EXPLOSIVE METAL FORMING, SINTERING AND PLATING

Max Goldberger, Wapping, and Hellfried Neuhold, Wethersfield, Conn., assignors to Pioneer Research, Inc., Manchester, Conn., a corporation of Delaware

Filed Apr. 25, 1966, Ser. No. 544,990

U.S. Cl. 72—50

INT. Cl. B21d 26/08, 28/18, 22/10

9 Claims

ABSTRACT OF THE DISCLOSURE

An explosive forming press and method are provided for producing formed metal parts comprising a sealable enclosure having contained therein a monogone fuel comprising an aqueous solution of a catalytically activatable material, a catalyst positioned within said chamber and contactably separated from the fuel, a die positioned within the chamber, and means for supporting a metal part adjacent the die, the fuel being located relative to the catalyst so that, during the forming operation, the fuel is caused to contact the catalyst whereby to generate a high forming pressure and form the metal part against the die.

This invention relates to metal forming and, more particularly, relates to impact metal forming.

Quantum production of formed metal parts is usually handled by heavy, expensive hydraulic presses which form the metal between matching dies. However, in small quantities, the construction of dies and the use of such hydraulic presses is uneconomical. Also, in forming some metal parts, it is advantageous to provide a forming stroke which has an extremely rapid pressure rise.

For these purposes, the art has provided several types of explosive forming apparatus. In such apparatus, the material to be formed may be placed against a die. A solid explosive such as gun powder or more sophisticated explosive mixtures are packed in a container and positioned against the unsupported side of the metal to be formed. The powder is then ignited and the explosive force generated thereby presses the metal against the die to form the same.

The explosive presses have many advantages. However, they do suffer from some disadvantages, particularly the danger of handling, storing and employing explosives in commercial facilities. It also has been found that there is some difficulty in obtaining a uniform distribution pressure over the metal plate caused by uneven ignition and travel of the ignition wave through the explosive.

It is, therefore, an object of the present invention to provide an explosive forming apparatus in which a much safer fuel is utilized.

It is a further object of this invention to provide an explosive forming press providing for uniform distribution of pressure on the material to be formed and using relatively safe and inexpensive fuel.

In accordance with these objects, there is provided, in a preferred embodiment of this invention, a forming mold comprising a die plate adapted to hold the forming die and over which is positioned the material to be formed. A chamber is clamped to the die plate enclosing both the die and the material to be formed. A monogone fuel such as an aqueous mixture of ammonia and hydrogen peroxide is positioned within the chamber in a container. Also mounted within the container is a catalyst such as a Raney silver catalytic element. To form the material, the liquid fuel is suddenly brought into contact with the catalytic element. The reaction is very rapid, giving rise to the buildup of gaseous pressure to form the material against the die. The material to be used may be sheet material or may be powdered material to be sintered by the high pressures generated in the chamber.

The fuel is, of course, relatively inexpensive and does not necessitate extraordinary handling precautions as is true with explosive fuels.

Having briefly described this invention, it will be described in greater detail along with other objects and advantages in the following portions of the specification, which may best be understood by reference to the accompanying drawings, of which:

FIG. 1 is a sectional elevation view of a press in accordance with a preferred embodiment of this invention;

FIG. 2 is a cross section view taken along lines 2—2 of FIG. 1;

FIG. 3 is a cross section view taken along lines 3—3 of FIG. 1; and

FIG. 4 is a partial sectioned view of another embodiment of the present invention.

In FIGS. 1-3, there is shown an explosive press in accordance with a preferred embodiment of the present invention which consists of a die plate 10 provided with a locating shoulder 12 to receive a die 14 positioned therein. As is conventional, a small aperture 16 may be provided through the die plate for venting of gas entrapped between the material 18 to be formed and the die 14 which is passed from the die face around the periphery of the die. In addition, as is also conventional, small vent holes may be provided through the die to relieve air entrapped between the material 18 and the die 14. Whether or not such entrapped gas relief is necessary depends primarily on the application intended such as the specific configuration of the die surface, the depth of formation of material and like considerations.

A chamber 20 is defined by a pressure cup 22 which is basically an open ended cup arrangement having the periphery thereof engaged in sealed relationship with the die plate by a plurality of bolts 24 extending through the die plate into the walls of the cup 22. Since the chamber must contain high pressure built up at high rise rates, it is usually desirable to provide a safety valve or safety plug 26 threadably inserted into the aperture 28 in the top wall 30 of the cup 22. A container 32 is mounted within the pressure cup as, for example, by ribs 34. A catalytic element 36 is mounted on the top wall 30 as, for example, by straps 38 secured to the top wall by screw fittings 40.

