Patented Feb. 15, 1944

2,342,037

UNITED STATES PATENT OFFICE

2,342,037

POWDER METALLURGY

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No Drawing. Application December 10, 1941, Serial No. 422,426

5 Claims. (Cl. 75—22)

This invention is concerned with powder metallurgy and particularly with the powder metallurgy of aluminum although it may be employed advantageously in the formation of compacts from a great variety of metal powders.

In powder metallurgy, a loose mass of metal powders is compressed in a die or mold. Thereafter the resulting compact is ejected, usually in a "green" or unsintered condition, although sintering of the compact may take place during compression or after compression while the compact is still in the die. The pressure employed to form the compact is high, i. e. 5 to 75 tons per square inch, and this forces the metal powder against the die wall to such an extent that the compact sticks in the die and requires considerable pressure to eject it. In some instances the compact sticks in the die so tenaciously that the force required for ejection breaks the compact. Thus a compact may be released suddenly from a die with such force that it is shattered into pieces. In less aggravated instances a considerable portion of metal is left as a skin on the die wall. This destroys the accuracy of configuration of the compact and also requires frequent die cleaning.

It has been proposed heretofore to lubricate the walls of the die with oil and the like, but this involves contamination of the compact, and may have a deleterious effect during sintering. Moreover, in many instances such lubricants do not prevent the compact from sticking.

As the result of my investigations, I have discovered that the above-described sticking difficulties (which are particularly serious with aluminum powders and aluminum alloy powders but which may also occur with other metal powders) may be eliminated by lining the mold or die, preparatory to introduction of the metal powder for the compact, with fine metal flakes which lie flat against the mold surfaces and are at least in part over-lapping. The entire interior of the mold or die may be so lined if desired but, in any case where sticking is likely to occur or ejection pressure may be high, the walls of the mold that extend in the direction in which the compact is pressed (and ejected) should be so lined, in which case the major axes of the metal flakes extend in the direction of ejection.

My invention is based upon the fact that a thin coating of overlapping flakes of metal of reasonably high malleability is not broken when the metal powder is compressed in the die, so that actual contact between the die walls and the powder of the compact is substantially prevented. In other words, the coating of overlapping metal flakes is strong in a direction transverse to the major surfaces of the flakes but relatively weak in the plane of those surfaces.

Flakes of non-metallic substances are, in general, insufficiently strong and lack the required ductility, malleability and resiliency. On the other hand, almost any metal that is sufficiently malleable to be hammered into flakes is admirably suited for the practice of the invention.

In some instances it is desirable to employ metal flakes per se without addition agents. However, especially in the case of aluminum it is desirable to employ metal flakes that have been treated with a suitable organic lubricant or leafing agent, say, stearic acid or aluminum stearate. These agents tend to hold the flakes in proper orientation with the die wall in an overlapping condition and also aid as lubricants.

The metal flakes, with or without the leafing agent, may be employed as a dry powder. However, in most instances, it is desirable to paint the flakes on the inside of the die. The vehicle employed with the flakes to form the paint preferably is such that it does not dissolve the leafing agent therefrom. Thus, aluminum flakes coated with stearic acid are conveniently suspended in a volatile vehicle, for example benzene, which does not dissolve the leafing agent—in this instance the stearic acid. However, other vehicles (say, acetone) in which the leafing agent (say, stearic acid) is soluble, are also satisfactory.

These and other features of my invention will be more thoroughly understood in the light of the following detailed description of my presently preferred practice.

To consider an instance in which aluminum powder is cold compressed in a die to form a compact which is sintered after it is ejected, a suitable lubricant comprises one volume of aluminum flake (such as is used in paint), one volume of stearic acid powder and two volumes of benzene or other volatile vehicle in which the stearic acid is substantially insoluble. The stearic acid powder and aluminum flake is thoroughly suspended in the benzene and applied to the die wall by means of an automatic wiper or spray or, in the case of a laboratory operation, with a brush. The benzene evaporates almost immediately leaving the wall thoroughly covered with overlapping flakes of aluminum powder together with some stearic acid. Thereafter the aluminum powder which is to form the compact is introduced into the die and compressed therein under a relatively high pressure, say, 40 tons per square inch.

