FORGED PART PRODUCTION OPTIMALIZATION BY TECHNOLOGICAL PROCESS PLAN REDESIGN

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Abstract

The article showed procedure of forging technological process plan design modification of real component – fork, with using of calculation and simulation. By using of primary technological process plan in the production was produced failure forgings, checking simulation showed incorrect material flow in filling of the die cavity, and therefore it was needed to design modifications. These modifications were suggested on base of the results obtained from technological process simulation he results were abolition of defects, resolution of problem and correctness verification of final forging technological flow.

Key words

die forging, forged part, simulation, technological process

Introduction

The technological job description of forged part (fork) is a complicated process. In this process is necessary to make provision for a number of factors that have influence for forging process, such as correct temperature of semi-product, choice of suitable forming tool and machine and last but not least dimensions of semi-product. Mistakes of forged pieces may cause incorrect suggested dimensions of semi-product and follow incorrect filling of impression of forging die by the material.

Simulation programs help with the removal of these problems, which make possible more deeply to understand regularities of forging process and depict mistakes.

The biggest advantage of forming process simulation is realization of experiments outside of real production without intervention into production and correct choice of technological parameters verification. Simulation programs make possible to follow plastic material flow in impression of die during its filling, deformation mesh in forming work piece, values of strain and stresses, continuance of faces as well as contact pressures on tool surface during filling of impression of die by material. By simulation are very quickly diagnosed the defects of incorrect material flow, unfilling spaces in impression of die or big veining which signalize excessively material consumption.

On the present days for simulation of technological processes it is available a lot of simulation programs. It was used in this case simulation program Simufact Forming, it belongs between CAE systems and it utilizes method of finite elements and method of finite volumes. The big advantage of this simulation program application is possibility of technological process simulation at various conditions and consecutive elimination of possible mistakes in technological process, saving of material, what will express on price reduction of final product in final consequence.

Present time forging technological flow of forged part fork

The forging part (fork) is made from steel 12 040 STN 41 2040 (what is an equivalent to DIN C35) it is carbon constructive steel to heat treatment. Strength limit Rm of this steel is between of 480 - 750 MPa. Chemical composition of material STN 41 2040 is on table 1.

CHEMICAL COMPOSITION OF STEEL 12 040 [per. by weight. %] Table 1

C	Mn	Si	Cr	Ni	Cu	P	S
0,32-0,4	0,5-0,8	0,15-0,4	max 0,25	max 0,3	max 0,3	max 0,04	max 0,04

These steels are suitable for production of big shaft of burning engines, steam engines, tow machine, rods etc.

Drop forging fork is part of so called screw shackle, which serves on tweak of wire tightening, let us say entire hanger between high voltage columns. Required dimensions and shape of forged part fork is on fig.1.

Semi-product is heat up on forging temperature 1150 -1200 °C. Heating -up semi-product at first is freely upset by plates onto diameter 30- 35 mm. After upsetting follows the preforging in the preforging die and after that follows the finish forging. Shape of drop forged is made of three press LZK 1000 stroke. After forging is clipped redundant veining on eccentric press. After forging are controlled forged piece measurements according to valid forged drawing.

Analysis of problem in present production at production of forged part "fork"

