FABRICATION OF ELONGATED PRODUCTS

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ABSTRACT OF THE DISCLOSURE

The fabrication of an elongated product from particulate material is accomplished by using a mold in an isostatic pressing assembly that is capable of neutralizing the powder-compacting force directed along planes parallel to the length of the elongated product. The mold comprises a tubular resilient end cap with the latter being prevented from displacement towards one another by supporting structure associated with the tubulation.

The invention described herein was made in the course of, or under a contract with the U.S. Atomic Energy Commission. This invention relates generally to the fabrication of elongated products, and more particularly to apparatus and method for pressing powders into products having length-to-diameter ratios greater than one.

In the field of powder metallurgy the use of isostatic pressing found to be highly desirable for forming compacts of certain materials not readily amenable to fabrication by conventional forming procedures. Isostatic pressing of metal or ceramic powders into shaped products that are relatively stress-free and of high green strength and density is achieved by stressing the powders with a force of about 15,000 to 30,000 or more pounds per square inch. This force is exerted against the powders in such a manner that the powders are subjected to equal stress converging from each and every direction. In a typical isostatic pressing operation as previously practiced, ceramic or metal powders may be placed into a suitably configured cavity of a resilient mold which may then be evacuated and centrally positioned in a container having deformable walls and containing a suitable pressure transmitting medium, e.g., a hard, noncoherent mass such as magnesia oxide particles. Or, if desired, the container may be filled with a suitable resilient material having a product powder receiving cavity formed therein. In either case, the container and its contents are placed in a pressure vessel in which is placed a suitable liquid, e.g., hydraulic oil, which is subsequently highly pressurized to subject the container contents to isostatically applied forces for uniformly compacting the powder into the product.

Isostatic pressing techniques as described above are exemplary of those previously practiced and are found to be particularly useful when forming products of substantially greater than its diameter or cross section suffering several shortcomings or drawbacks which detract from its usefulness. While the compacting force is uniformly applied to the powder, a non-uniform compaction of the powder is obtained since there is substantially more powder disposed in one direction than the other, thereby requiring more pressure to obtain equal compaction. This non-uniform compaction provides undesirable orientation or directionality of properties within the product in that the component of force acting in the direction corresponding to the longitudinal or lengthwise dimension of the powder charge creates transverse stress areas in the product which cause a "poker-chipping" effect to occur in elongated products. The term "poker-chipping" is descriptive of a structural condition in which transverse cracking or breakage readily occurs at one or more longitudinal points on the product so as to resemble a stack of poker chips. Consequently, previously known isostatic pressing techniques are not suitable for forming elongated products such as drill bits and the like which necessarily require sufficient strength in a transverse direction to withstand operating conditions.

The present invention aims to obviate or substantially minimize the above and other shortcomings or drawbacks suffered by elongated products as produced by previously known isostatic pressing apparatus and techniques. The present invention accomplishes the above and other desiderata by providing a mold for use in an isostatic pressing assembly whereby a certain directional component of the applied powder-compacting force is essentially neutralized while utilizing all other directional components of the applied force to provide the desired compact. Generally, the mold of the present invention comprises a tubulation of resilient material provided with longitudinally oriented supporting structure and relatively rigid end caps. The end caps or covers and the supporting structure prevent the mold from isostatically applied to the mold from acting upon the product powders contained in the mold in a longitudinal direction with respect to the configuration of the powder charge. Thus, the force component laterally or radially directed against the powder charge is utilized to compact the powder into a product of desired dimensions without encountering the deleterious effect of the longitudinal force component.

An object of the present invention is to provide for the fabrication of products having length-to-diameter ratios greater than one by compaction of ceramic or metal powders.