The compact is then ejected from the press in the usual fashion, say by moving the lower plunger of the press upwardly with respect to the die.

The presence of the oriented overlapping metal flakes on the die wall reduces the pressure required for ejection to but a small fraction (say, 10%) of that required when customary lubricants such as oil or graphite are employed and completely eliminates the "jamming" and "cold sintering" which usually characterizes the compression of aluminum or aluminum alloy powders in a mold. Moreover, the compacts do not tend to rupture or develop flaws during ejection and the die walls are maintained in a substantially clean condition over long operating periods.

Numerous aluminum alloys, particularly age hardening aluminum alloys of the "17—S" and "24—S" variety, are not strongly resistant to corrosion. In forming compacts of such alloys by powder metallurgical methods, it is desirable to line the mold with pure aluminum flakes. These flakes form a thin film on the outside of the compact which is considerably more resistant to corrosion than the compact itself, thereby increasing the corrosion resistance of the resulting finished piece.

Parts compressed in accordance with my invention may be sintered in accordance with the usual practice. Thus, the invention is adapted to hot compression as well as to the more customary operation in which sintering takes place after the compact has been ejected from the die.

In the formation of compacts other than those of aluminum, the metal flake die lining is also highly desirable. Thus, in one instance a 70–30 atomized brass powder was compressed at 50 tons per square inch in a die lined with oriented aluminum flakes. Thereafter the resulting compact was ejected and subjected to the usual sintering procedure, during which the minute film of flake aluminum on the outside of the compact scaled off to leave a smooth clean brass surface.

It will be understood that the application of the invention is not limited to the use of aluminum flake and that flakes of a variety of other metals may be employed. Thus, fine brass and copper flakes may be used either as a suspension in a vehicle or in a dry condition and with or without a leafing agent.

Metal flakes of the size (say minus 300 mesh) customarily employed in paints, lacquers and the like are well adapted to the practice of the invention. These flakes customarily are produced in a stamping operation and the surfaces thereof usually are coated with a thin film of oxide which in turn is coated with a small proportion, say, 1½% on the weight of the metal, of a leafing agent that tends to cause the flakes to orient themselves with respect to the surface of a liquid film in which they are suspended. It is believed that the presence of the oxide film in addition to the lubricant is desirable, and aids in reducing ejection pressures in the practice of my invention.

I claim:

1. In a powder metallurgical process involving compression of metal powders in a die and the subsequent ejection of the resulting compact from the die, the improvement which comprises lining the die with a thin film of metal flakes lying flat against the die wall preparatory to compressing the powders therein, said flakes being of a metal of the group consisting of aluminum, copper and brass.

2. In a powder metallurgical process involving compression of metal powders in a die and the subsequent ejection of the resulting compact from the die, the improvement which comprises lining the die with a thin film of overlapping malleable metal flakes filmed with oxide and lying flat against the die wall preparatory to compressing the powders therein, said flakes being of a metal of the group consisting of aluminum, copper and brass.

3. In a powder metallurgical process involving compression of metal powders in a die and the subsequent ejection of the resulting compact from the die, the improvement which comprises lining the walls of the die which extend in the direction in which the compact is pressed and ejected with a thin film of overlapping metal flakes prior to introducing the bulk of the metal powder into the die, said flakes being of a metal of the group consisting of aluminum, copper and brass.

4. In a powder metallurgical process involving compression of metal powders in a die and the subsequent ejection of the resulting compact from the die, the improvement which comprises lining the die with a thin film of overlapping metal flakes coated with a leafing agent and laid flat against the die wall preparatory to compressing the powders in the die, said flakes being of a metal of the group consisting of aluminum, copper and brass.

5. In a powder metallurgical process involving compression of metal powders in a die and the subsequent ejection of the resulting compact from the die, the improvement which comprises lining the walls of the die which extend in the direction in which the compact is ejected with a thin film of overlapping metal flakes laid flat against the die wall, prior to introducing the bulk of the metal powder into the die, the flakes being coated with a leafing agent and being introduced into the die as a suspension in a volatile vehicle in which the leafing agent is substantially insoluble, said flakes being of a metal of the group consisting of aluminum, copper and brass.

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