DIE-SET MONITORING OF FORGING PRESSES

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1. INTRODUCTION

Setting up of the forging press and inspection of the condition of its key components is a time-consuming process. Many key parameters, such as ram guides or bolster condition, can be inspected only during the machine downtime. If these parameters are not monitored in real-time, it can lead to low-quality production and damage to the press. This can be avoided by monitoring of the machine's set-up, condition and processes using sensors and real-time data analysis.

2. MONITORING SYSTEM DESCRIPTION

Sensors of the 4dot Monitoring system are installed on the surface of the ram and embedded into the bolsters. There are two three-axis vibration sensors mounted on the ram. These are installed on the imaginary space diagonal of the ram to monitor the ram's movement in the horizontal plane as well as the tilting movements of the ram caused by multi-stage forging. A three-axis vibration sensor is placed both to the lower and upper bolster in a machined pocket. A strain gauges are installed on the bottom side of the lower bolster in machined grooves. These sensors are placed in the middle of the bolster below the dies in the location of the largest deformation. The lower bolster is also equipped with temperature sensors to increase the accuracy of the analyses.

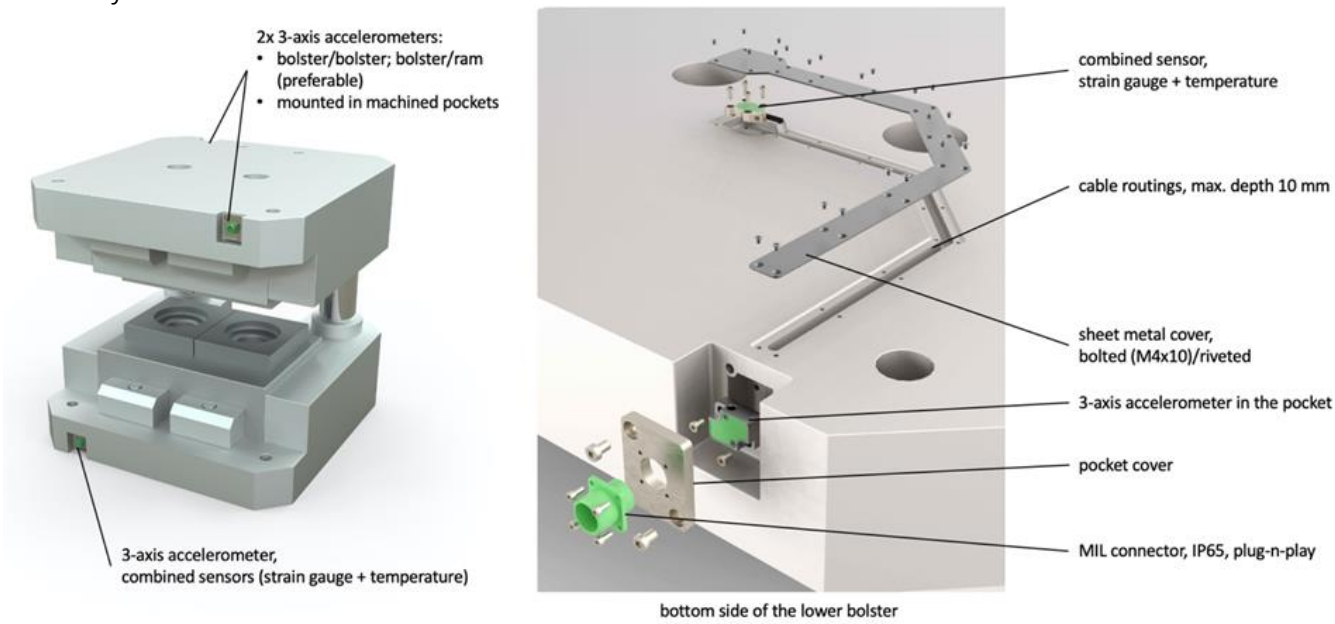

Figure 1 Bolster embedded sensors. Both bolsters are equipped with three-axis vibration sensors. The lower bolster is also equipped with a strain gauge. The whole system was developed to withstand the harsh environment of forging presses - high impacts (vibrations), temperature and forging lubricants.

The required mechanical adjustments of the die holder are carried out in such a way that no reduction in stability and as little impact on the fatigue strength as possible are expected. The groove for the sensors is filled in with insulation material and closed with sheet metal cover to maximize the lifetime of the sensors. After initial problems and optimizations, the sensors, which have now been specially developed for the purpose, have been in multi-shift use for over 9 months. In the event of a defect, these can be replaced without calibration, which is very easily possible, in particular for the easily accessible acceleration sensors. The sensors are connected through plug-and-play connectors so they can be unplugged in case of service intervention. The 4dot monitoring system can be installed in a few days during planned machine downtime.

3. DATA PROCESSING

Various machine parameters can be monitored using the 4dot monitoring system. The way how data is being processed can be explained on monitoring of the ram guides play and correct mountings of the bolsters. The system continuously measures vibrations during the whole stroke of the press. Based on the press kinematics, the data is analyzed at certain points of the press stroke and examined for special deviations. One such point is the engagement of the guides of the die holder. Incorrectly adjusted guide strips on the ram or an incorrectly installed bolsters lead to misalignment and ram tilting, which leads to a higher mean value of the vibrations. At the same time, this value is compared to other parameters from other sensors within complex analyses to determine the cause of the problem. The trend of the measured values are monitored in order to detect changes in the operation of the machine and to report it to the operating or maintenance personnel. The principle of ram's guide monitoring is depicted in Figure 2.