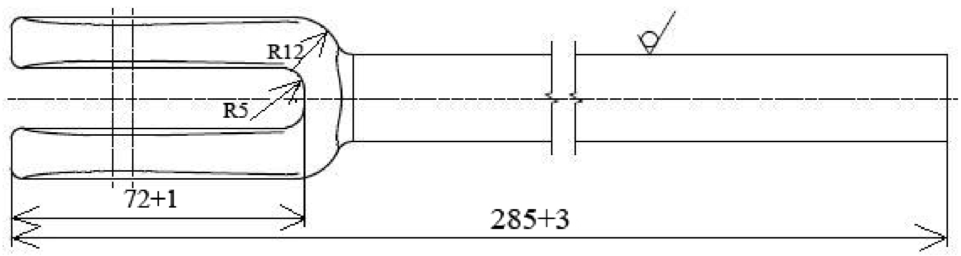
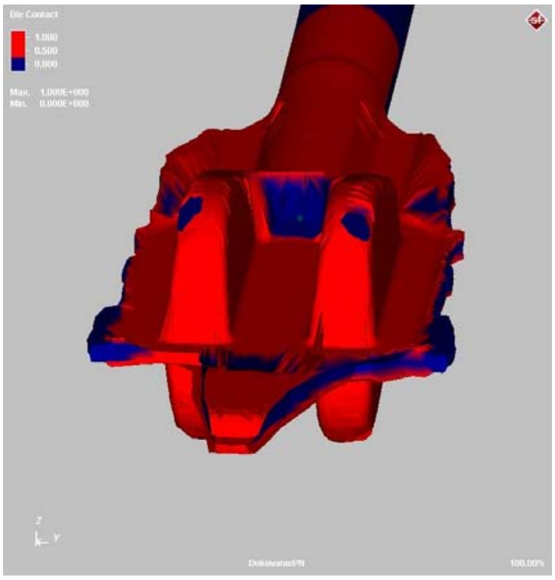


Fig. 1 *Required dimensions of forged part fork*

Present day production of forged fork brings often repeated fault of redundant material flow from head of semi product into shank, what causes its inappropriate elongation and incorrect filling of the finishing die. Following simulation confirmed big material flow from head of semi product into shank.

Primary dimensions of semi-finished product were ø 40 x 285 mm. Length of head was 70 mm and diameter of shank is ø 22 mm.

We modeled and simulated the present state of production. Simulation showed, that flow defect rise on the same places how at real production. It means that our model behaves likewise as real fork.



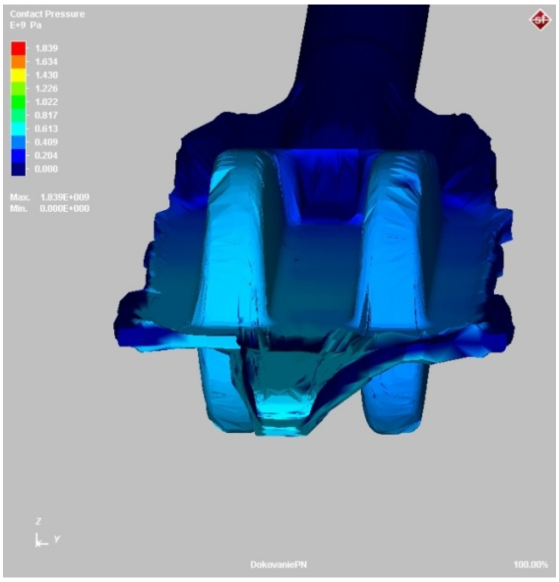


Fig. 2 *Incorrect filling impression of finishing die*

Fig. 3 *Course of contact pressures in forged part*

Insufficient filled of impression of finishing die is on fig. 2, on fig. 3 is possible to follow course of contact pressures in impression of finishing die. It is see from fig. 3 that pressures are low, that means that impression of finishing die was not filled correctly.

Simulation confirmed, that incorrect shape and dimensions of semiproduct were cause of creation mistakes.

Simulations with optimalization of semi-finished product dimensions

I. Alternative

In the suggestion of the first option it goes out from assumption that incorrect semi-finished product dimensions were reason of mistakes creation. The dimensions of semi product were optimized by calculation based on volume maintenance rule.
Optimized semi product I. had main dimensions:
Diameter of head d_1 = ø 42 mm
Height of head v_1 = 63,49 mm
Length of semi product l = 285 mm.

