TITLE

Liquid Forged Article

FIELD OF THE INVENTION

This invention relates to articles formed by liquid forging, particularly to articles having through holes filled with a molten metal.

BACKGROUND OF THE INVENTION

Articles such as motor rotors are conventionally made by die casting a metal such as aluminium (Al) into inserts having long through holes with small diameters.

Although copper (Cu) provides better conductive properties than Al, die casting Cu at around 1200°C to 1300 with inserts is not ideal because of the high melting point of Cu which shortens the lifespan of a conventional die made of H13 alloy. Moreover, porosity in the article is inevitable with die casting.

SUMMARY OF THE INVENTION

According to one aspect, there is provided an article having high aspect ratio cavities wherein said cavities are filled with a metal by liquid forging. The metal may be selected from the group consisting of: Al and Cu. The high aspect ratio cavities may be long through holes. The holes may be 20-60 mm in length and at least 4 mm in diameter. The liquid forging may be selected from the group consisting of: counter gravity liquid forging, gravity assisted liquid forging and horizontal flow liquid forging. Die tools may be made of materials selected from the group consisting of: H13 alloy, Mo, W and Ni - based alloys, and carbides of Si, W and B.

According to another aspect, there is provided a method of forming an article, the method comprising providing an article having at least one cavity in a mold, providing an at least partially molten metal for filling the at least one cavity, closing the mold to allow pressurized contact of the article with the metal, and applying pressure on the molten

metal such that the molten metal fills the at least one cavity. The molten metal may fill the at least one cavity by flowing either horizontally or vertically into the cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the present invention may be fully understood and readily put into practical effect, there shall now be described by way of non-limitative example only preferred embodiments of the present invention, the description being with reference to the accompanying illustrative drawings.

In the drawings:

Fig. 1 is a schematic front view of counter gravity liquid forging in accordance with one embodiment of the invention;

Fig. 2 is a schematic front view of gravity assisted liquid forging in accordance with a second embodiment of the invention; and

Fig. 3 is a schematic front view of horizontal flow liquid forging in accordance with a third embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to one aspect, there is provided an article comprising an insert having long through holes filled with a metal, such as a motor rotor. The metal may be Al or Cu. The cavities are filled by liquid forging of the metal to produce articles with low porosity, maxing it inexpensive and suitable for mass production.

As shown in Fig. 1, the article 12a is placed in a mold 14a, ready for molten metal 16a to flow through the cavities 18a. When the mold 14a is closed, pressure builds within the molten metal 16a and flow upwards through the cavities. The article is ejected using the pin 20, as depicted by arrow 22.

Another embodiment is shown in Fig. 2, where liquid forging is gravity assisted. In this embodiment, molten metal 16b is poured on top of the insert 12b. When the mold 14b is

closed, the molten metal 16b flows into the cavities 18b under pressure exerted by the punch 24, as shown by arrow 26, as well as by the pull of gravity.

Fig. 3 shows a horizontal flow liquid forging arrangement, wherein the molten metal 16c is to flow horizontally into the cavities 18c when the plunger 28 is pushed, as shown by arrow 30.

The cavities 18a, 18b, 18c can range in length from 20-60 mm and have a diameter of at least 4 mm. Wall thickness between adjacent cavities or holes can range from 300 μm to several centimeters.

Die tools for liquid forging of Al are made of H13 alloy. For liquid forging of Cu, die material is selected from the group consisting of: molybdenum (Mo), tungsten (W) and nickel (Ni) based alloys, and carbides of silicon (Si), tungsten (W) and boron (B). The die materials principally must have an elevated temperature strength, thermal shock resistance and hardness of about 40 HRC for longer die life. For Cu, standard liquid melt treatment is adopted.

Whilst there has been described in the foregoing description a preferred embodiment of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made without departing from the present invention. For example, other metals than Al and Cu can be used depending on the article to be formed. The method can also be used on inserts having cavities of other sizes and geometries.

CLAIMS

1. An article having high aspect ratio cavities wherein said cavities are filled with a metal by liquid forging.
2. The article according to claim 1, wherein the metal is selected from the group consisting of: Al and Cu.
3. The article of claim 1 or 2, wherein the high aspect ratio cavities are long through holes.
4. The article of any one of the preceding claims, wherein the holes are 20-60 mm in length.
5. The article of any one of the preceding claims, wherein the holes are at least 4 mm in diameter.
6. The article of any one of the preceding claims, wherein the liquid forging is selected from the group consisting of: counter gravity liquid forging, gravity assisted liquid forging and horizontal flow liquid forging.
7. The article of any one of the preceding claims, wherein die tools are made of materials selected from the group consisting of: H13 alloy, Mo, W and Ni -based alloys, and carbides of Si, W and B.
8. A method of forming an article, the method comprising:
    a. providing an article having at least one cavity in a mold;
    b. providing an at least partially molten metal for filling the at least one cavity;
    c. closing the mold to allow pressurized contact of the article with the metal; and
    d. applying pressure on the molten metal such that the molten metal fills the at least one cavity.
9. The method of claim 8, wherein the molten metal fills the at least one cavity by flowing vertically into the cavity.
10. The method of claim 8, wherein the molten metal fills the at least one cavity by flowing horizontally into the cavity.