METHOD OF PRODUCING ELONGATED HIGHLY DENSIFIED POWDERED METAL ARTICLES

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ABSTRACT

An elongated air-tight can with rounded top, bottom and ends and a filling stem is prepared from heat-resistant material, filled with the powdered metal to be compacted, exhausted to a high vacuum, and the stem sealed while maintaining the vacuum. The powder-filled evacuated can is then heated to a high temperature of approximately 2,100°F for about 1 hour, then compressed in the die cavity of a press having a recess in one of its plungers for the stem, and with at least one of its plungers having an end of reduced diameter to provide a clearance space into which the peripheral portion of the can flows as compression proceeds. When the density reaches 100 percent, the peripheral portion of the can and the surplus metal powder therein continue to move axially into the clearance space around the plunger or plungers, producing an axially projecting lip extending around the periphery of the can and containing metal powder at a somewhat lower density than in the remainder of the can. The walls of the can are then removed by machining or pickling, together with the less dense peripheral portion of the now substantially solidified elongated metal billet thus produced.

10 Claims, 5 Drawing Figures
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METHOD OF PRODUCING ELONGATED HIGHLY DENSIFIED POWDERED METAL ARTICLES

BACKGROUND OF THE INVENTION

In my co-pending application, Ser. No. 779,151 filed Nov. 26, 1968 there is disclosed a "method of highly densifying powdered metal" wherein the metal powder is inserted into a cylindrical can which is then evacuated and compressed to densify the contents to approximately 100 percent density. In order to prevent the can from buckling or wrinkling, as had hitherto occurred during compression, the peripheral portion of the container and its contents are permitted to flow or deform axially during compression into a clearance space around one or both of the press plungers. This, as well as in the present method, is especially valuable for producing blanks from so-called super-alloy powders composed primarily of cobalt or nickel for corrosion-resistant and minimum deformation with retained tensile strengths at higher temperatures than are possessed by ordinary alloys. Such super-alloys, prior to the method set forth in my above-identified co-pending application, have been available solely in cast form lacking metallurgical characteristics and containing impurities in amounts excessive for aerospace use. My previous method mentioned above produces disc-shaped or pancake-shaped billets or bodies which, while possessing better and more uniform metallurgical characteristics substantially free from impurities, are of insufficient mettallurgical sizes for producing elongated workpieces without a considerable waste of such metal. The method of the present invention enables the production of elongated billets which facilitate the production of elongated workpieces without serious waste of such metal.

In the drawings,

FIG. 1 is a vertical section through an elongated powder-filled, evacuated and sealed container in the die cavity of a press, ready for compression;

FIG. 2 is a vertical cross-section taken along the line 2—2 in FIG. 1;

FIG. 3 is a horizontal cross-section taken along the line 3—3 in FIG. 1;

FIG. 4 is a vertical section similar to FIG. 1, but after the powder-filled evacuated can has been compressed; and

FIG. 5 is a perspective view of the densified metal billet produced by this method.

Referring to the drawing in detail, FIG. 1 shows a powder-filled evacuated sealed container generally designated 12 which has been filled with a charge 14 of metal powder which is to be compacted to an extremely high density approaching or equalling solidity or 100 percent density. The powder charge 14 has previously been inserted in the interior chamber 16 through a tubular filling and evacuating steam 18, the tip 20 of which has then been pinched and sealed as by welding, in order to maintain the high vacuum in the chamber 16. The container 12 is of heat-resisting material, preferably of ordinary steel or stainless steel and has approximately cylindrical upper and lower walls 22 and 24 respectively, shown inverted in the drawing from the upright position occupied during filling and evacuating thereof. The container 12 has flat parallel opposite side walls 26 (FIGS. 2 and 3) and toroidal opposite end walls 28 (FIGS. 1 and 3).

The die set, generally designated 30, within which the container assembly 10 is to be compressed, consists of a die 32 containing a die cavity 34 of elongated cross-section (FIG. 3) having flat parallel opposite side surfaces 36 joined to one another by substantially cylindrical end surfaces 38. Entering into the upper and lower ends of the die cavity or die bore 34 are an upper punch 40 and a lower punch 42 having corresponding cross-sections. The punches 40 and 42 are of similar configuration and each has a nose portion 44 of reduced size but of similar cross-section to the shank 46 of each plunger 40 and 42 so as to leave a clearance space 48 extending around the nose portion 44 between it and the die bore 34. From FIG. 1 it will be seen that the die bore 34 is slightly larger in cross-section than the cross-sectional size of the can 12 so as to also leave a clearance space 50 therebetweenthe lower punch 42 has a socket 52 extending downward from the top surface 54 of the nose portion 44 thereof (FIGS. 1 and 2) for receiving the sealed filling stem 18.

The die 32 is preferably yieldingly supported on the bed or bolster (not shown) of a conventional hydraulic or mechanical press (also not shown) as by a conventional die cushion 56 consisting either of compression springs 58 or of a conventional hydraulic die cushion (not shown). Such die cushions are well known in the press art and their details are beyond the scope of the present invention. The lower punch 42 is preferably connected to a lower press plunger (not shown) which is stationary during pressing but which is movable in order to eject the finished workpiece, as is well known in the press art. The upper punch 40 is preferably connected to the vertically movable platen (not shown) of the conventional press mentioned above.

