ISOTHERMAL PRECISION FORGING PROCESS OF ALUMINUM ALLOY CYLINDRICAL HOUSING①

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ABSTRACT A lot of theoretical analyses and repeated experience were carried out in the study of the forging process of cylindrical housing. Some important steps during the process were introduced, including the determination of the forging process, structure of the die and location of the die parting surface. The heating problem and the plastic pad which can avoid the raising of the die were introduced too. These have special significance in the precision forging process of aluminum alloy.

Key words aluminum alloy isothermal precision forging assembled die heating range

1 INTRODUCTION

7075 aluminum alloy cylindrical housing is a key part of a certain plane. It supports propeller axis and transmits propeller raising force. It undergoes numerous load during the launch, flying and landing of the plane. So the cylindrical housing not only has complicated shape but also must have high physicochemical and mechanical properities; the grain size of forging piece must be fine and uniform and the flow line must fit with the profile of the forging piece strictly. The distortion of flow line, circular current and piercing are not permitted, the longitude and latitude properties of forge must meet the target.

In order to meet the above-mentioned requirements, many technique problems need to solve. They are discussed below.

2 DETERMINATION OF FORMING TECHNICAL SCHEME

If traditional model forging method was adopted to form cylindrical housing, that is, a heated blank (the temperature is 450~ 470 ℃) was taken from the furnace and put into a preheated cavity of the die (the temperature is about 150 ℃) and pressed, a non-uniform temperature field was formed between the deformed blank and die because of the large difference of temperature. The quantity of heat of the blank was absorbed by the die quickly, so the deformation temperature of the blank was far lower than 460 ℃, in some cases lower than 380 ℃, because of this, the deformation restraint force of the blank increased sharply and the plasticity of it decreased obviously. The earing was formed difficultly. But the conditions were different when the isothermal precise forging was adopted. By this method, the blank was heated to the forging temperature and put into the cavity of the die which was heated to the blank's deformation temperature, then the blank was pressed and a uniform temperature field was formed between the blank and the die. The blank flowed and deformed under the ideal temperature constantly. So the plasticity and flowing ability of the blank were improved and the deformation force decreased. Complicated shape, high dimension precision and high internal structural property forging piece can be forged.

During the research of isothermal precise forging of cylindrical housing, several scheme tests were carried out and two of them were introduced as follows.

(1) Direct backward extrusion forging by

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press punch(Fig. 1). Fig. 1 shows the schematic diagram of direct backward extrusion forging, then the metal's deformation flow can be classified into two stages.

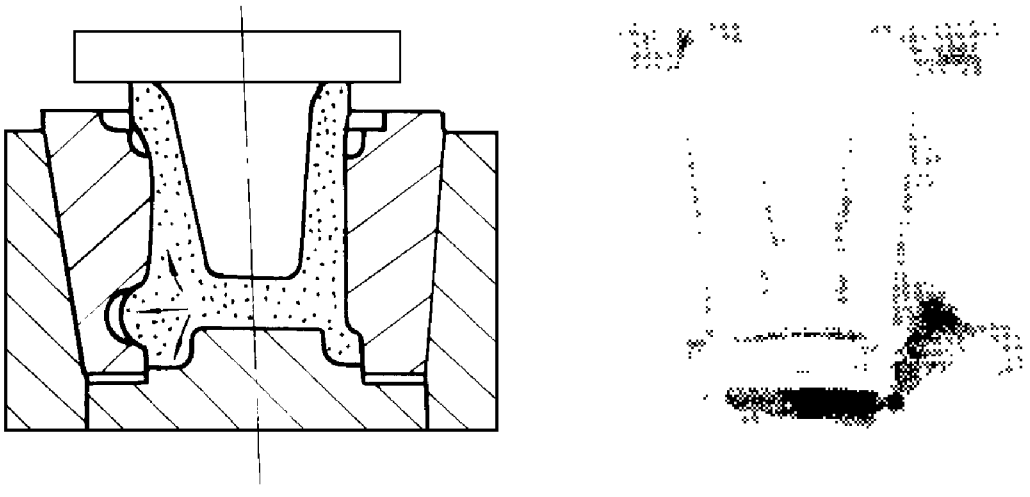
The first stage begins from the contact of the under ear section of the blank and the blank. In this stage the bottom of the housing will fill up, but the earings can't fill up fully. Because the filling of flowing metal decreases the unfilled section of die cavity, the filling of cavity will cause large plastic deformation and the restraint force of the metal filling the earings increases greatly. So the metal flows upward along the axial direction, the filling movement of earings becomes more difficult.