Another object of the present invention is to provide a novel and reusable mold for use in combination with isostatic pressing apparatus whereby selective portions of the forces isostatically applied to the mold are precluded from deleteriously influencing the formation of an elongated powder compact.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

A preferred embodiment of the invention has been chosen for purposes of illustration and description. The preferred embodiment illustrated is not intended to be exhaustive or to limit the invention to the precise form disclosed. It is chosen and described in order to best explain the principles of the invention and their application in practical use to thereby enable others skilled in the art to best utilize the invention in various embodiments and modifications as are best adapted to the particular use contemplated.

In the accompanying drawings:

The figure is a perspective, longitudinal sectional view, partly broken away, showing in detail the novel mold of the present invention as it may appear in an isostatic pressing apparatus.

In the figure there is shown an isostatic pressing apparatus which may be used for fabricating compacts of desired configurations from metal or ceramic powders. This apparatus may comprise a tubular or cylindrical pressure vessel having a reciprocable piston or pistons which are receivable therein at one or both ends thereof, as shown. A suitable, non-compressible, pressure transmitting medium, e.g., hydraulic oil, is placed within the pressure vessel and sufficiently stressed by...
piston movement to cause the liquid to exert a force of about 15,000 to 30,000 p.s.i. or more against surfaces contacted thereby. A portion of the surface area subjected to this force is represented by a partially resilient or deformable mold 18 preferably centrally disposed in the pressure vessel by suitable supporting structure (not shown) and containing a charge 20 of metal or ceramic powders in a desired configuration 24.  

Inasmuch as essentially the entire external surface area of the mold 18 is contacted by the high pressure liquid 16, the forces acting upon the mold 18 are uniformly or isotropically applied to the latter so as to stress the mold and force its expulsion from the mold cavity 22.  

Normally, the molds as previously known are constructed so that the forces isotropically applied to the mold surface are uniformly transmitted to the confined powders. However, the mold 18 of the present invention differs from these previously known molds in that the mold 18 is constructed in such a manner as to restrain or otherwise prevent some of these forces from influencing the compaction of the powder charge 18. By restraining these forces, applicant has found that compacts of particular configurations may be formed with desirable structural qualities. For example, with a powder charge having a length-to-diameter ratio greater than one, the reaction of the force component acting on the powders in the longitudinal direction causes the powder compaction to be effected by essentially only the radially directed forces so as to form a compact devoid of the undesirable transverse stress areas described above.  

In order to neutralize the longitudinally directed force component with respect to powder compaction, the mold 18 may comprise a flexible tubular or cylindrical shell 22 of a resilient material such as epoxy resin with the oppositely disposed open ends of the shell 22 being provided with relatively rigid covers or end caps 24 and 26. The shell 22 is constructed in such a manner that the end caps thereon are precluded from approaching each other during the application of the isotropic forces against shell and caps and yet enable the shell to be compressed or moveable in a radially inward direction to effect compaction of the powder charge 20. To achieve these desirable features the shell preferably has embedded therein a plurality of circumferentially spaced apart metal rods 28 which are coextensive with the length of the shell 22 so as to abut against the end caps 24 and 26. The end caps 24 and 26 are also preferably formed of metal and of a sufficient thickness so as to withstand the stresses applied thereagainst without excessive deformation. Further, the end caps are preferably of a diameter sufficient to overlap the open ends of the rods 28 to assure that relative movement may be achieved between the radially moving shell 22 and the stationary end caps.  

In order to transmit the forces applied to the shell 22 to the powder charge 20, the shell 22 is preferably filled with a suitable resilient pressure transmitting medium 30 having a centrally disposed and configured cavity 32 formed therein for receiving the powder charge 20. Satisfactory results have been achieved by using naphthalene or the like as the transmitting medium 30 in that this material, in liquid form, may be poured into the shell 22 around a suitable mandrel and allowed to solidify. After solidification the mandrel is readily removable from the naphthalene to form the powder receiving receptacle or cavity 32 in the configuration of the mandrel.  

