Proceedings of the ASPF 2003 (The 8th Asian Symposium on Precision Forging), October 15 - 18, 2003

A STUDY OF THE MULTI-ACTION FORGING DIE SET CONTROLLED BY THE SCREWS MECHANISM

Jin-Bin Yang[1] and Jue-Jung Fang[2]

[1]National Kaohsiung First University of Science and Technology
Dept. of Mechanical and Automation Engineering, Taiwan, R.O.C.
[2]Zoeng Chang Industry Limited Co., Taiwan, R.O.C.

Abstract

The multi-action forging process is one of developing directions of forging technologies. In this study, the multi-action die is designed and developed by the screws mechanism and the forging simulation is conducted by using plasticine to investigate the optimum conditions for the design of the screws. The results show the design variables are optimum when the diameter is 30 mm and the screw angle is 60° for the upper screw rod and the outer diameter is 60 mm and the screw angle is 23.4° for the lower screw tube. It makes the relative velocity between the upper punch and the die to be two to one, which is the expected condition. The material flow of the plasticine forgings is uniform. Therefore, it is feasible to use the screw set as the multi-action mechanism for controlling the movement of the multi-action forging die set.

keyword : multi-action, screw, plasticine

1 Introduction

The developing trends of forging technology in the world are precision in dimension, saving the materials and rapid production in considering the goals such as low cost, high added value and high competition. The so-called precision and multi-action forging die set technology which combines precision forging and near net forging technologies can reach the above goals. Because the forgings are precise and flashless by using this technology, it will result in saving materials and reducing the machining amount. However, there are many kinds of mechanisms can be used in designing the multi-action die set. Which is the most suitable should depend on the shape of forgings. As for the spider forgings used in cars, which die set should be designed not only with the floating die for clamping but also with the punches moving vertically and opposite at same speed. Then, the forgings will be made with good quality and uniform flow. At present, there are some types of die sets developed such as gear type, wedge type, link type and spring type. All can have the performance like the above mention. Except the above mechanisms, there should be other mechanisms worth developing.

In this study, a set of screws is used as the mechanism of multi-action and the optimum design variables of the screws are investigated.

2 The Experiment Procedure

The procedure in this study is to collect the information about the types of vertical double action die sets first and investigate their multi-action mechanisms. A new multi-action mechanism is found and investigated, which is a screw set in this study. According to the design of mechanism of the screw set, the experimental multi-action die set is designed and developed. The forming simulation by using plasticine as billets is proceeded. Finally, the feasibility relative to the multi-action mechanism and the design of the die set is investigated.

3 Results and Discussions

3.1 The design of the multi-action die set

The design of the vertical double action forging die set and its movement procedure are shown as figure 1. The steps are loading billets, die clamping, finishing and ejecting forging. In the design of die, both the upper and lower die plates are designed with floating adapters floating by springs and springs are chosen to provide enough clamping force. On both floating adaptors, there are punches and dies set. Besides, there are two screws set on both sides of the upper die plate and there are two lower screw tubes, which have the internal screw and the outer screw, set on both sides of the lower die plate. The screws are assembled in the lower screw tubes which will rotate when the screws come in. Moreover, the lower screw tubes are also assembled in the middle screw tubes of internal screw, which set through the lower floating adaptor. The middle screw tubes can only move vertically. When the forging process begins, the billets are put into die cavities and the upper die moves down to clamp with the lower die to form a closed die cavity. At the same time, the screws also move down to drive the lower screw tubes rotating. So, the lower screw tubes bring the middle screw tubes moving down up to their flanges toughing the lower floating adaptor. When forging continues, the springs under the back of the floating adaptor shrink. The upper punch moves into die cavity and makes the billet deformed. In addition, the lower die with the floating adaptor are pulled down simultaneously by the middle screw tubes which are pulled due to the screw moving into the lower screw tubes and making them rotating. At this time, the upper die and lower die still clamp together and move down with the lower floating adaptor gradually. Because the lower punch is stationary, the billet is also deformed by the lower punch. When the slide of press continues moving, both the upper punch and the lower punch also continue deforming the billet on both sides up to die cavity filled completely. Therefore, the separate speeds for the upper punch, the lower punch and die are different. Taking the die as the base point, the forming situation can be considered that both the upper punch and the lower punch move into the closed die cavity to deform the billet on a certain relative speed. The relative speed between these two punches depends on the design variables of the screw set which include the screw, the lower screw tube and the middle screw tube. When the relative speed between the upper punch and the die is 2 to 1 as expected, it can be considered that the upper punch and the lower punch move into die cavity opposite at same speed. In order to get the above situation, the design variables of the screw set should be investigated.

