ram reports in applied measurement

Measuring strain in a forging hammer in order to compensate for finite element computations

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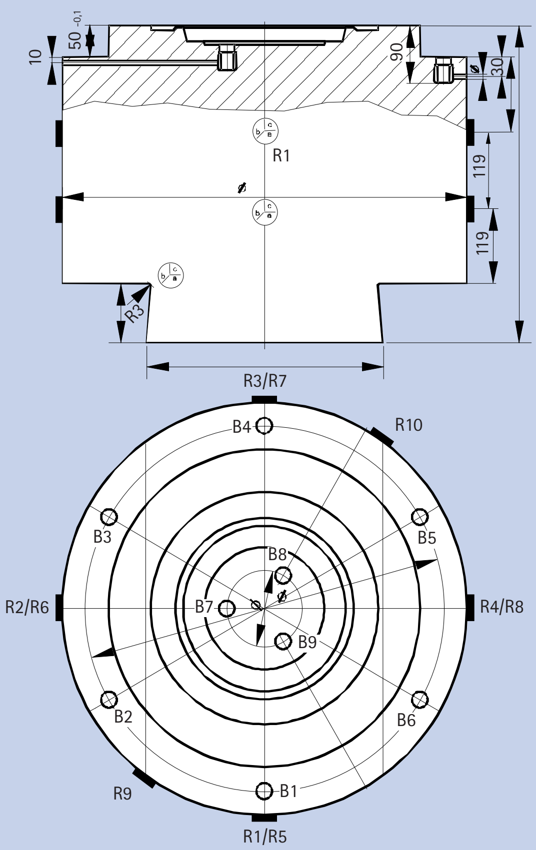

Rammer:
Piezoelectric acceleration transducer B&K 4315 linear up to 15 kHz

Column (left, right):
Piezoelectronic acceleration transducer B&K 4391

Measuring pin driven into cavity or impact surface:
SG full bridge, HBM
Type XY 3/350 (B7...B9; B1...B6)

On die surface:
SG rosette, HBM
Type 120 RY 31 (R1...R10)

Rammer displacement:
Cable displacement transducer, ASM comp., dynamically modified

Fig.1: Layout of the measuring points on the die

Introduction

Although forging hammers have disadvantages when compared with presses due to the noise and vibration nuisance they create, their relatively low rate of output and the difficulty involved in automating them, nonetheless they will continue to hold their place in drop forging, since they are less costly to purchase and maintain, and simpler to retool (small batch sizes can be manufactured).

Defining the problem

The high dynamic loads in drop hammers, especially in modern hammers with high striking velocities (up to 8 m/s), cause problems in practice. The shock waves propagated and reflected in the elastic material of tools and machine components can give rise to beat effects leading to local and very short period stress peaks. These can manifest themselves in the form of micro-flaws and sudden breakage (die shatter). Computations based on the finite element method can be used to optimise the design of drop forging dies. Static computation models are insufficient for the purpose, as dynamic input quantities are required for the FE model. A finite element program with a module for system dynamics was used to compute the dynamic deformation waves that arise during impact on the anvil bed. Starting with an interconnected volume model, the deformation or stress responses were simulated using a specified excitation force. To substantiate the computer results, strain and acceleration measurements were carried out on two different reciprocal impact hammers [Lit. 1].

The test die

Fig.1 shows the location of the measuring points on the drop-forging die prepared for the purpose.

In order to measure local progression of the strain over time, nine measuring pins in total, each wired as a strain-gage full bridge, were driven into the cavity or impact surfaces of a die. Holes were specially drilled so that the wires could be passed through to the outside. In addition ten SG rosettes (HBM120 RY31) were applied to the die cover. These made it possible to determine the direction of the principal stress.

Since the die is pre-heated to some 150 °C for forging and retains this temperature even during the forging operation, the SG was applied using EP 310 heat-curing adhesive. Teflon insulated wiring was used. The measuring points were masked with high-temperature silicone. The silicone was also used in conjunction with temperature-resistant adhesive tape to attach the wiring to the die cover as well as to the measuring pins in the drill holes. This type of installation proved to be robust and durable even under typical forging conditions (heat, dirt, dynamic loading).