Forging job description of fork was be identical with original production, simulation of forged consisted of three stages, semi product upsetting, preforging, and finish forging in open die.
Simulation will be realized how 3D and will be computed by method of final volumes.
Optimized semi product was input for simulation forging of forged part. Semi product, which had predetermined temperature 1150 °C (hot forging), is at first upseted by plates on head diameter 32 – 37 mm.

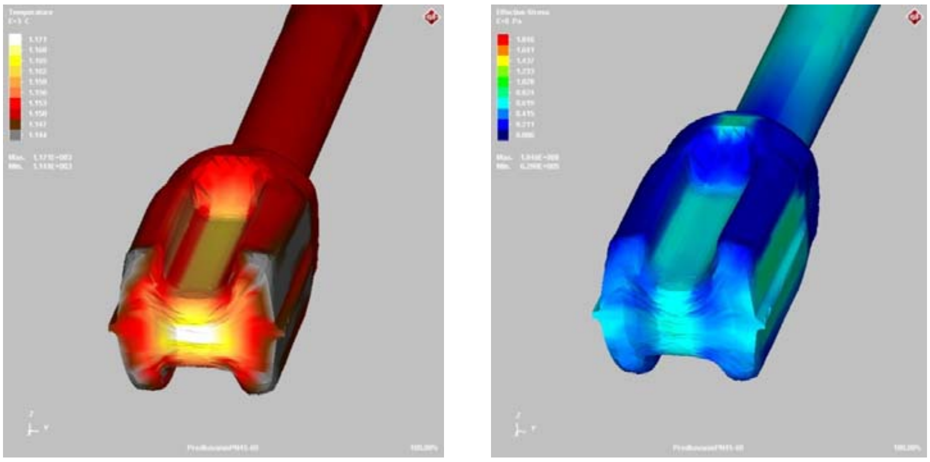


Fig. 4 *Shape of pre-forged part and course of temperature and efecctive stresses in pre-forged part*

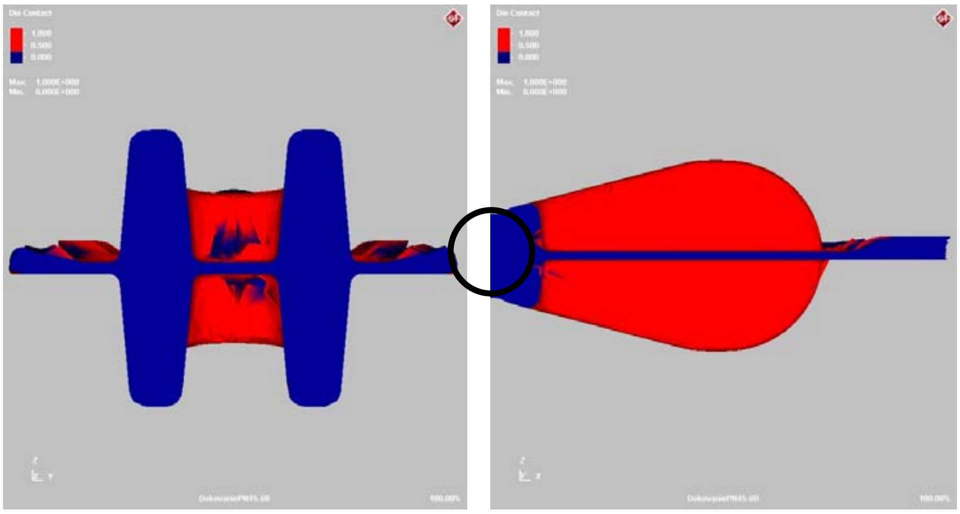


Fig. 5 *Shrink hole creation in forged part*

The simulation brought marked improvement of forging process (Fig.4), but the forged part had shring hole (Fig.5). It was necessity of another modifications, especially semi finished product geometry and to realize the next simulation.

II. Alternative

It was not succeed elimination of mistakes on first alternative, therefore was made modification dimensions of semi finished product again. In suggestion of second alternative it goes out that incorrect dimensions of semifinished product were cause of mistakes creation. Semi finished product dimensions were optimized by calculation on base of the law of volume maintenance. Optimized semi finished product was entrance for fork forging simulation.

