FORGING DIE AND METHOD

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This invention relates to a forging die and particularly to a closed die for working on non-ferrous alloys, to produce forgings of irregular configuration, such forgings having surfaces finished to machine tolerances.

The primary object of the invention is to provide a forging die which may be used to produce light metal alloy forgings with walls having no draft and finished to machine-surface tolerances.

A further object of the invention is to provide a method and a forging die for forging light metal alloys having accurately controllable heating elements whereby accurate forgings may be produced.

Another object is to produce improved forgings by properly controlling the temperature within a range where a few degrees difference in temperature result in a considerable difference in fluidity of the metal and controlling the velocity of metal flow within a die by regulating the speed of descent of the plunger into the cavity.

A still further object of the invention is to provide a means of obtaining uneven metal flow from a metal blank in a closed die to produce an asymmetrical forging having walls of unequal thicknesses and heights.

The production of intricate shapes in light metal alloys from forgings has heretofore required considerable machining of the forging to obtain the desired surfaces and tolerances. In the past, a forging was made with considerable excess metal which had to be trimmed off by known machining processes to obtain the part as it was to be used. The die of the present invention can produce forgings having surfaces finished to the desired tolerances without requiring additional machining. The upsetting walls or fins may be forged with no draft so that they have a constant thickness throughout.

The invention is illustrated in a preferred embodiment in the accompanying drawings in which:

Fig. 1 is a vertical sectional view through the die showing heating elements and controls diagrammatically;
Fig. 2 is a vertical section through the die taken substantially along line 2—2 in Fig. 1;
Fig. 3 is a horizontal sectional view taken substantially along line 3—3 in Fig. 1, and looking down into the cavity of the cavity block;
Fig. 4 is a perspective view of a metal blank from which a forging is made in accordance with the principles of this invention can be made; and
Fig. 5 is a perspective view of a finished forging made from the metal blank of Fig. 4.

Many parts of aircraft and other machinery are made of high strength aluminum alloy by forging a rough piece approximating the shape of the finished piece, which piece is then machined to proper shape. In the present invention, a forging may be formed having the finished shape as it emerges from the die. Some parts may require some machining on outer surfaces. Fins and walls may be formed with no draft so that excess metal in the finished piece is avoided. The grain structure of the forging is such that maximum strength throughout is obtained.

One forging which may be made by the present invention is shown for the purpose of illustration in the accompanying drawings. The finished forging is shown in Fig. 5 and the blank 7 from which the forging is made is shown in Fig. 4. From an observation of the metal blank and the forging of Figs. 4 and 5 it can be ascertained that the finished piece has a rather thick wall 8 at one end flanked by a pair of cavities 9 and 10 which extend downwardly to a bottom wall which is invisible. These cavities and the wall 8 are formed from the heavy end 11 of the blank 7. The other end of the forging has a pair of rather thin walls 12 and 13 which are joined by a thin base 14 all formed from the rather thin part 15 of the blank. An intermediate upsetting wall 16 separates the cavity 10 from the space between the walls 12 and 13 and this wall is formed of metal from the intermediate portion 17 of the metal blank. Each of the walls 9, 16, 12, and 13 is formed with no draft, that is, these walls have parallel inner and outer surfaces and emerge from the die in this finished state. The inner surfaces of the walls are smooth and do not require any additional machining. The piece may be machined to proper configuration for use in its intended place by removing some metal from the bottom and by cutting off the diagonal wall forming one side of the cavity 9. Any small fins on the upper wall edges may be machined off if necessary.

The die used to perform the forging operation is one of the closed type having a die block in which a cavity of the shape of the piece to be formed is present and a top block carrying a plunger or punch which enters into the cavity with forging pressure to perform the forging operation and cause the metal of the metal blank 7 to flow into the shape of the finished piece 6. Forging as used herein means to shape metal under pressure.

In Figs. 1 and 2 the die for performing the forging operation is illustrated and includes a cavity block 20 having therein a cavity 21 having the shape as shown in Fig. 3 which corresponds to a plan view of the finished piece 6. The cavity block is supported by a pair of spaced parallel bars 22 above a base plate 23 which may be placed in a suitable forging press. Machine bolts 24 secure the base plate, bars and cavity block together in light relationship. A cross bar 25 rests upon the base plate and carries a knock-out plunger 26 for removing the forging from the cavity 21 after it is formed. In Figs. 1 and 2 the metal forming the piece 6 is shown in place between the cavity block and plunger. In Fig. 1 the end wall 8, the intermediate wall 16 and the base 14 are all visible in section.