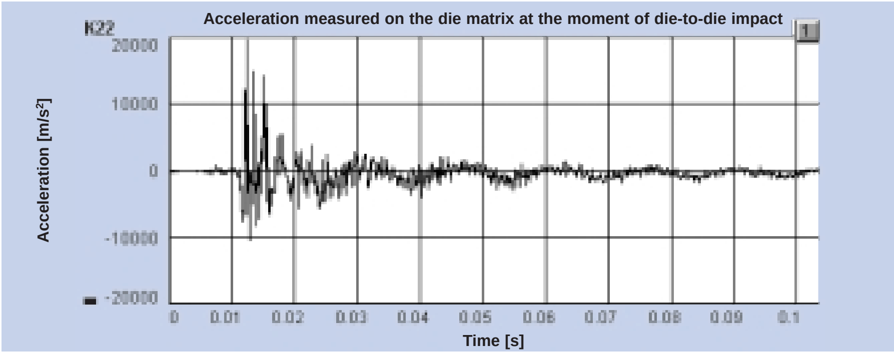

Fig. 3: Acceleration at the test die as a function of time

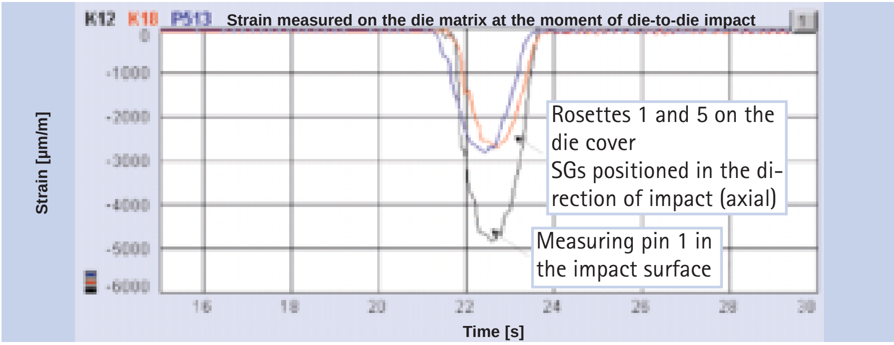

Fig. 4: Strain at the test die as a function of time

The test die after an impact

Fig. 2 shows the die fitted in the hammer immediately after a forging stroke. It is impossible to fasten the wires with clips since the fastenings break after a few impacts on account of the high acceleration at the die (higher than 20000 m/s^2, **Fig. 3**).

Signal conditioning of all 39 SG channels was carried out in parallel over DC measurement bridges (DMCplus from HBM) up to a bandwidth of 4.8 kHz. Measurement time amounted to 100 ms per stroke, when the last two strokes of a series were recorded.

At the end of the series of impacts the deformation resulting from contact between the impact surfaces is close to that for die against die (duration of die-to-die impact approx. 2 ms). **Fig. 4** shows the strain signal from a measuring pin in the impact surface. This signal can be used as input for the FE computation.

The other plots in **Fig. 4** show the response signal, measured at the die cover in the direction of impact (axial), on two SGs attached at different heights. This signal can be used to adjust the FE model. **Fig. 5** shows the stress distribution calculated with the aid of the measured force trends at the instant when the greatest reference stress according to Von Mises occurred. The greatest stresses occur in the radius of curvature of the die joint.

In addition to the strain measurements, acceleration was measured at the rammer and at the hammer frame. Rammer speeds prior to striking the die were measured with the aid of a dynamically modified cable displacement transducer. Comparisons with rammer speed measurements carried out in parallel using an optical correlation measurement system [Lit. 2] gave close agreement.

These experiments form part of a project sponsored by the AIF (Association of German Industrial Research Organisations) known as "Dynamic Loading and Design of Hammer Dies" (AIF 11171B).

Literature

[1] "Dynamische Belastung und Gestaltung von Gesenken in Hämmern" AIF project 11171B, IWU Chemnitz, FSV Hagen, 01.06.97-31.05.99 (Dynamic Loading and Design of Hammer Dies)

[2] Fiedler, O. "Optische Sensoren zum berührungslosen Messen von Geschwindigkeiten" MM-Maschinenmarkt, Heft 27 (1.7.96) (Optical sensors for contactless velocity measurement)

Fig. 2 The test die after an impact

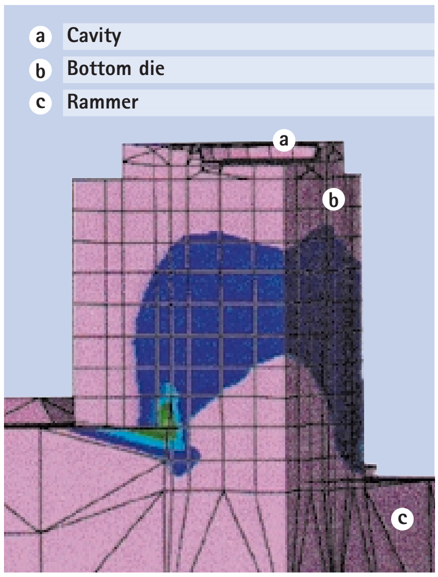

Fig. 5: Stress distribution at the bottom die and bottom rammer (quarter model, section)