THERMAL ANALYSIS OF THE FORGING PRESS LZK 4000

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Abstract

Thermal loading of mechanical forging press is one of the most important factors which are influencing its function and final accuracy of forgings. It is necessary to eliminate deformations caused by thermal loading of all main parts such as ram and frame. This is done generally by correct settings of clearances in ram guidance. This article deals with measurement of thermal loading during forging with mechanical press LZK 4000. Numerical simulations are also performed. These simulations are performed with aim to compare virtual and real measurements. This results can be used for virtual prediction of thermal loading and corrections without real testing during machine operation.

Keywords: forming machines; mechanical forging press; FEM; thermal load; thermal measurement

1. Introduction

The mechanical forging press [13], [14] works with preheated tools. Maximal temperature can be about 250°C. The preheating is usually done by gas burners that are inserted into the machine's working space. These burners warming up tools during defined time period up to specified temperature. [10]

Deformations of frame and ram are caused from preheating and from forging process. These deformations are influencing accuracy of press. This is reason why is necessary to know exact distribution of temperature on forging press. Clearances in guidance has to be set according these deformations. This article deals with measurement and virtual simulations of thermal behaviour of forging press LZK 4000 during technological process. Thermal preheating is problematic process because of usage of gas burners.

Because of hardly defined heating by burners is final temperature of tools non- uniform. This causes asymmetric deformations of forging press. This asymmetric behaviour can be found also during forging process. The preheated steel part with initial temperature of about 1200°C [8], [9] enters the work area where it is usually formed in three to five die cavities [1]. Movement is realize in one direction according to following figure.

Fig. 1. View of one direction forging

Manipulation by forged product is robotized nowadays [4], [7]. Final product is cooled down during forging process. The temperature at the end of process can be lower by 50°C. This can lead to possible asymmetry of thermal loading and on both sides of press (ram and frame).

2. Measurement of thermal influence during hot forging process

Measurement of thermal influence was performed on forging press LZK 4000. Product with diameter 68 mm, length 117 mm and weight 1,9 kg was preheated on 1230°C and forged in this press. Forging was performed in four steps (positions):

1. upsetting
2. preforming
3. final forging
4. punching and cutting

The production cycle took 13 seconds. At first stroke were performed operations in positions 1 and 3. Second stroke was in tool positions 2 and 4. Temperature of forged part didn't get under 1150°C during forging process. The temperature was measured at 10 points on frame. Four representative points were chosen for results interpretation. Two points are on frame and two on ram.

Fig. 2. Location of selected measurement points on ram and frame of mechanical press

3. Measurement results

Measurement was performed during 40 minutes in machine operation and also during another 120 minutes during changing of lower die. There was no additional heating of ram and frame during temperature measurement. Temperature was almost constant temperature during measurement (with respect to measurement error and other influences such as preheating accuracy, changes of ambient temperature, etc.)

This can be seen in following picture. After stop of forging was temperature of ram decreasing very slowly. Maximal temperature change of the ram was $1,4^{\circ}\text{C}$ of the frame was $4,6^{\circ}\text{C}$. It is possible to see results from measurement (after 10 minutes) by thermographic camera on following pictures. Measurement of point on the ram was necessary to perform when ram was in lower position.

Fig. 3. Measurement results in representative points after 10 minutes of measurement

4. Simulation of thermal influence during hot forging

Numerical CAE model of mechanical press LZK was created in software Siemens NX. [2], [3] Boundary conditions of simulation were set up according real measurement [11], [12]. Initial temperature of both tools was arranged according real conditions with gas burners. The value was 250°C and time-dependent cooling was allowed. Initial temperature of forged parts was 1150°C according real lowest temperature.

Positions were active according 1+3 and 2+4 scheme (see following picture). This leads to real time 13 s of one operation. Virtual simulation was performed as time-dependent [5], [6] and total time was 40 minutes according experimental measurement (Fig. 6 and Fig. 7).

Fig. 4. Temperature in representative points- time dependency

Fig. 5. Location of forged parts and temperature effect during forging simulation

It is possible to see results from simulations in Fig. 6 and Fig. 7. It can be found, that technological forging process doesn't lead to temperature increasing of ram and frame. The temperature of tool is not significantly changed and it is on constant level (according initial pre-heating). The simulation was continuing 120 minutes more for confirmation that no significant thermal load of machine will appear.

Fig. 6. Temperature results after 40 minutes of forging (°C)

Fig. 7. Temperature distributions (detail) - comparing of simulation and measurement

5. Conclusion

There are advanced software tools, which can be used for thermal simulations of industrial products behaviour. In our case was tested mechanical forging press LZK 4000. Results from this simulations are highly dependent on initial boundary conditions which are sometimes hard to define. It is necessary to perform experimental measurement for correct settings of simulations. In our study was achieved complex model of thermal loading at forging machine. This can be used for validation of another simulations without need for real measurement.

This article is representing measurement of thermal influence during operation of mechanical forging press. This thermal load is caused be hot- forging technology. Main aim of this paper is validation of performed virtual simulations and then use them for thermal deformation prediction.

Our measurement didn't agree with previous simulations and end-users experiences about thermal loads in mechanical forging press. Main reason was in performed technology which was during measurement producing only small products. This products didn't have significant influence on temperature changes during forging process.

It is necessary to perform more measurements with products, which has maximal dimensions possible to forge in press mentioned above.

Access to forging factories is the biggest limitation. Another limitation is change of boundary conditions during forging. Technologies are changed and it is hard to use completely same in simulation and in measurement. This research will continue because it is necessary to collect more measurement data for virtual simulations validation.

This article was focused on experimental measurement of temperature and virtual validation. Evaluation of temperature deformations will be next step. This has to be performed for all individual component of forging machine. Impact of all deformations has to be analysed with respect to forging process. This analysis has to consider deformations caused by mechanical loading and also thermal deformations. This will lead to complex thermal evaluation of mechanical forging press.

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7. References

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