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Procedia Engineering 69 (2014) 1064 – 1069

Procedia Engineering

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24th DAAAM International Symposium on Intelligent Manufacturing and Automation, 2013

Using of a Hydraulic Press in Production and Manufacturing of Large Rings

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Abstract

This article deals with possibilities of using a hydraulic press in production of large forged rings. These rings are used in nuclear or petrochemical industry. Three methods for their production are supposed and evaluated in terms of energy. Because production of large rings causes specific loading of hydraulic press, FEM simulation is performed. The result is complex design for large rings production machine.

Selection and peer-review under responsibility of DAAAM International Vienna

Keywords: forming machines; hydraulic press;ring rolling; FEM simulation

1. Introduction

Demand for large rings is caused by the development of nuclear power plants. For the construction of nuclear reactors are large steel rings with diameters up to 10 meters necessary. The height of the ring can be up to 6 meters. Production of rings with these dimensions allows you to modify the current design of a reactor vessel. A design with a lower number of rings is better, because there are not so many welding operations [6].

Production of rings with these dimensions is not possible in a normal hydraulic forging press (Fig. 1) described in [1, 2, 3]. The distance between columns of the press B_1 must be greater than the diameter of the ring D_K. Also maximal distance between places for tools R_{MAX} must be greater than diameter of the ring D_K. And finally, the length of ring L_K must be less than length of forging table L_{ST}. For rings with diameter around 10 meters is there not such a big press in the whole world. It would be possible to design a hydraulic press with this enormous size, but it would cost a large amount of money.

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Selection and peer-review under responsibility of DAAAM International Vienna
doi:10.1016/j.proeng.2014.03.091

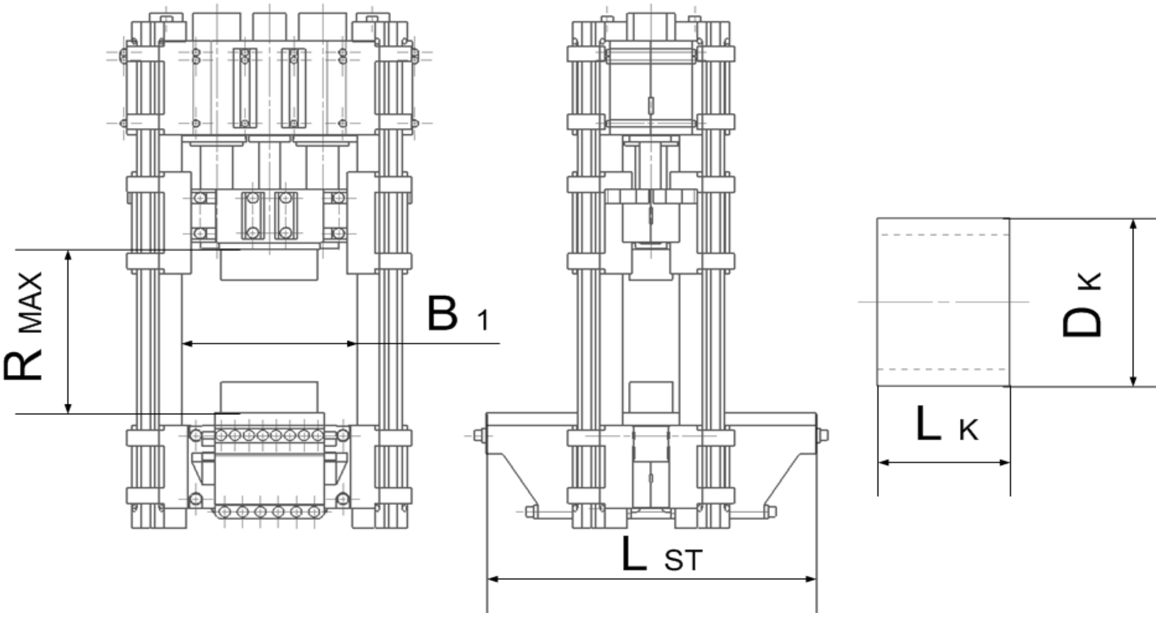

Fig. 1. Dimensions of hydraulic press and forged ring.

Another option for producing these rings is to produce them in special equipment for rolling. This rolling device must also cooperate with the hydraulic forging press. This press can have smaller parameters, because it will produce only stocks for a ring rolling machine. Special rolling equipment also means additional investment in production.