The catalytic element is preferably formed of a nylon cloth having a Raney silver catalytic surface applied thereto. A full description of the formation of Raney silver surface is contained in my application Ser. No. 447,511, filed Apr. 12, 1965 for Raney Metal Sheet Material. The fuel is preferably a monogone as, for example, an aqueous solution of hydrogen peroxide and ammonia. Such fuels, of course, are highly stable and even when strong solutions are used, do not require more than ordinary handling precautions for this type of material. When the press is sealed and it is desired to form the material 18 against the die, the entire press may be inverted to suddenly dump the fuel on the catalytic element. When the fuel contacts the Raney silver catalyst, the oxygen is dissociated from the hydrogen peroxide in a nascent state and immediately reacts with the hydrogen available from the ammonium hydroxide. This provides a reaction product consisting of nitrogen gas and steam. The steam is produced since the reactions are exothermic and byproducts of the reactions are water. There are three sources of exothermic reactions. The first is the dissociation of the hydrogen peroxide. The second is the formation of water from the hydrogen and oxygen available from the above dissociation. The third is the heating of the Raney silver catalyst by the oxygen during catalytic dissociation.
The chemical reaction that takes place can be represented generally by the following equation:

\[ 2\text{HNO}_3 + 3\text{HOOH} \rightarrow \text{N}_2 + 8\text{H}_2\text{O} \]

This reaction is very rapid and produces forming pressures which are controllable by selection of the strength of the aqueous solution. Normal working range is of the order of 500,000 to 600,000 p.s.i. The rise time is also controllable but is normally maintained quite short, e.g., within the range between thousands of a second and milliseconds.

For the purpose of complete disclosure but not by way of limitation, the following examples of material formation is given.

**EXAMPLE I**

Material and forming—3-in. diameter, depth \( \frac{1}{4} \)-in. thick—brass; depth of forming—4 mm., cup shaped

Fuel—150 cc., aqueous solution \( \frac{1}{2} \) \( \text{H}_2\text{O}_2 \) (50%), \( \frac{1}{2} \) \( \text{NH}_4\text{OH} \) (30%)

Catalyst—a 1" x 5" strip, both surfaces coated with Raney silver catalytic surface (10 sq. in.) of catalytic exposure

**EXAMPLE II**

Material and forming—copper sheet \( \frac{3}{4} \)-in. thick against a die carrying imprints with a \( \frac{1}{4} \)-in. depth of forming

Fuel—the same quantity and composition as Example I

Catalyst—a band 1" x 5" coated only on one side with Raney silver catalyst (5 sq. in. of Raney silver)

**EXAMPLE III**

Sintering of aluminum powder, preformed into a self-sustaining cake

Fuel—per Example I

Catalyst—a band 1" x 3" coated on one side (3 sq. in. of catalytic surface)

Comment.—It is interesting to note that if the fuel and catalyst of Example I is used with aluminum powder, the compression is so severe that the aluminum powder reaches the point of which it melts and self-ignites.

**EXAMPLE IV**

Sintering of nickel powder

Fuel—same as Example I

Catalyst—a band 1" x 4" carrying Raney silver on one surface thereof (4 sq. in. of catalytic surface)

Comment.—If the fuel and catalytic surface of Example I is used, the nickel powder is compressed to self-ignition.

In these examples, the peak p.s.i. was of the range of 500,000 to 600,000 p.s.i. with a rise time within the range between a thousandth of a second to several milliseconds.

In those applications where small amounts of material are to be subjected to increasingly higher pressures, the piston type arrangement of FIG. 4 may advantageously be employed. In this arrangement, the die plate is provided with an internal smooth wall 44. A piston 46 is slidably mounted within the die plate and may be provided with sealing rings 48. The piston is provided with a plunger 50 extending into cavity 52 in the die plate. The material 54 to be treated is positioned within the cavity 52. The rest of the press is identical to that of FIG. 1. Upon activation thereof, the pressures applied to material 54 are mechanically multiplied in accord with the ratio between the area of the piston 46 and the area of the plunger 50. This arrangement can provide extraordinarily high forming pressures without the necessity of designing the entire mechanism to withstand such pressures.

This invention may be variously modified and embodied within the scope of the subjoined claims.

What is claimed is:

1. A forming press for producing formed metal parts comprising a sealable chamber, a monogolee fuel contained therein comprising an aqueous solution of a catalytically activatable material, a catalyst positioned within self-ignition. In this invention, the fuel and catalyst are separated from said fuel, and means for supporting a metal part adjacent said die, the fuel being located relative to the catalyst so that, during a forming operation, the fuel is caused to contact the catalyst whereby to generate a high forming pressure and form the metal part against said die.

2. A forming press in accordance with claim 1 in which said enclosure comprises a die plate and a cup secured to said die plate to form said chamber.

3. A forming press in accordance with claim 2 in which said die plate includes locating means for receiving a die positioned therein.

4. A forming press in accordance with claim 1 in which said fuel comprises an aqueous solution of \( \text{H}_2\text{O}_2 \) and \( \text{NH}_4\text{OH} \).

5. A forming press in accordance with claim 1 in which said catalyst comprises a Raney silver catalyst.

6. A forming press in accordance with claim 2 in which includes a piston slidably mounted within said chamber, said piston having a plunger protruding therefrom, and in which said die plate includes a cavity into which said plunger fits.

7. A method for the explosive forming of metal parts which comprises placing a metal part to be formed adjacent a die within a sealed chamber having a catalyst mounted therein and containing a catalytically activatable monogolee fuel contactably separated from said fuel, and then causing said fuel to contact said catalyst during a forming operation, whereby to generate a high forming pressure and form said metal part against said die.

8. The method of claim 7 wherein the fuel contacting said catalyst is an aqueous solution of \( \text{H}_2\text{O}_2 \) and \( \text{NH}_4\text{OH} \).

References Cited

UNITED STATES PATENTS

3,156,089 11/1964 Baumgartner

RICHARD J. HERBST, Primary Examiner.