OPTIMAL PREFORM DESGIN BY TRACING THE MATERIAL FLOW : APPLICATION TO PISTON FORGING

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Abstract

In this paper, a new preform design method is proposed to eliminate the excessive flash in metal forging process. After carrying out finite element simulation of the process with an initial billet, backward particle tracing is performed from the outlet of the flash. Then, the region which belongs to the flash is easily found. The process is analyzed again with the redesigned billet which is removed that region the above mentioned region. The optimal preform shape which minimizes the amount of flash without changing the forgibility can be obtained in several iterations.

Keywords: optimization, perform design, material tracing

1 Introduction

Generally, the preform design depends on the experience and the know-how of the designer. Therefore, several systematic approaches, such as design methods using the data-base obtained by previous design rules or optimization of object functions have been developed[1-4]. However, these can be applied to only simple three dimensional or axisymmetric problems. In this study, a new method of preform design which can obtain a desirable forged shape with a proper flash in the general three-dimensional forging processes is proposed.

2 Methodology of Design Procedure

Fig.1 shows the behavior of piston forging process which makes excessive flash. Therefore, the designer should make the preform shape to save the cost of material and improve the flow of material and die life. Although there are several studies about preform design by using optimization technique, they are difficult to be applied to complex shapes. And, tremendous computation time is consumed to optimize the object function. The proposed method in this study, so called backward particle tracing method which is described in Fig.2, is as follows:

Step 1. Analyzing the process with an initial billet.

Step 2. Generating the flow net at the outlet of flash

Step 3. Backward particle tracing with the flow net

Step 4. Eliminating the region formed to the flash from the initial billet

Step 5. Analyzing the process with the redesigned billet.

After several iterations, the optimal preform design which minimizes the amount of flash can be obtained.

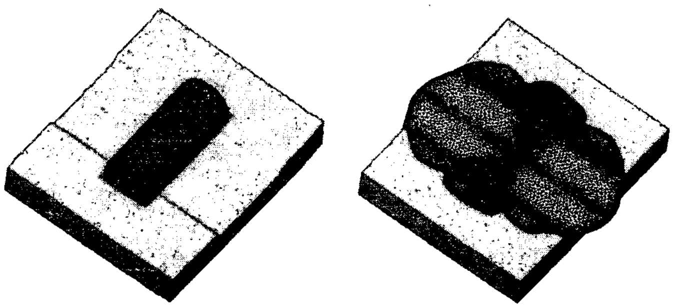


Fig. 1 FE simulation of piston forging process with initial billet

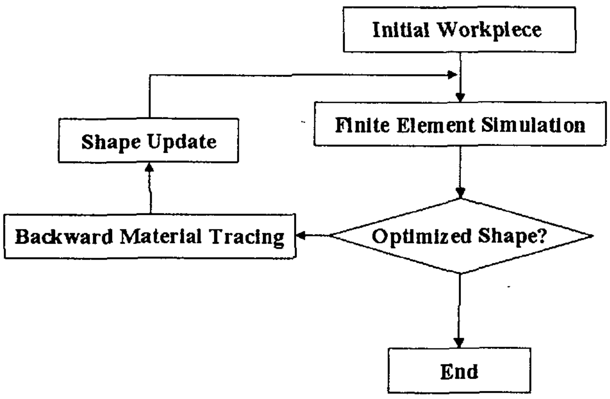


Fig. 2 Flow chart for the optimization of preform design

3 Tracing the flow of material

In Fig.3, a point p^t in the (n)th step has information of element which it belongs to and its local position. Global position of the point p^t can be obtained by the position of vertex nodes of the element and the local position of the point p^t. In the (n+1)th step, if the mesh undergoes remeshing procedure, information of the point is changed. Therefore, it is necessary to renew information of the point with a searching algorithm. If the mesh does not undergo remeshing procedure, only update of the global position is needed.

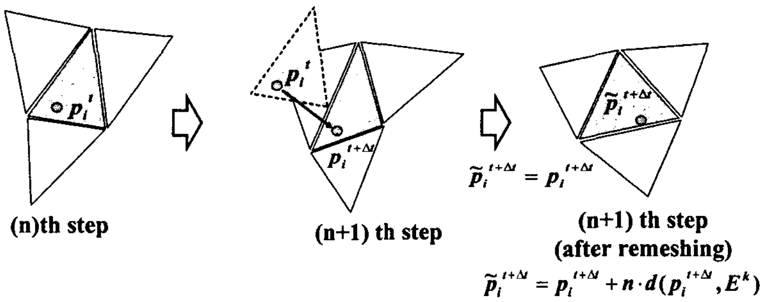


Fig. 3 Schematics of particle tracing

Fig.4 shows an example of tracing the flow of material. The flow of material can be traced through both of forward- and backward- directions.