The second stage is from the end of the first stage (the contact of upper and section with blank) to the full filling of the die cavity. In this stage the cylindrical section will be filled quickly and the flange will be deformed. But with the press of the punch, the contact area of upper section of the punch and the blank increases quickly and the press force of deforming flange becomes larger and larger, then the force caused by bottom section of the punch becomes smaller and smaller. So the deformation of the earings becomes more diffcult. Unfilled section will be more difficult to fill up. Fig. 1(b) is the section photo of cylindrical housing (1∶3 decreased proportion product) the mesh of the earings distorts greatly, the metal's plastic deformation is great and the earing and flange sections do not fill up fully, therefore this scheme should not be adopted.

(2) Forward extrusion by plain punch firstly and then backward extrusion by extruding punch. Fig. 2 shows the schematic diagram of forward extrusion, which is mainly radial extrusion deformation. The lower and earings of the housing are filled up fully, then the press punch extrudes backward, the flange is deformed at last. This scheme can make the earings filled up fully, the forging piece's profile is clear and the dimensions meet the requirements. So this scheme is practicable.

3 DESIGN OF STRUCTURE OF DIE AND SCHEME OF DIE SPLIT

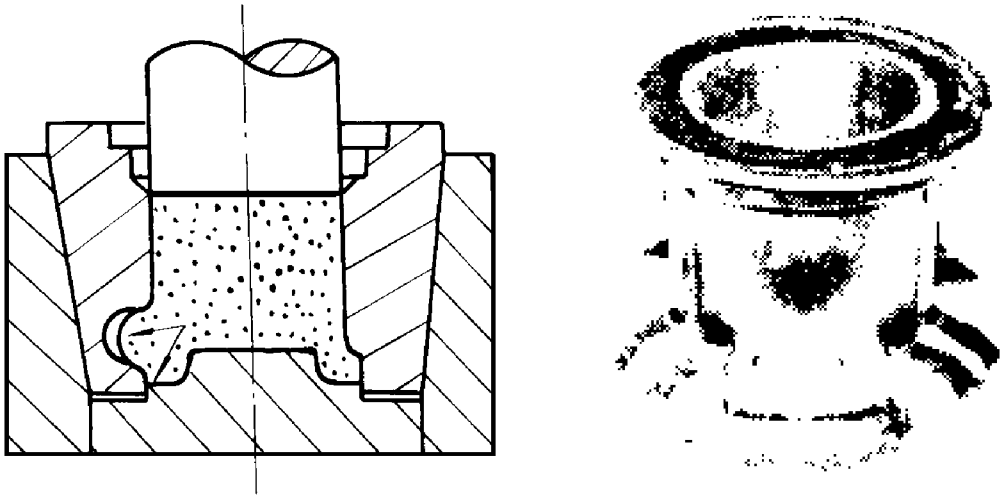
The cylindrical housing has complex shape with high cylinder and deep cavity. There are flange at one side of the cylinder and four earings, which do not stay uniform and symmetrical at the opposite side. The outer surface does not need machining. Considering the deformation of earings and requirements of demoulding, the female die is a combined one with four parts (Fig. 3), and a rod is used to locate the four parts. The outer surface of the male die is a conical surface and contacts closely with the inner surface of the female die. The female die is fixed in the coat through bolt (part 10), and directed loop



(a) (b)

Fig. 1 Direct backward extrusion deformation

(a) —Schematic diagram of deformation scheme; (b) —Section photo of product



(a) (b)

Fig. 2 Forward-backward extrusion deformation

(a) —Schematic diagram of deformation scheme; (b) —Photo of product

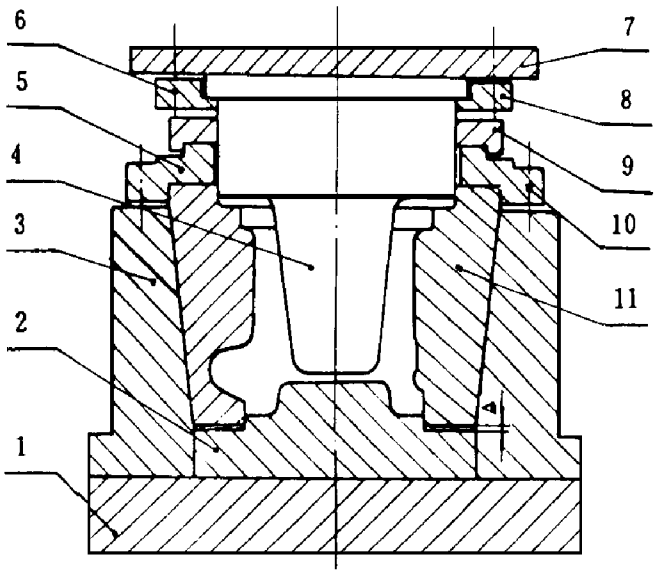


Fig. 3 Dies diagram of cylindrical housing

(part 5). The whole lower die is installed on the lower work plane of the press through pressing board and bolt.