Therefore potential extreme ring manufacturers are looking for new solutions to their production.

2. Device for forging rings - variant 1

The principle of the solution is in inserting a special crossbar, which is adjustable, supported on one side and on the other side is a tool. Force is transmitted between the movable crossbeam of the press and this crossbar. Between the tool and the lower crossbeam is formed a ring, hanging on the mandrel.

Special shims can be adjusted depending on the thickness of the forged ring. In this variant there is no maximum limit to the diameter of the ring.

3. Device for forging rings - variant 2

The functional principle of variant 2 is an additional hydraulic mechanism. A movable crossbeam pushes the plunger of the additional mechanism. This causes an increase of pressure and motion of the output member which is forming the ring. In this variant there is no limit to the maximum diameter of the ring.

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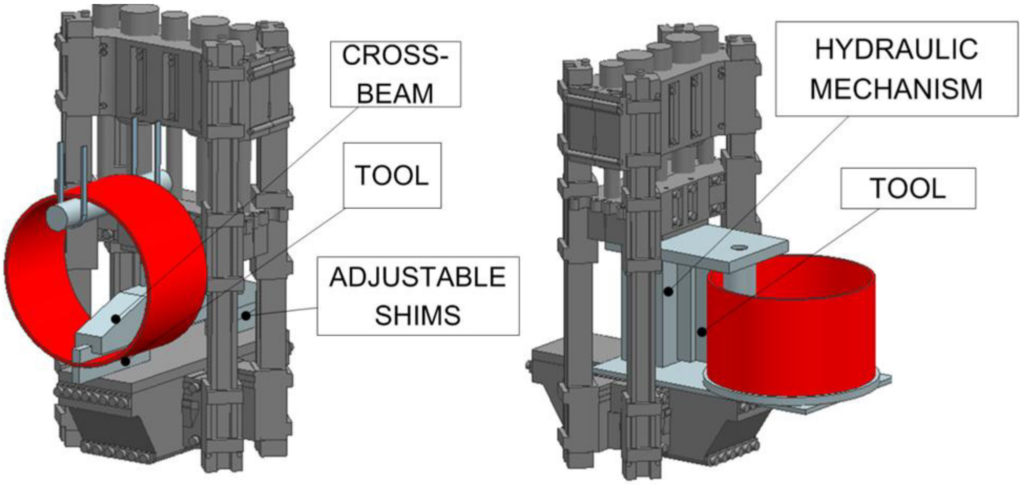

Fig. 2. Device for forging rings (left-variant 1, right-variant 2)

4. Device for rolling rings

This option is a combination of forging and rolling rings. In the hydraulic press is ring forged up to maximum dimensions allowed by the press.

After forging in the hydraulic press, ring with the forging mandrel is transferred to the rolling equipment. The forging mandrel has in the rolling equipment the function of rolling. The final shape of the ring is created by rolling. This operation is situated next to the hydraulic press.

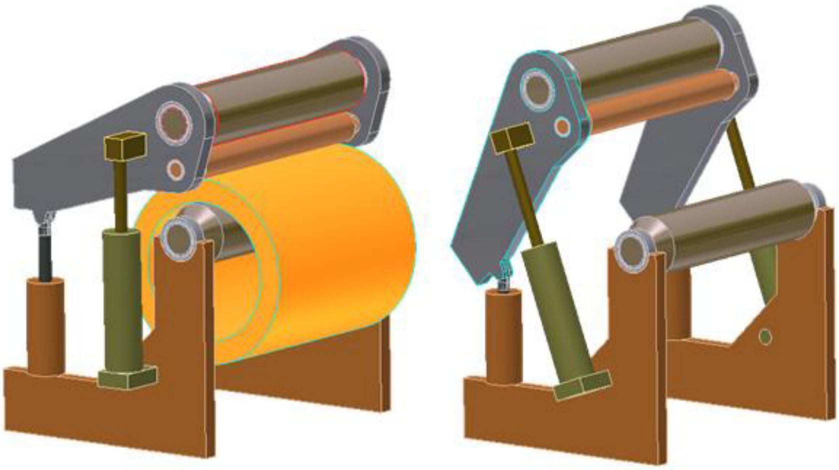

Fig. 3. Device for rolling rings.

