Association of Metallurgical Engineers of Serbia
AMES

Scientific paper
UDC: 621.73.077

EXPERIMENTAL OPTIMIZATION OF THE DIE FORGING TECHNOLOGY OF PLIERS

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This paper was previously presented at
4th International Conference Processing and Structure of Materials
held on Palic, Serbia May 27- 29, 2010

Abstract

It is very important for the industry how to decrease the costs without decreasing the quality of products by keeping the technology. Both the optimization of material utilization and the optimization of manufacturing technology are very important in the course of forging. In order to optimize the material utilization, initial products having different geometrical shapes can be and shall be planned. Not only the costs of raw material but the costs of energy and tools can be decreased by saving the material. The theoretical and practical results can be compared within a short time by the experimental optimization. The die-forging die and the manufacturing technology are planned for the optimum samples made as a result of the experimental series. The method of experimental optimization is widespread when producing small-size workpieces. This method cannot be used in case of larger workpieces or when alloyed material-grades are used. In these cases, a computer-simulation model equipped with physical parameters shall be developed.

Key words: forging, material utilization, optimizing

Introduction

Traditional hand-tools (pliers) are made in Hungary only at the Company for Manufacturing and Forging Pliers Ltd. in Szeged. In the recent economic situation, it is very important to choose the suitable initial piece as it influences the costs of basic materials, the costs of energy and tools. This company is trying to solve the following problem: How can they decrease their costs by keeping the present, experienced technology merely by changing the geometrical sizes of initial piece without decreasing the quality? In our experiment, the investigation of the optimum material utilization during the die-forging of pliers of given type is described.

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The process of manufacturing pliers

The manufacturing process starts with arriving and taking over the basic material at the site. The basic material is a hot-rolled flat steel of C60 grade with a length of 6 m that is taken over together with a quality clearance. Then the basic material is cut up; in the course of this procedure, the initial pieces necessary for forging are made by cutting them by using an excentric press.

Fig. 1. Initial pieces during heating

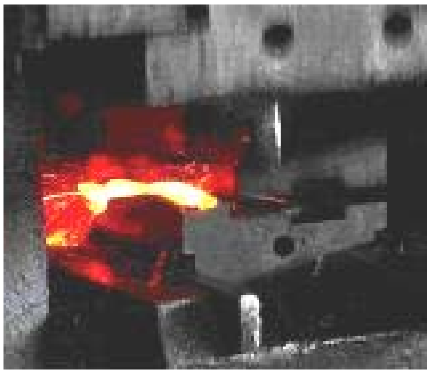

Fig. 2. The process of material distribution

The cut pieces are placed in a furnace where they are heated up to a min. temperature of 1050 °C in accordance with the technological prescriptions (Fig. 1). After heating, the pieces are die-forged (in two passes). The process of bending and material distribution takes place in the first pass (Fig. 2) and the process of forging to shape takes place in the second pass. After the forging procedures, the burring is carried out by means of which the superfluous material is removed in a hot state. The piece cools on an open air and a fine ferritic-perlitic structure develops which is very difficult to machine. The forged piece shall be annealed at a temperature of 650-700 °C with duration of holding for 24 hours. After heat-treatment, the scale is removed from the workpieces by an abrasive blasting process then the workpieces are calibrated to their sizes. The next step is the machining which consists of more successive steps – they are as follows: boring, countersinking, broaching and edge-milling. After completing the aforementioned procedures, the workpieces are fit together so that the two half-parts are clinched. The contour of pliers is shaped in an assembled state then they are edged and the shank-distance is adjusted. The following step of the manufacturing process is the improving heat treatment by which the pliers get their prescribed strength. It is followed by the checking – it consists of the measurement of hardness and the test of shank loading. It is necessary to perform an induction hardening in order that the cutting edges of pliers become hard enough. This procedure is followed by the grinding, polishing and chromating of pliers depending on the requirements of buyers. At last the handle is attached – these handles shall meet the aesthetic and safety requirements as well.

The planning of engineering piece

The base of planning of the die-forging pieces is the drawing of the engineering (finished) piece presented by the customer to the forge shop. The forging can be done as well on the basis of forging drawing or sample made by the customer (Fig. 3). Independent of the method of order, the surfaces to be machined subsequently (the surfaces that shall be machined subsequently), the places of clamping necessary for machining, the place and method of taking samples, the necessary heat treatment methods as well as the other different conditions of taking over shall be indicated in the forging drawing [1].