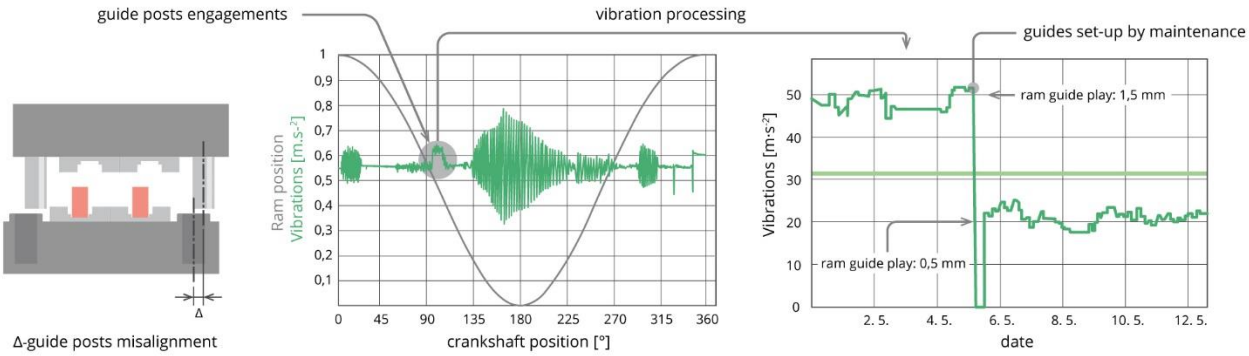

Figure 2 Principle of data processing for ram's guide monitoring. The vibrations are measured during the whole stroke (in the middle). The vibrations are analyzed at the moment when the guides of the bolster engage. Changes in the final value are monitored in time - trend monitoring (on the right).

A wide frequency spectrum of the measuring and monitoring system also allows the monitoring of processes with more time-critical processes, such as those that occur with forging hammers, screw presses or high-speed horizontal forging presses. The following machine parameters are monitored:

- ram guide play,
- tilting movements of the ram and thus the die during forging,
- correct clamping of the bolsters,
- forging force to monitor the forging process and to protect the machine against overload.

At the same time, the following failure modes can be identified in real-time:

- failure of the mounting bolts,
- a ram guide play increased beyond the permissible level,
- condition of the bolsters, detection of crack initiation,
- surface unevenness of the press table and bolsters which leads to a gap between the table and bolster.

All these parameters can be monitored on the information panel of the machine and in the 4dot web application.

4. BOLSTER CONDITION MONITORING

The monitoring of a plastic deformation of the press table or of protective plates in connection with a bend in the die holder allows the condition of the die holder to be monitored and a failure forecast to be made. The cavities created by the deformation of the parts change the ratio of normal and bending stress within the bolster. The bolsters are not designed to work under such stress, which increases the risk of failure. Unless the press table is machined, the deformation of the bolster can lead to crack initiation up to fatal failure.

An example of the utilization of 4dot technology is the monitoring of 3 150 ton crankshaft vertical press. After the system indicated a change in the behavior of the bolster a visual inspection of the bolster was done. A crack in the corner of the ejector hole was discovered. The crack was ground out to eliminate the stress concentrator. At the same time, the press table was machined. With these measures, the bolster has been saved and its lifetime increased.

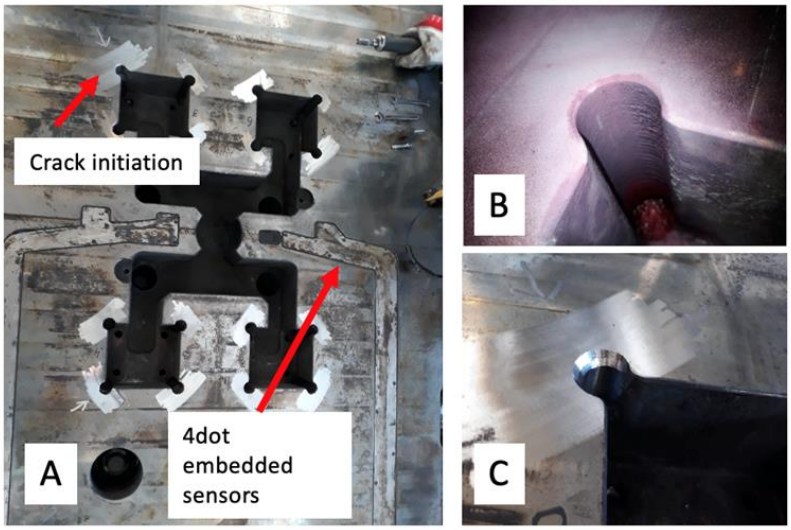

Figure 3 Inspection of the damaged bolster. The cracks usually occur in the corners of the ejector pins holes (A). In this case, developing crack was localized (B), which could have been grounded out (C), thus the bolster lifetime was increased.

Data from the system does not serve only for failure prediction. The data and experience gained by using of the system can complement the stress analyses made by the tool designer to improve the bolster design.