In carrying out the method, the container 12 is first prepared in the shape shown in FIGS. 1, 2 and 3 as described above, and is then completely filled with the charge 14 of powdered metal, which may be of the super-alloy type containing cobalt or nickel for retaining high tensile strength at a high temperature as well as for resisting deformation and corrosion. Filling is accomplished with the container 12 in an upright position as shown in FIG. 18 uppermost. After the chamber 16 has been completely filled with powdered metal through the stem 18, the latter is connected to a high vacuum pump (not shown), and the chamber 16 evacuated as completely as is commercially possible in order to prevent subsequent oxidation of the particles of metal powder in the charge 14 thereof at the high temperature to which the latter is subjected. While the chamber 16 is still being maintained in a highly evacuated state, the stem 18 is sealed off, as by pinching and welding, so as to produce the sealed pinched air-tight tip 20.

The evacuated sealed container filled with the metal powder charge 14 is then placed in a suitable furnace and heated at a temperature of approximately 2,100° F. for approximately 1 hour and then inverted and immediately transferred to the die cavity 34 with the stem 18 projecting downward into the recess 52. The parts are now in the positions shown in FIGS. 1 to 3 inclusive.

The upper punch 40 is now caused to descend into the die cavity 34, while the lower punch 42 is held stationary thereby compressing the powder-filled evacuated sealed container assembly 10 (FIG. 4). As this hot pressing operation proceeds, the container 12 is deformed into the shape shown in FIG. 4, and densification of the powdered metal charge 14 progressively increases as the powdered metal particles are forced into closer and closer engagement until fusion thereof occurs as a result of the combined action of the initial high temperature and the added heat resulting from the energy produced by the compressive force being exerted.

As the density of the powdered metal charge 14 increases until it exceeds 90 percent, the charge 14 becomes denser at its central portion than at its periphery where the clearances 48 occur in the lower and upper punches 42 and 40. As a result, when the density of the charge 14 approaches 100 percent to form a completely solid central portion 60 (FIG. 4) it can be compressed no further. Consequently, the peripheral portion 62 of the container 12 deforms as it moves into the clearance spaces 48 around the reduced size nose portion 44 of the upper and lower punches 40 and 42 to form a pair of oppositely extending lips or hollow flanges 64 while the excess powdered metal 66 is extruded into the channel 68 in each lip and is of lower density than the remaining portion 60 of the now substantially solidified charge of powdered metal resulting from the compression of the original charge 14.

The operation of the press (not shown is now reversed to raise its platen (not shown) and the upper punch 40 out of the die cavity 34, whereupon the lower punch 42 is caused to
move upward to the top of the die cavity 34, thereby ejecting the now compressed solidified metal-filled container assembly, generally designated 70, from the die cavity 34. The container 12 is now separated and removed from the solidified metal charge 60 by machining, pickling of other suitable means, also removing the less dense opposite end portions and peripheral portions 66 within the lips 64. The result is an elongated billet 72 having a rectangular mid-portion 74 from which the rounded opposite ends 76 have been cut off (FIG. 5) but otherwise corresponding in cross-section to the cross-section 5 of the die cavity 34 (FIG. 3).

If the container 10 has been made of ordinary steel, the sheet metal forming its walls can be peeled off the solidified or compacted metal billet 72 after the compacting procedure has been carried out, thereby effecting removal thereof more rapidly in a simpler and less expensive manner than by machining it off or removing it by pickling. The temperature of 2,100°F. and the time of 1 hour will vary with the size of the billet to be produced. The range of temperatures from 2,000°F. to 2,200°F. has been found satisfactory for the range of sizes ordinarily produced whereas the stated period of one hour is necessarily increased as the size and weight of the billet 72 to be produced are also increased.

I claim:
1. A method of making a substantially solid elongated body from powdered metal, comprising
encasing the powdered metal in an elongated metal container having rounded opposite ends,
evacuating said container with the powdered metal therein,
heating the evacuated powder-filled container to a temperature sufficient to facilitate subsequent deformation of said container and effect coalescence of the powdered metal particles,
applying compressive force to the thus-heated powder-filled container transverse to the longitudinal axis thereof sufficient to deform the same transversely and to compact the powdered metal therein into an elongated substantially solid body,
restraining the powder-filled container from expanding longitudinally during the application of the transverse compressive force while permitting a peripheral portion of the powder-filled container to deform transversely thereto, terminating the application of said compressive force, and removing the thus-deformed container and the peripherally deformed portion of the now solidified powdered metal from said body.
2. A method, according to claim 1, wherein the longitudinal deformation is produced transversely to the direction of application of the compressive force.
3. A method, according to claim 1, wherein the peripheral portions of the container and its contents are permitted to deform transversely thereto in opposite directions on opposite sides thereof.
4. A method, according to claim 1, wherein the container has an elongated longitudinal wall which has a rounded portion therealong on at least one side thereof.
5. A method, according to claim 1, wherein the container has an elongated longitudinal wall which has rounded portions therealong on opposite sides thereof.
6. A method, according to claim 5, wherein the container has substantially flat longitudinal wall portions disposed on opposite sides thereof and interconnecting the rounded portions thereof.
7. A method, according to claim 5 wherein the rounded portions are of approximately cylindrical configuration.
8. A method, according to claim 1, wherein the container is confined in a cavity having restraining side walls and having end walls closing said cavity and having clearance spaces between said side walls and end walls adapted to receive the deformed portions of said container during deformation thereof, at least one of said end walls being movable for applying said compressive force.
9. A method, according to claim 1, wherein said rounded opposite ends are of substantially toroidal configuration.
10. A method, according to claim 1, wherein the container is permitted to undergo a predetermined limited deformation longitudinally before being restrained from further longitudinal deformation.