Fig. 3. The engineering samples

The planning of die forging

The technology of die forging is developed as a result of two part-processes of planning being in relationship with each other. There are two chief elements of planning the technology: the planning of forged piece and the planning of technology proper (the method of pre-forging, the determination of the initial piece, the clarifying of the temperature conditions, the choosing of shaping machine and the planning of die- and burring tools). The planning of forged piece is influenced to a certain extent by the later method of shaping, the type and size of shaping machine, etc. It is necessary to know the forging machine in order to determine the optimum temperature. We should know the deformation processes taking place in the pass in order to determine the sizes of gutter (gutter-bridge) however these processes are strongly influenced by the sizes of the applied gutter bridge. Therefore the planning of technology must not be a mechanical activity. It is necessary to perform the permanent control. Each part-task shall be handled as a whole and it is necessary to know the interaction of a lot of factors. In the course of the planning process it occurs that the planner shall step back one or two steps of planning, he has to perform the necessary modifications then he has to do the calculations again by taking into consideration the changed circumstances [3].

The steps of planning the forged piece:

The choosing of dividing plane, the determination of the mass of engineering piece, the determination of machining and technological activities, the determination of skewness, the determination of the radii, the determination of the mass of forged piece, the determination of type and size of gutter, the determination of forging tolerances [2].

Fig. 4 shows the finished forged piece planned after performing the aforementioned planning steps by using the engineering piece shown in Fig. 3 at the Company.

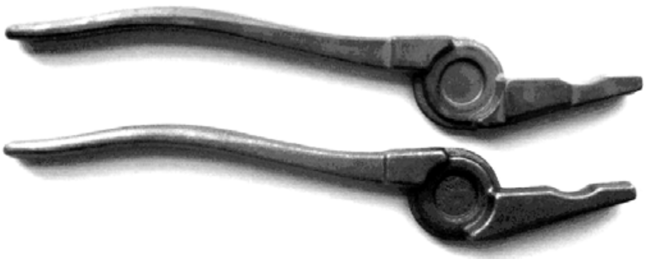

Fig. 4. Finished forged pieces

The determination of the initial piece

The size of initial piece shall fully fill the finishing pass in order that suitable forged pieces can be made. The initial piece (marked by 1) and the forged piece were sectioned at their characteristic cross-sections along their length then the sectioned areas were determined as it can be seen in Fig. 5. The calculated areas of cross-sections were represented in the Cross section [A] – Length [1] coordinate system (Fig. 6). The area being under the cross-section diagram is identical with the volume of forged piece and with the volume of initial piece. An exact result can only be obtained by integrating the curve. The area under the curve was determined by a graphical integration by means of the Microsoft Office Excel 2003 program.

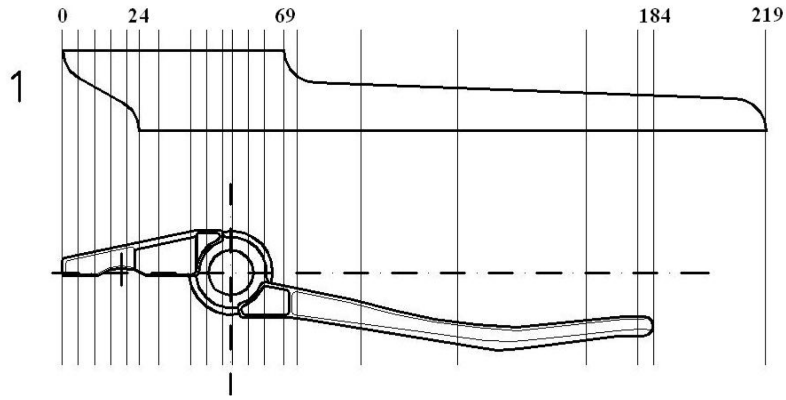

Fig. 5. The principle of construction the cross-sectional diagram

It is extraordinary important to draw the cross-sectional diagram shown in Fig. 6 in a precise and exact way because the pre-product, the method of pre-shaping and the sizes of initial piece will be determined by means of it besides the mass of piece [3].