3.2 The design principles of the mechanism of the screw set

As the above mentioned, the designed mechanism for controlling the action of the multi-action die set in this study is the screw set. The movement of the screw set is shown in figure 2. When the screws go down, the lower screw tubes rotate and the middle screw tubes are pulled down. The stroke of the screw, the same as that of the press, will determine the stroke of the middle screw tube, which is the same as that of the floating adaptor, through the transfer of the lower screw tube. It is possible to control the ratio of the stroke per unit time, speed, between the screw and the middle screw tube by the design of the screw angles. The optimum speed ratio of the upper punch and the die is 2:1. So, the desired stroke ratio of the screw to the middle screw is 2 to 1. If the speed of the upper punch, the same as that of the screw, is V_1 and the speed of the die, the same as that of the middle screw tubes, is V_2, V_1/V_2 has to equal 2. Then, the other variables of the screw set can be assumed as follows:

a: the outer screw angle of the screw and the inner screw angle of the lower screw tube
b: the outer screw angle of lower screw tube and the inner angle of middle screw tube
D_1: the diameter of the screw and the inner diameter of the lower screw tube
D_2: the outer diameter of lower screw tube and the inner diameter of middle screw tube
L: the stroke of the screw, l: the stroke of the screw, V_1: the speed of the screw, V_2: the speed of the middle screw tube

Then $V_1=\frac{L}{t}$ 、 $V_2=\frac{l}{t}$, $\tan a^\circ=\frac{L}{\pi D_1}$, $L=\tan a^\circ \pi D_1$, hence $\tan b^\circ=\frac{l}{\pi D_2}$, $l=2\tan b^\circ \pi D_2$,

$V_1=\frac{L}{t}=\frac{\tan a^\circ \pi D_1}{t}$, $V_2=\frac{l}{t}=\frac{2\tan b^\circ \pi D_2}{t}$, when $V_1=2V_2$, we get $\tan a^\circ D_1=2\tan b^\circ D_2$

If the screw angle of the screw is 60°, its diameter is 30 mm and the inner diameter of the middle screw tube is 60mm. We can get the inner screw angle of the middle screw tube is 23.4°. According to the above design, the expected goal can be attained. Figure 2 show the sketch of the movement of the screw set and their appearance. Figure 3 are the comparison of the speeds between the screw and the middle screw tube. The results show the ratio of the stroke per unit time is 2 to1, which is corresponding with the expect value. So, the forming mode of opposite double action at same speed can be reached.

3.3 The forging simulation of plasticine

After the die set is manufactured and assembled, the actual forging process proceeds by using plasticine as billets to certify the feasibility of the die design. Figure 4 shows the appearance of plasticine forgings and the procedure of the actual forging operation. The flow lines in the plasticine are uniform as expected, which shows the die design are certified to be feasible. So, this designed die set can reach the goal of vertical double action by using a set of special screws to control the relative speed between punches and dies. The design of this die set can be as reference for industries to develop the practical dies for mass production.

4 Conclusions

4.1 The speed ratio between the upper punch and the die, 2 to 1, can obtain, when the diameter is 30mm and the screw angle is 60° for the screw and the outer diameter is 60mm and the outer screw angle is 23.4° for the lower screw tube.

4.2 The flow line of the plasticine forgings is uniform by forging with the designed die set in this study and it is corresponding to that of the real forgings.

4.3 According to the results of the forging experiment, it shows feasible for the designed die set to control the multi-action of the die set by using the developed screw set.

5 References

[1] H.Yoshimura and K.Tanaka, Precision forging of aluminum and steel, J. of Materials Processing Technology, 98(2000), 196-204.

