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FINITE ELEMENT SIMULATION OF THE HOT FORGING OPERATION IN MANUFACTURING OF BEARING RINGS WITH SPECIAL EMPHASIS ON MANUFACTURING SPEED

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Hot forging of steel billets is a key manufacturing technique in manufacturing of bearing rings. The method has a major benefit of production speed and reduced forces in forming; yet the problem arises in tool wear since the forming operation is performed at considerably high temperatures and under high pressure. The first process is the upsetting process of the billet. Secondly, the backward can extrusion is performed to obtain the geometry of the rings. Third and fourth stations are for removing the outer ring and the inner ring and the scrap. A detailed schematic of the process and process steps in detail can be found in [1]

The major problem in manufacturing of bearing rings using hot forging is the excessive tool wear due to elevated temperature, high pressure and material flow over the die surface. A preform in the upsetting station presents a considerable solution [1], yet with present loading/unloading mechanism of the transfer presses used in manufacturing, it is very hard to transfer the preformed shape to the forming station (the third station where the backward can extrusion is made).

In this study, as an alternative to increase tool life, changing the forming speed is studied. To do this, firstly, the current process is modeled with the finite element method (FEM) using a commercial package program, Simufact. For the model to sufficiently represent the process as it is in the field, several pre-studies are made: Firstly, the heating process is observed in detail revealing the temperature-time graph of the material which is cut. By a simple model to represent the backward can extrusion process, the characteristic strain rates during the process are obtained. Then, in a Baehr forming dilatometer, within the

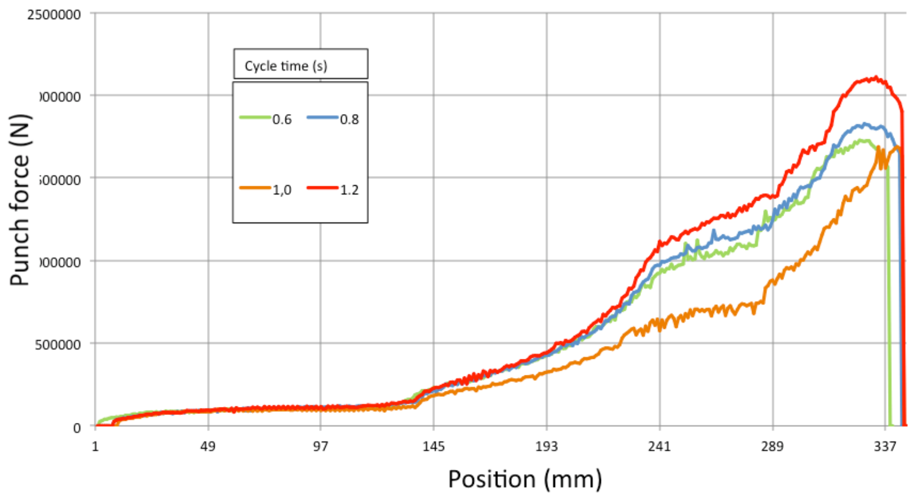

Figure 1: Force-displacement graph for the punch at backward can extrusion station

range of possible strain rates and temperatures, detailed flow curves of the material used is obtained. These flow curves are inserted into the FEM program.

A second step in modeling the manufacturing system as it is would be the simulation of each manufacturing step in FEM and comparing the results with the manufacturing data. At each manufacturing station, individual and repeated temperature measurements are taken using a calibrated infrared laser thermometer. Also, the product after each forming station is taken and the material flow lines at the central section are obtained experimentally. Also, punch force is read on the load sensors on the mechanical transfer press. With successive FEM runs changing the conduction coefficient of the material with the dies and the convection coefficient between the medium and dies/material, a best match with the experimental data and the simulation is obtained. At this point, the obtained model would be ready to be used in further analysis which would involve any change in process parameters (eg., speed of the press, die design, etc.).

In this study, a detailed study on forming speed is performed and the dependence of the punch force on the forming speed is observed numerically using FEM. It has been seen that, there appears an optimum press speed below which the punch force increases due to the cooling of the material (as the material cools, its flow stress increases) and above which the punch force increases due to the increased strain rate of the material. It is observed that, with changing the speed approximately 20% gain can be obtained in punch force and the total energy spent on the process (see Figure 1).

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