5. Evaluation of all variants

Technological evaluation was carried out using the Deform 3D program, which is used for forming process simulations. The energy necessary for creating similar rings by both methods (forging by variants 1,2 or rolling by variant 3), is compared here.

For comparison of these two methods, production of a ring with initial wall thickness 475 mm and final wall thickness 430 mm is chosen.

Production of forged rings is from material point of view described in [9]. In the following text is shown energetic point of view and comparing of different possibilities of production.

5.1. Energy required for creation of a ring

The FEM simulation of forging has two steps. The first step is pushing the tool into the ring. The second steps simulate the steps after the first step. The forged ring is rotated in step two and pushed by the tool again.

The simulation model considers a perfectly rigid tool and mandrel. The mandrel is not moving. With a pre-defined speed 2 mm / s, the tool is moving vertically. For simplification of the simulation only part of the ring is modeled.

The Fig.4 shows on the left consumption of energy during the forging of a ring. Only the first two strokes of the tool are considered. Delay in increasing of energy means a time gap for rotating the ring and lifting the tool.

In this simulation the energy necessary for additional support operations, such as manipulation with the ring in the working space and lifting of a movable crossbeam, is not considered.

The total energy is calculated as the sum of the energy required for the first stroke and energy for following strokes. The energy of the following strokes is determined from the energy for the second stroke and the total number of strokes.

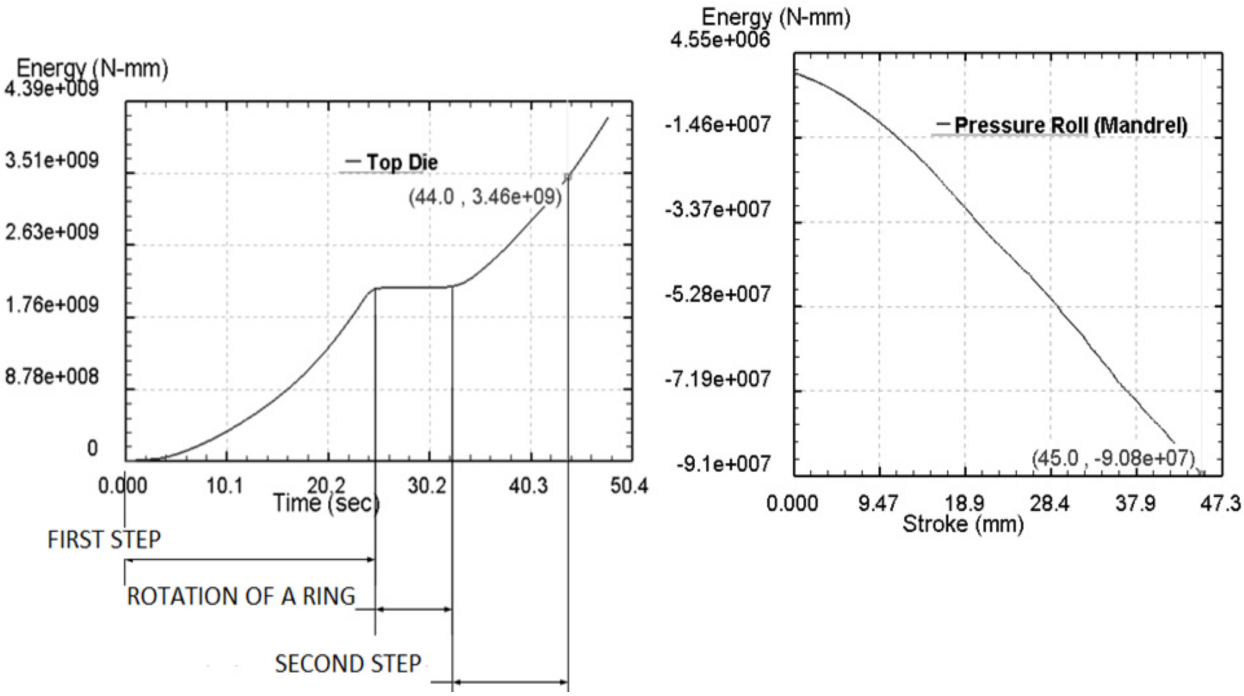

Fig. 4. Energy consumption during production (left-forging, right-rolling)

Total energy for forging is calculated as follows [4,5]:

$E_T = E_{STEP\ 1} + X.E_{STEP\ X}$

$E_{STEP\ 1} = 20.10^9$Nmm= 20 MJ
$E_{STEP\ X} = 14.10^9$Nmm= 14 MJ
X= number of partial rotations
X= 360 / 5= 72 partial rotations
$E_T = E_{STEP\ 1} + X.E_{STEP\ X} = 20 + 72*14 = 1028$ MJ

Total energy for rolling is 90 MJ as is shown in Fig.4. This energy is completly determined by Deform 3D.