The investigation of the optimum material utilization

The experimental die forging of universal cushion-like pliers of a size of 180 mm was performed by using initial pieces with different sizes and shapes.

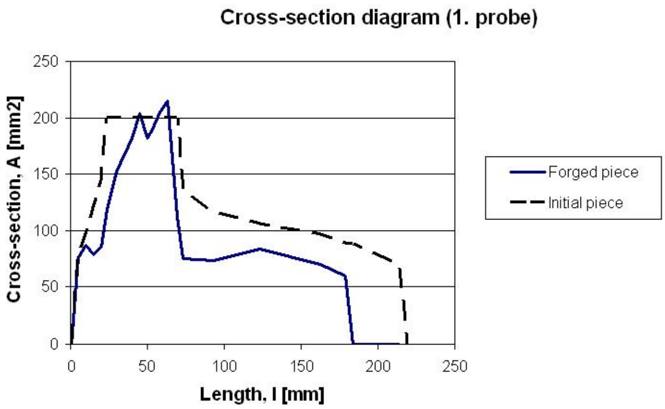

Fig. 6. The cross-section diagram of the forged piece and the initial piece

We used three different kinds of basic materials – they were as follows: a hot rolled flat steel of a grade of C60 with the following section-sizes: 25x8 mm (width x height), 22x8 mm and 20x8 mm. We made samples (indicated by 1, 2, 4) with three different geometrical shapes from the above material. The sample indicated by 1 is the initial piece used at the Company while the samples indicated by 2 and 4 are our own design. New initial pieces were planned from the basic materials having a size of 20x8 mm and 22x8 mm (marked by 3 and 5) (Fig. 7). In order to evaluate the experiment exactly, three samples were necessary from each type – two of them were hit as well. When planning the samples, it was necessary to choose such a geometrical shape that the cut can be done without any scrap.

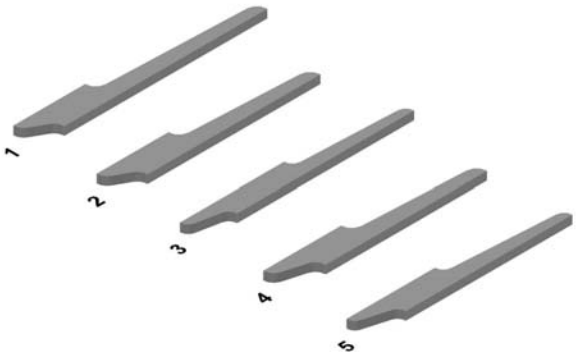

Fig. 7: 3D models of the initial pieces

Further 3 initial geometrical shapes were offered by the Company for the investigations in addition to the shown samples. The size of sections of these samples was 25x8 mm.

The demonstration and evaluation of experiments

The experimental initial pieces were made at the Company for Manufacturing and Forging Pliers. They were manufactured by using a milling machine because no a cutting tool was available at that time. Naturally, the development of a new cutting tool would seem to be reasonable depending on the results of experiment. We had a possibility to follow the manufacturing by using different initial pieces at the Company. Fig. 8 shows the pieces forged in the course of the experiment-series.

Fig. 8. Pieces forged in the course of the experiment-series

Maybe we could have obtained the highest value of material saving with the 3 samples shown in Fig. 9 (an amount of material saving of about 18%) but the filling of pass did not realized.

Fig. 9. A 3 sample

Fig. 10. A 4. sample

On the basis of the performed experiments it can be concluded that the highest amount of material saving could be obtained by using sample 4 shown in Fig 10 (the amount of material saving is about 13% /piece in this case). The material saving decreases not only the costs of raw material but the energy consumption decreases as well at about the same extent. The life of tool also increases owing to the fact that the size of initial piece is smaller.

Summary

Our purpose was to decrease the mass of initial piece by changing the geometrical shape of the existing cutting tool by keeping at the same time the existing engineering equipment and the shapes of passes. In the course of solving this task, pieces with different geometrical shapes were planned that were manufactured in operational conditions at the named Company. The ready-made pieces were evaluated by taking into consideration the prescriptions of forging technology by means of flash. Proposals were made concerning the question: which type of initial piece planned by us shall be used during the manufacturing process in order to save material. In the end, an amount of 13% of material/piece could be saved. In addition to the saving of material, the energy costs as well as the tool-costs also decreased.

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