Semi product diameter of head d_2 = ø 45 mm

Height of head v_2 = 55,3 mm

Length of semi product l = 285 mm

Technological process of semi finished product make ready will be identical with previous production. Semi finished product heated on required temperature was upsetted by plates, after upsetting ensues pre-forging in pre-forging die and it ensues the final forging.
The forged part has elongation of middle in the space of tolerance and it was reached full filling of die impression.

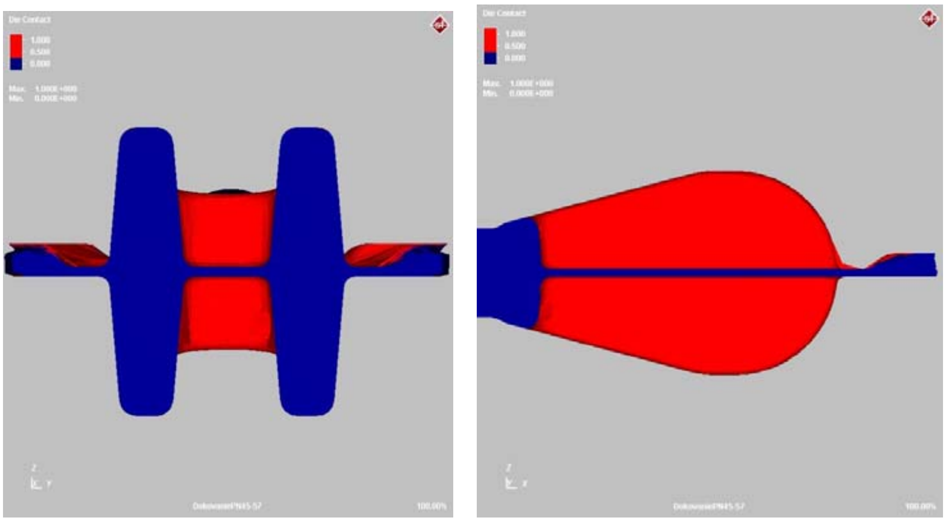


Fig. 6 *Contact of forged part with die*

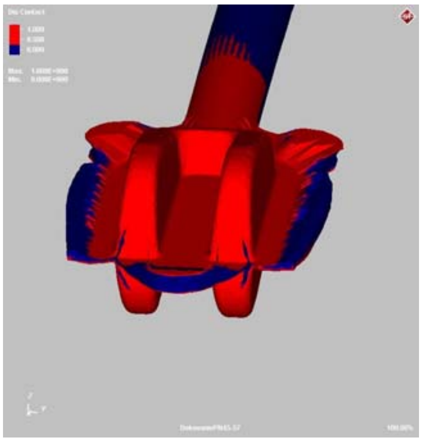


Fig. *7 Three dimensional model of forged part with die contact*

Simulation provides quantity results, which are for example contact forged part with die fig. 6, 7. Course of contact pressures mention on right filling of die impression and correct correction of semi finished product dimensions.
The last simulation showed, that material right fill die impression and real forged part would not have former mistakes. Verification in practice proves correctness of suggested change, what confirmed results acquired by simulation of the technological production process.

Conclusion

The simulation programs represent source of information required for semi finished product dimensions optimalization, whereby are eliminate mistakes already in preparative phase production of forging.

They provide a lot of advantages all but one, especially obtaining quantities information about forging process, what allows in relatively short time to obtain optimally alternative of production, and so to avoid economically and time - consuming experiments.

Based on this article it succeeded to mention at justification computer simulations utilization in technological processes. Results of simulation allowed improving production without times and costly modifications of technological and geometric parameters realized on real device by method of experiment mistake. Numerical simulation confirmed semi finished product dimensions correctness and this is assurance of forged part - fork production effectiveness.

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