In a typical pressing operation, such as, for example, during the formation of a drill bit, a mandrel, e.g., a conventional drill bit of any desired size may be used to form the cavity 32. Powder suitable for forming drill bits such as tungsten or tungsten carbide is then poured into the cavity to the desired height. A naphthalene plug 34 may then be inserted into the cavity 32 to fill the remaining portion of the cavity. After filling the cavity, the end caps 24 and 26 are positioned against the opposite ends of the shell for closing the latter. The end caps may be held in place for handling purposes by taping or otherwise lightly securing the caps to the shell. The mold 18 is then preferably placed in an elastic non-porous bag 35 to prevent the liquid pressure transmitting medium 16 from entering the mold during the pressing operation. The bag 35 is preferably evacuated and sealed prior to pressing since the presence of a compressible medium in the vessel and product configuration 24, 26 may lead to the fabrication of undesirable product.  

After subjecting the filled mold to an isostatic pressure of about 30,000 p.s.i., the mold may be removed from the pressure vessel and the product removed from the mold by disengaging the naphthalene with a suitable solvent such as acetone.  

During the pressing operation the shell 22 remains flexible to assure that the stress applied by the oil 16 is uniformly transmitted the powder charge. However, due to the co-action between the metal rods in the shell walls and the relatively rigid end plates or caps, longitudinally compression of mold is precluded while radial compression of the mold takes place to effect powder compaction. This operational characteristic is possible since, as the mold shell 22 is flexed radially inwardly, the metal rods 28 slide upon the inner surface of the end caps to prevent movement or displacement of the end caps in a longitudinal direction.  

The product resulting from the above described "cold" pressing operation is a self-supporting structure which is substantially identical in external appearance to the mandrel. Very little shrinkage occurs during the powder compaction to assure that the dimensions of the compact closely approximate those of the mandrel. The pressed product has considerable surface roughness when it is removed from the mold, but this surface may be readily polished with a minimum of grinding.  

While a compact fabricated as described above may be used as is, it may be preferable to further treat the compact to assure attainment of the desired properties and characteristics. For example, the compact may be subjected to a conventional isostatic pressing operation without restraining the longitudinally directed stress component and at a temperature corresponding to room temperature or at a higher temperature, as desired. The product of this final pressing does not possess undesirable transverse stress areas, but does posses the desirable properties of isotropically pressed products. It will be seen that the present invention provides a unique apparatus for fabricating elongated products from materials not readily amenable to fabrication into desired configurations. Further, obvious monetary savings are realized by the advantage of rod ends of the rods 28 to assure that relative movement may be achieved between the radially moving shell 22 and the stationary end caps.  

As various changes may be made in the form, construction, and arrangement of the parts herein without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in a limiting sense.  

What is claimed is:  
1. A mold for use with an isostatic pressing apparatus to effect the fabrication of a product having a length-to-diameter ratio greater than one, comprising an open-ended tubulation, discol cover means formed of a material substantially rigid throughout the tubulation and disposed at each end of the tubulation for forming therewith an enclosed volume, each of said cover means overlapping diametral end portions of the tubular with the latter being movable radially inwardly and relative to the cover means to decrease the cross-sectional dimension of the enclosed volume during constriction of the tubulation when the cover means and tubulation are
subjected to externally applied forces, support means projecting between and contacting said cover means for preventing displacement thereof towards one another during the application of said forces, and resilient means essentially filling said volume and having a receptacle therein for receiving powders from which said product is to be fabricated.

2. A mold as claimed in claim 1, wherein said support means disposed between said cover means comprises a plurality of elongated member embedded in the tubulation at circumferentially spaced-apart locations with each of said members being of a length essentially coextensive with and formed from a material exhibiting substantially more rigidity than that of said tubulation.

3. A mold as claimed in claim 2, wherein said elongated members comprise metal rods, the cover means are formed of metal and are sufficiently thick so as to withstand said forces without excessive deformation thereof, and wherein said tubulation is formed of epoxy resin.

References Cited

UNITED STATES PATENTS
3,177,553 4/1965 Archibald.

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