[2] Takashi Nakano, Modern applications of complex forming and multi-action forming in cold forging, J. of Materials Processing Technology, 46(1994) 201~226。

[3] J.B. Yang, A study on the warm flashless forging process, Forging, Vol.3, No.1, pp. 93~104, 1994.4。

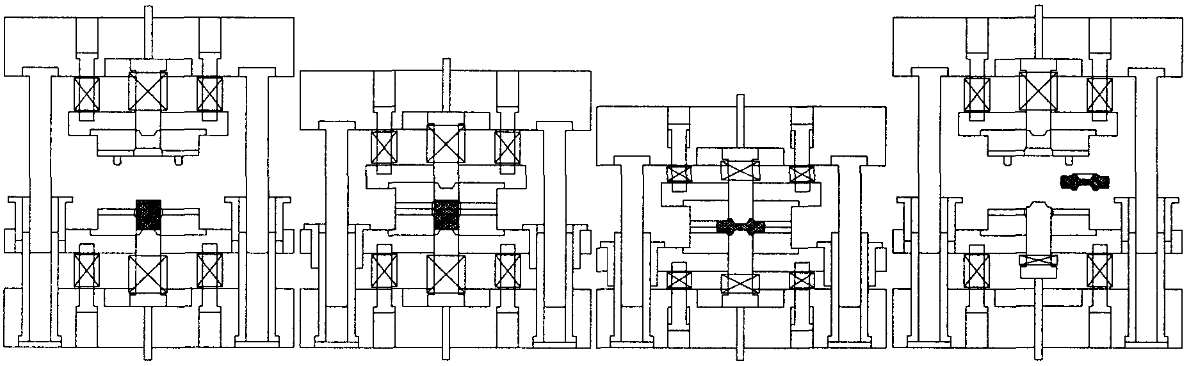

Fig.1 The procedure of the designed multi-action die set including loading, die clamping, finishing and ejecting.

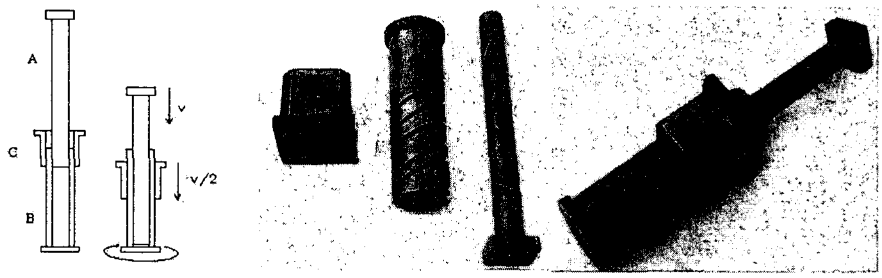

Fig. 2:The appearance of the screw set and their movement

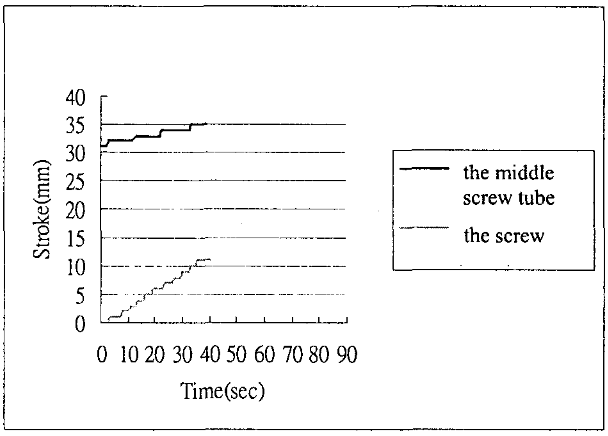

Fig. 3:The speeds of the middle screw tube and the screw rod.

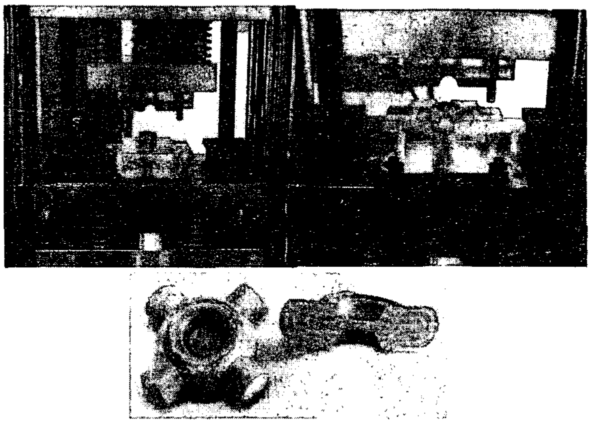

Fig. 4:The appearance of the designed die and placticine.