The above-mentioned die not only guarantees the intimate contact of four parts of the female die, but also guarantees the contact of female die and the sleeve. In precise forging, this structure can meet the requirements to separate or combine conveniently. It is important to secure the forging piece precision and improve productive efficiency.

The female die is a key part of the whole die, its design, especially the split scheme is very important. After the comparison of schemes, the scheme that each earing is formed in two parts of the die, the female die is held out after deformation, and the four constitutional parts can be assembled and disassembled conveniently, is chosen(Fig. 4). So the advantages of this scheme is that the machining of the earing is easy, the forging piece is easy to get out, the forming precision of the earings is high.

4 HEATING OF BLANK AND DIE

The forging temperature range of 7075 aluminum alloy is narrow. If the heating temperature is high before forging, coarse grain will form because of super-heat or local superheat. On the contrary, if the forging temperature is lower, the restraint force is high and is not subject to fill up the cavity. Moreover coarse grain structure will form after solid solution treatment of forging piece caused by incomplete recrytallization. According to the plasticity diagram and restraint force diagram, the temperature at which the metal with high plasticity and lower restraint force is chosen as heating temperature, and the temperature is 460 ℃.

The determination of heating temperature of the die should meet such re quirements, so

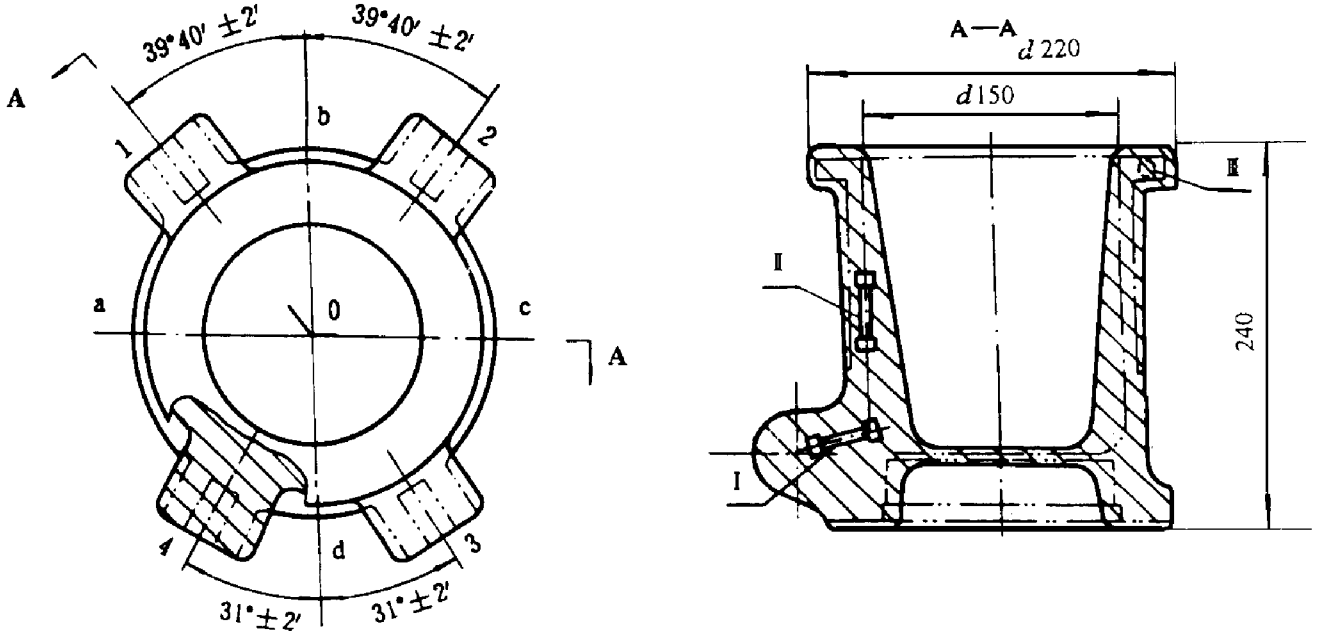


Fig. 4 Forging diagram of cylindrical housing

that the structure of forged blank meets the target, the actual deformation temperature is not lower than the recrystallization temperature and the restraint force is lower. In order to avoid microscale structure defects caused by heat efficiency phenomenon, the heat temperature is chosen as 440 ℃ in the experiment.

Resistance heating mode was adopted, the temperature was controlled by automatic device. The punch, male die and female die are working parts and the sleeve undergoes the highest force during forging deformation (Fig. 3). Moreover the decrement of temperature is up to 60 ~ 70 ℃, in the position of the contact of the female die and the sleeve. So the heating device must have heating house inner and out.

5 CONCLUSIONS

The cylindrical housing machined by above-mentioned heating speculations and heating device has fine and uniform grains. The flow line of forging piece fits with the requirement of shape strictly. Longitude and latitude properties of subscribed location all surpass the target. The precision of the forging piece is higher than those of foreign parts.

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