Heat is supplied to the cavity block by one or more heaters and in the present instance, two tubular type resistance heaters are shown. Heater 27 appears on the left side of Fig. 1 and is very similar to heater 28 on the right hand side of Fig. 1. Heater 28 is provided with electrical lead lines 30 which extend to a rheostat 29 as illustrated in Fig. 2 diagrammatically. Each heater is provided with its own rheostat so that the temperature provided to one end of the block as compared with the other end may be varied in accordance with the desired metal flow.

The top plate 31 is used to support a heater and punch retaining plate 32 which is secured thereto by means of a number of machine screws 33. The punch 34 is mounted on the heater and punch retaining plate by a number of screws 39 and aligning pins 40. The punch is formed with bosses to fill the cavities 9 and 10 and to fill the space between the walls 12 and 13. In Fig. 2 the boss 36 forms the cavity 10 and the boss 37 forms the cavity 9. In Fig. 1 boss 36 is visible in the section as is a boss 35 which fills the space between the walls 12 and 13. All four sides 38 of the punch are made to fit tightly within the cavity so that the die formed between the cavity in the block and the punch is a closed
The top plate 31 and the bottom plate 23 on the separate die parts are flat so as to be placed within a forging press and to accept pressure applied there-against to move the punch into the cavity and against metallic blank 7 therein. A number of leader pins 32 guide the top punch in proper alignment into the cavity of the die block. Stop blocks 49 secured to the heater retaining plate 32 limit downward travel of the punch toward the cavity block.

The punch is heated in a manner similar to the supply for the cavity block and in this particular instance a pair of heaters 42 and 43 are shown as tubular resistance elements fitted in appropriate bores in the heater retaining plate 32. These heaters are each provided with lead electrical lines 48 and a separate rheostat 44. While we have herein shown the heaters as tubular in form and fitting tightly within bores in the block and retaining plate respectively, strip type heaters may be used by fastening them tightly against the sides of the block and retaining plate. Each of the heaters may be separately controllable so as to provide means for a heat differential between portions of the blank to obtain increased metal flow in the warmer portions. In order that a workman operating with the die of this invention shall be informed of the temperature of the block a number of thermocouples are provided in the cavity block and in the punch. In the present instance thermocouples 47 and 48 are provided in the cavity block at each end of the die and a thermocouple 46 is provided substantially centrally of the punch. Additional thermocouples may be provided as desired and needed.

The material used for aircraft forgings is an aluminum alloy having a tensile strength of the order of 60,000 to 90,000 p. s. i. This metal is forged under considerable pressure at elevated temperatures. In order to obtain a forging with surfaces finished to machine tolerances, the metal blank 7 is preheated to substantially the forging temperature. The cavity block and the punch may be preheated to have the desired temperature differential. In some instances, the block and punch may be preheated to within a temperature range of 550°-700° F. without maintaining a differential. The metal blank is placed in the cavity in the cavity block and the punch is descended thereupon under forging pressure. A temperature differential in the die causes increased metal flow in parts of the die having the higher temperature. The heating temperatures in the die are used where the greatest metal flow is needed. The speed of descent of the punch is very slow and is substantially slower than a press working on cold metal or the usual forging presses. A top forging temperature for aluminum forgings is generally around 870° F. and the present forging is done in a range substantially lower than the top range and is often performed at temperatures of about 600° F. The dies are usually made of 5% chromium air-hardened die steel designed to operate at elevated temperatures so that the temperature at which the forging is made does not adversely affect the die even though it may be used to make many forgings and the time for actual forging is longer.

There are several factors which come into play in making a successful forging in the present method of operation. The shaping of the blank to place the metal adjacent the space it is to occupy in the finished forging is important in that lateral flow of the metal in the upward extending sides of the piece such as 12 and 13 shown in Figure 5 is to be avoided. The bottom of the punch is formed with a slight inclination adjacent the wall so that the metal does not have to make too sharp a turn in passing upward between the punch and cavity wall. By forging within a temperature range below 700° F., the die is not subjected to deterioration as early as is the case when forging is conducted at the usual 850° F. This permits the utilization of more time in forming the forging and allowing the metal to flow and fill the die. In practice, 85 to 90% of the die may be filled in the first 30 to 40 seconds of applied forging pressure. The last 10 to 15% of the die may require an additional 20 to 30 seconds under a high pressure in order to fill the die. After the punch has traveled downwardly to its limit, the pressure is ordinarily increased considerably and a dwell period of 30 to 60 seconds under such pressure is applied to the die parts. The metal under these circumstances completely fills the die and since the temperature is maintained throughout the operation, the finished piece comes out requiring very little machining. Any machining that is required is on the outside surfaces and may be due to a necessity of forming walls to obtain metal flow even though the wall is not needed in the final part.

