this layer were connected by rigid coupling in holes for circular keys. These couplings simulate the bodies of hydraulic units which hold plates together. Displacements were not allowed only in normal direction to the layer. The model was loaded in holes for circular keys by the radial force. The force was equally divided between holes.

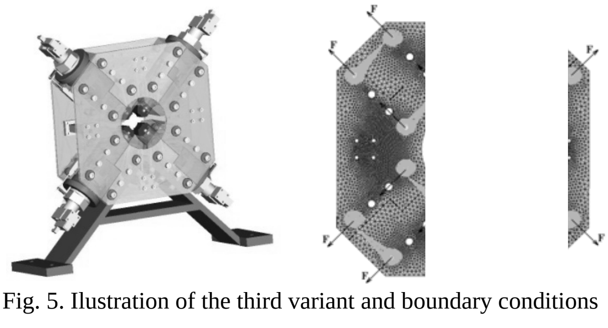

Fig. 5. Ilustration of the third variant and boundary conditions

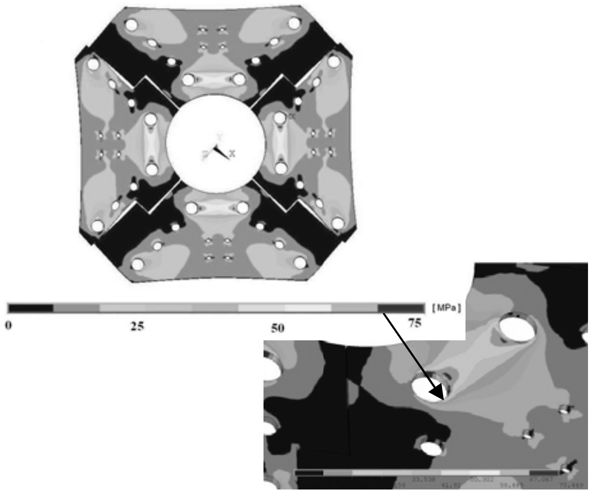

Fig. 6. Stress distribution in the third variant

4. EVALUATION OF VARIANTS

For comparing of all variants we have to take a closer look at deformation and stress distribution results. From the stress viewpoint are all of variants suitable. In all variants don't reach stresses up to 80MPa (Fig. 4 and Fig. 6). Resultant value of deformation consists in each case of different sub deformation which have to be taken in consider. The easiest is the first variant where the biggest displacement is the final deformation. In the second variant the final deformations consist of the biggest deformation of welded triangles which is in area of crosswise keys (for that distance will move whole hydraulic unit) and deformation of hydraulic unit. Especially deformation of the part of unit where is a contact with the cover of hydraulic unit. Equal situation is in the third variant where the final deformation consists of radial deformation of circular keys. That deformation would be valid only in condition that all layers were loaded equally. For that displacement we have to also add the deformation of hydraulic unit.

5. CONCLUSION

Three frame designs were designed and then checked by FEM analyses. The main purpose of the analyses was to determine and compare radial deformation and stress distribution in the frames. Variant three was chosen because it had the best ratio of material usage and frame rigidity. According to the results will be designed and manufactured frame for the machine.

6. ACKNOWLEDGEMENTS

This paper includes results created within the project 1M06032 Research Centre of Forming Technology. The project is carried out within the framework of the Research Centres (1M) programme and subsidised from specific resources of the Czech state budget for research and development.

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