In terms of energy are both variants comparable. The difference between forging (1028 MJ) and rolling (900 MJ) is caused by different distribution of plastic strain in the material. Disadvantage of forging is energy requirements for lifting of tool and additional surface finishing.

6. Specific loading of the hydraulic press during rings production

This is not a frequent operation in hydraulic press, but a very specific technology, in terms of load. Ring hanging on a mandrel is placed on supports placed on the edges of the forging table. The design of the press (especially of lower crossbeam and forging table) must be done with consideration of this technological operation. During this is nominal force not in the middle of the press, but on the sides of forging table.

In the following figure is computational model for FEM analysis and stress distribution in lower crossbeam. The stress is under the critical value for casted parts. Strength problems during long lifetime of press can by caused by not properly chosen places for core holes [7, 8].

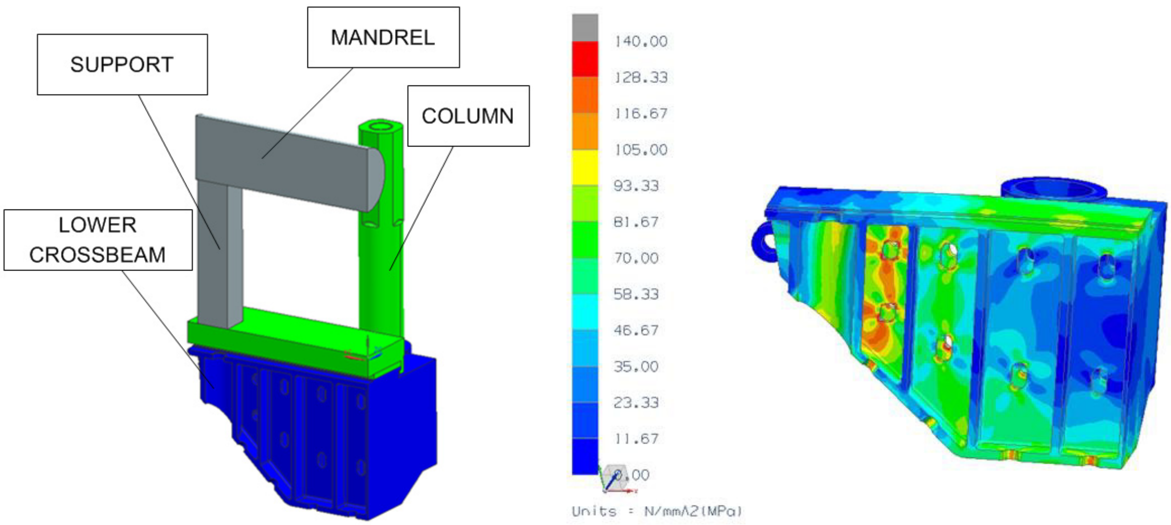

Fig. 5. Computational model and stress distribution in quarter model of lower crossbeam.

7. Conclusion

This paper includes a simple overview of the possibilities for producing large rings and influences of this technology on hydraulic press. This production is currently often under discussion. These rings are mostly used in areas of the nuclear industry, especially in reactor vessels.

In this paper are considered several options for large ring production. Chosen are only those which are suitable for real production. The Research Centre of Forming Machines at the University of West Bohemia in Pilsen deals with this problem. Currently basic calculation and design work is being carried out. In the future is this topic going to be more precisely described in terms of technological process. First step, which is going to be done is comparing of real and virtual simulation.

The technological comparison clearly shows the advantages of rolling in this case. It is better from energetic point of view. The main danger here is the possibility of ring deformation during forging because rings will be thin and also strength problems caused by core holes.

Acknowledgements

The paper was supported by the TA CR – project TE01020075 and company TS Plzen.

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