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DEVELOPMENT OF DOUBLE CUP FORMING IN PLATE FORGING

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Summary

A new plate forming method for producing a double cup product, which is presently made by joining two parts, with one-piece design is proposed. At first, a process with 6 stages is put forward, and experimentally confirmed. Then attempts are made to reduce the number of stages with simulation. A 4-stage process is successfully completed by employing reverse re-drawing. On the basis of the 4-stage process, the number of stages is reduced to 2 by assuming the usage of a multiple-action forming press. The 2-stage process for hot rolled carbon steel sheets developed by numerical simulation is experimentally examined using a multiple-action hydraulic press. The double cup product is successfully formed without defects. The shape and dimensions of the product and forming load agree well with those of the simulation.

1. Introduction

Production of light weight products with high accuracy is strongly demanded by the automotive industry. Plate forging was developed to make light weight product with complicated shape and high precision by combining sheet forming and cold forging [1 – 5].

In the early stage of a plate forging process, sheet forming such as drawing, ironing, etc. is used to make the rough shape of the product. In the later stages, local shapes with high dimensional accuracies are made by upsetting, ironing and other cold forging processes.

Since the forming load tends to become too high in plate forging, it is difficult to form relatively thin parts only by forging operations such as upsetting and extrusion.

Problems encountered in plate forging are as follows; 1) many stages are necessary to make a precision product; 2) the forging pressure is quite high to make precision products; and 3) increase in wall thickness is sometimes requested.

In this paper, new plate forging process of a double cup part, which is usually made by joining of two pieces, is proposed based on one-piece design.

2. Double cup product

The double cup part shown in Fig.1 was originally made by hot forging with subsequent machining. In Fig.1, a double cup product made by machining of a hot forged pre-form is also shown. Because of the large material loss and long production time, machining was avoided.

To eliminate machining, methods as shown in Fig.2 by joining two metal formed parts, the outer cup and the boss, are now often used. From the viewpoints of productivity and yield rate of the material, one-piece design is desirable.

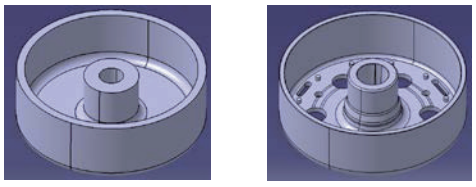

Fig. 1 Hot forging parts

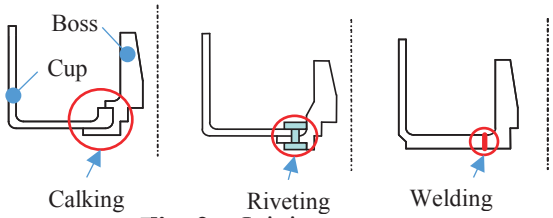

Fig. 2 Joining process

3. Double cup forming by plate forging

3.1 6-stage process for one-piece design

Fig. 3 and **Fig. 4** show the double cup of one-piece design and its forming process. In this case, a steel sheet of 4mm in thickness with a hole is used as the starting blank. Cup drawing is carried out in the first step and then multiple boss stages of boss drawing are performed. The disadvantage of this process is that a large number of operations are needed.

Fig. 3 Double cup

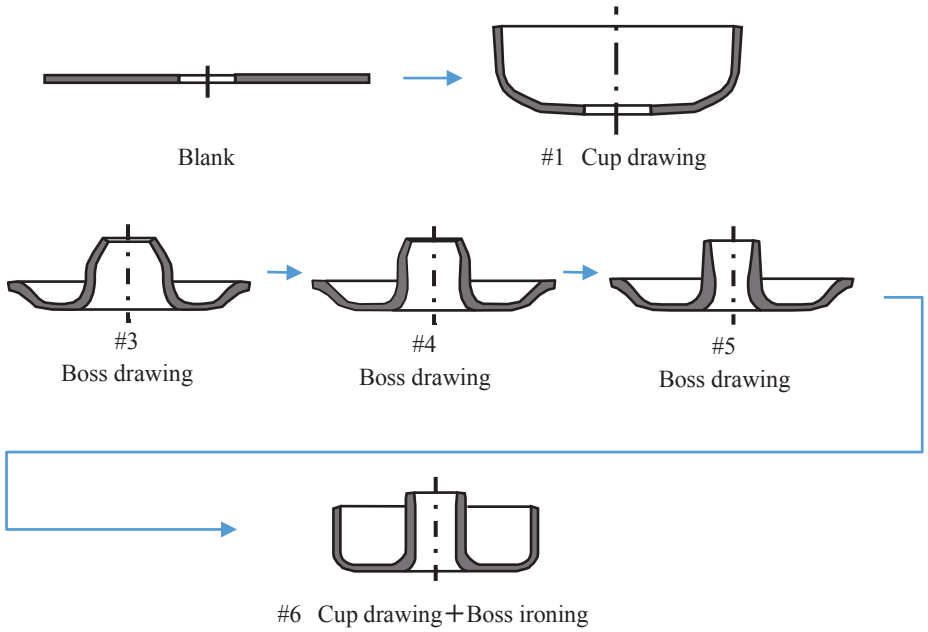

Fig. 4 One-piece design(6-stage process)

3.2 Reduction of number of forming stages

1) From 6 stages to 4 stages

To reduce the number of stages, a forming process employing reverse re-drawing is examined. Fig.5 shows the new process to reduce the number of stages. In this process the initial blank has not a hole, and cup drawing is carried out in the first stage.