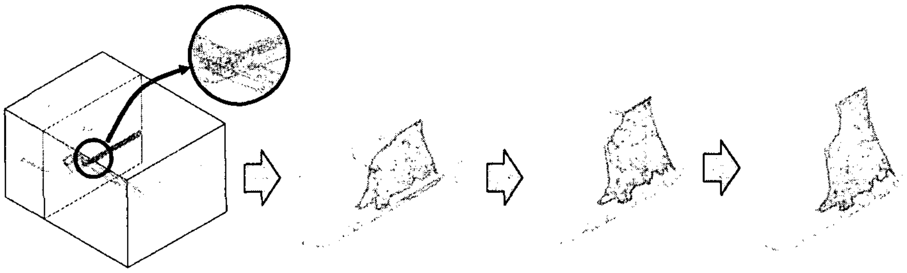


Fig. 4 Schematics of backward particle tracing

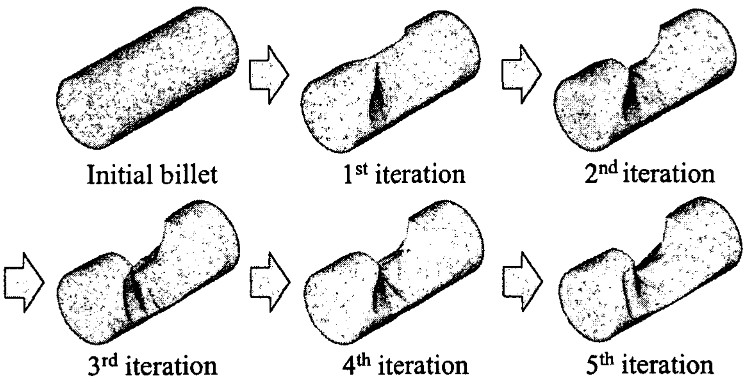
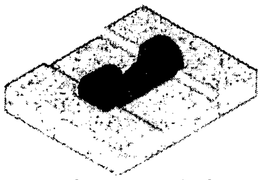


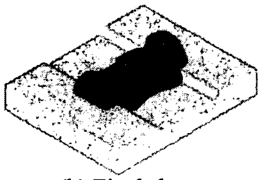
Fig. 5 Change of preform design in each iteration

4 Optimal Preform Shape of the Piston forging

The proposed method has been applied to a piston forging process. Fig.1 shows the result of analysis. A flow net is constructed at the outlet of the flash and traced backward (in Fig.4). After the flow net is compared with the billet, the abundant region is removed. In five iterations, preform shape is changed as shown in Fig.6(a) and the result of FE simulation is as shown in Fig.6(b).

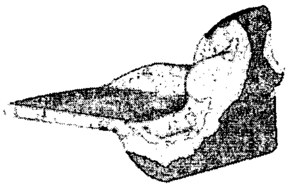


(a) 5th preform design

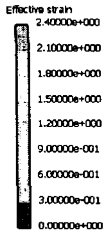


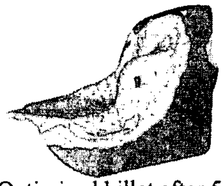
(b) Final shape

Fig. 6 Result of FE simulation with optimized design of preform



(a) With initial billet





(a) Optimized billet after 5 iterations

Fig. 7 Comparison of strain distributions

As shown in Fig. 6(b), the amount of flash is dramatically reduced. Moreover, because the removal process of the material is done with the flow net, the flow of material and forgibility are not changed as compared with the result of analysis with initial billet (Fig7).

5 Results

A new preform design technique which minimizes the flash without changing the metal flow and forgibility is proposed by tracing the material flow. The preform can be designed within short time. And, it is easy to design the preform. Usually, the excessive flash is generated in the aluminum forging. And, it causes die-wear and interferes the flow of material. The proposed method in this study would be more useful in the application.

6 References

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