An example of the forging practice followed utilizes a blank as shown in Figure 4 weighing approximately 161/2 oz. This blank is removed from a preheat furnace at 700° F. and placed in the forging die cavity which is maintained at 640° F. The punch at 620° F. forces by hydraulic pressure action to the resultant configuration as the ram pressure is increased to 300 tons. At the end, the pressure is increased to 600 tons and held for 30 seconds' dwell time and then released. In this particular example, the temperature throughout each part of the die and forging is the same and no temperature differential is used. In parts having walls of unequal height, a temperature differential may be used if, upon experimental forming, operators deem it desirable. After the forging has been formed and the punch has descended to its inward extent as determined by the stop blocks on the side of the heater retaining plate 32, the punch is retracted while the heaters maintain the forging temperatures throughout the cavity block, the punch and die block. The finished forging may be removed from the cavity by the use of the knock-out plunger 26 and this forging will have its finished shape. Its walls have parallel surfaces and are perpendicular to the bases. All fillets and irregular surfaces are perfectly formed. The use of this method permits the forging of intricate shapes of aluminum alloy without fear of producing parts with weakened internal structure. The temperature is varied in order to obtain metal flow so that the grain structure is the most desirable throughout and the grain ordinarily assumes a pattern a few the corners aligned with the outer surface metal. The strength of the forging is substantially the same throughout all its parts and is generally greater than that obtained by forgings made with excess metal which is later trimmed off by machining. The foregoing detailed description is given for clearness of understanding only and no unnecessary limitations should be understood therefrom as modifications will be obvious to those skilled in the art.

We claim:
1. The method of producing forgings having walls of different thicknesses and heights in a closed die having a cavity block and a punch, comprising: preheating the cavity block to provide a differential in temperature between portions of the block; preheating the punch to provide substantially the same temperature and temperature differential in corresponding portions of the punch; preheating a metal blank to have a uniform temperature throughout; placing the heated blank in the cavity block, and pressing the punch into the cavity with sufficient force to cause the metal to fill the die; and maintaining said differentials in temperature, during the forging.
2. The method as specified in claim 1 including the step of maintaining said temperature differential in the die while withdrawing the plunger and while removing the finished forging from the block cavity.
3. A method of forging light metal alloys in a closed die having a block formed with a cavity and a punch adapted to enter the cavity to form therewith a space for a forging having draftless side walls comprising: preheating the block and punch to substantially forging temperature; providing a differential in temperature between
5 various portions of the block and of the punch with adjacent portions of the block and punch having the same temperature; preheating a metal blank uniformly to substantially forging temperature; placing the heated metal blank in the cavity and pressing the punch against the blank with forging pressure to cause the metal to flow within the die; maintaining said differential in temperature between said portions of the die to obtain increased metal flow in the portions of the die that are heated to a higher temperature; and then maintaining said heated condition while withdrawing the punch from the cavity after forming the forging and while removing the finished forging from the cavity.

4. The method of forging light metal alloys in a closed die including a block formed with a cavity having draftless sidewalls and a punch adapted to enter and close the cavity forming a closed space in the die parts for a forging, comprising: preheating the die parts to a temperature within a range of 550° to 700° F.; preheating the metal blank to generally the same temperature as the die parts, placing the preheated blank in the preheated die cavity, bringing the die parts together to seal and confine the metal blank within the closed space in the die, moving the die parts together upon the blank without impact while maintaining said temperature of the die parts within said temperature range; applying pressure on the die parts and confining metal blank until the metal of the blank has flowed to fill the closed space within the die, and then removing the forging from the die parts while maintaining said parts at said specified temperature.

6. The method of producing light metal forgings as specified in claim 5 including the step of increasing the pressure on the die parts after the limit of movement of the die parts together has been reached and holding said increased pressure for a short period to insure filling of the closed die.

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