Subsequently reverse re-drawing is carried out for 3 times. During reverse re-drawing, a given load is applied to the bottom of the boss by a punch supported with an air die cushion not to cause fracture of the boss. The number of stages is reduced to 4 by this method.

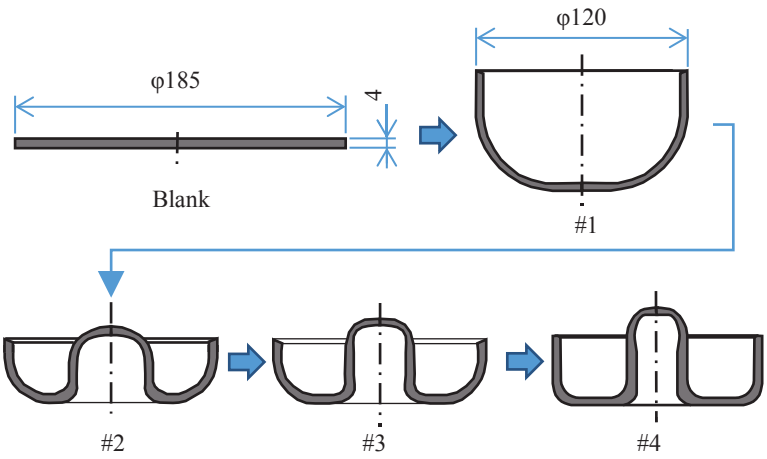

Fig. 5 4-stage process

2) 2-stage process with multiple-action press

The reason why 3 stages are needed to form the boss in the above process is that the load applied to raise the boss is limited to avoid breakage of the boss wall.

It is considered that multi-action press may be able to reduce the number of stages for boss forming. The basic idea is that a higher boss may be formed even by keeping the load applied to the boss-forming tool low enough not to cause breakage, if other tools are driven properly to push the surrounding blank material to the boss.

As a result of many trial and errors in simulation by assuming a 3-axis press, a process that the boss can be formed in one stage is found as shown in Fig.6. By employing this boss forming process, the total number of stages is reduced to 2.

The simulated process is examined with an 11-axis hydraulic press shown in Fig.7. The process shown in Fig.6 is carried out using 3-axes of the press. The main axis in the upper side of the press drives the main punch downward, and the upper sub-axis moves the sub-punch downward. The lower axis moves the counter punch upward to form the boss.

Fig. 8 shows the product made by the process of 2 stages shown in Fig.6. Hot rolled carbon steel sheet "SPHC" of 4mm in thickness is used as the experimental material, and the blank is made by machining the sheet. A machine oil is applied to the overall surfaces of the blank with a brush. The total forming load needed to form the product is about 3,000kN.

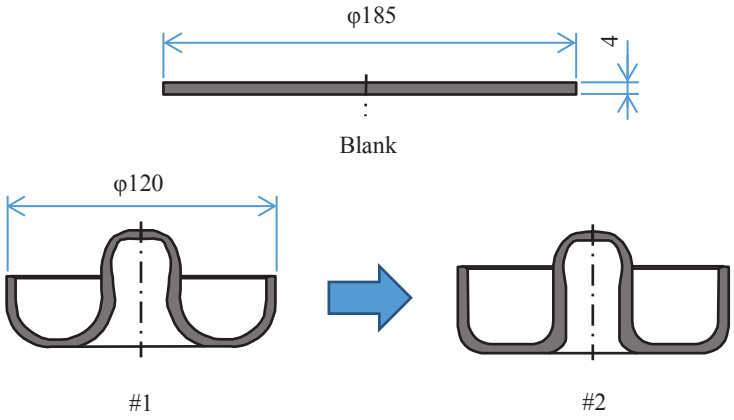

Fig. 6 2-stage process with 3-axis press

Fig. 7 Multiple-action forming press

Blank #1

#2 #2 Cross section

Fig. 8 Forming parts

4. Concluding remarks

A new plate forming method for producing a double cup product with one-piece design is developed. By utilizing simulation, a process that produces the double cup product with 6 stages is first developed.

To reduce the forming stages from 6 to 4, reverse re-drawing in which the lower punch is pushed up the boss part with a constant load is employed.

To reduce the stages to 2, a multiple-action forming press is assumed and the axes are driven to push the surrounding blank material to the boss.

The proposed 2-stage process is experimentally examined with hot rolled carbon steel sheets and a multiple-action hydraulic press. The double cup product is successfully formed without defects.

In developing the plate forging processes, it is experienced that numerical simulation is essentially necessary because deformation freedom of plate is very large and movements of plural axes of multiple-action press are complex.

References

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