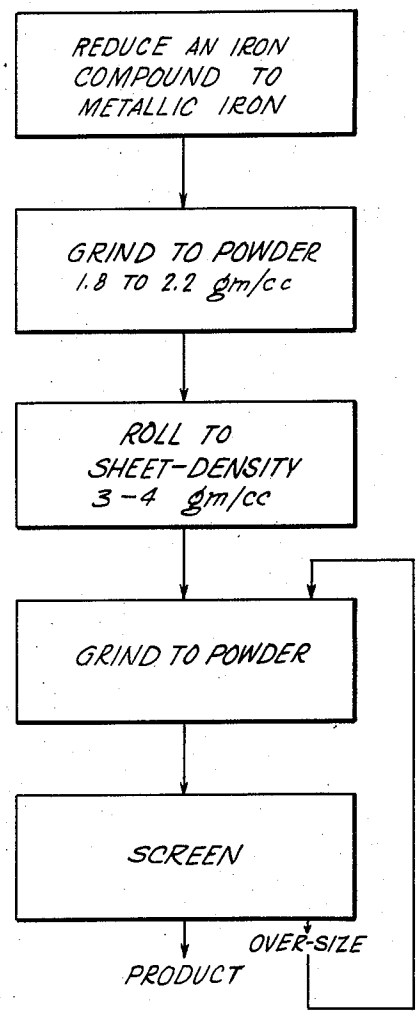
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INCREASING THE DENSITY OF IRON POWDER BY ALTERNATE ROLLING AND GRINDING

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INCREASING THE DENSITY OF IRON POWDER BY ALTERNATE ROLLING AND GRINDING

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The present invention relates to increasing the density of iron powder by alternate rolling and grinding, while controlling the flow characteristics thereof and while minimizing the work-hardening of the powder incident to the treatment thereof so that the powder as finally produced will be useful in powder metallurgy.

In the production of iron powder for the purpose of powder metallurgy, it is conventional to reduce some one or more of the compounds of iron, using some available reducing agent or agents, so as to leave the iron substantially all in metallic form, but usually in a physical form wherein a part at least thereof is sponge iron or analogous thereto in its physical characteristics. This is true, for example, whether the iron be reduced from an iron halide, such as ferrous chloride, by the use of hydrogen or some similar reducing gas, or whether it be reduced from one or more of the oxides of iron by the use of some suitable reducing agent. Other compounds of iron, such as the formate, have also been reduced by gaseous reducing agents.

In some instances, the temperatures used during the reduction are sufficiently high, so that some or all of the iron so produced may be in the form of sponge iron. Under other circumstances and particularly when quite low temperatures are used, the iron is in the form of powder. In either case, i.e. whether the iron be in the form of a sponge or in the form of powder, the bulk density thereof is substantially less than that which is required commercially by the users of iron powder for powder metallurgy. Thus, if the iron powder produced as aforesaid were used directly and without any further treatment, molds in which the final articles are formed would have to have a very substantial overcapacity to accommodate the large volume of powder required in order that a sufficient weight thereof be provided for making a desired article.

A primary object of the present invention is to provide a method of treating the powder and/or sponge iron produced as aforesaid in accordance with the inventions of others and/or in accordance with the prior art, so as to increase the bulk density thereof to the value desired by fabricators of such iron powder, this desired bulk density usually being, in practice, in the range of about 2.3 to about 2.5 grams per cc. It is also required, in order to provide an iron powder which will be satisfactory to fabricators of powdered iron products, that the flow characteristics of the product shall be within certain desired limits.

Summarizing the present invention, there is hereby provided a method of treating iron produced as aforesaid to provide an iron powder which will be acceptable and useful in powder metallurgy. To do this, the original iron material, which is usually at least in part in sponge form, is comminuted by a first grinding step into the form of a powder having a bulk density in the range of about 1.8 to about 2.2 grams per cc. This grinding may be effected by any of the known types of grinding equipment as more particularly hereinafter discussed, but is preferably accomplished by a disk-type attrition mill. The next step is to roll the powder into the form of a frangible sheet by passing it between smooth surfaced rolls, which are usually located with their axes in the same horizontal plane. The frangible sheet thus produced has a bulk density in the range of 3 to about 4 grams per cc. This frangible sheet is then ground in a second grinding step to produce iron powder approximating the final desired product. With the exception of a step which is often, but not necessarily, performed of screening out oversized particles to bring the powder within the particular requirements of individual manufacturers, the product of the second grinding step aforesaid may be considered as the final product. In order to comply, however, with the particular requirements of different fabricators of the powder, it is usually required that a screening or a separation step be effected with the oversized particles to be returned to the process at a stage at least as early as the second grinding step. It may, of course, be returned to the process either to the first grinding step or to the rolling step aforesaid.

The process above generally described is illustrated in the accompanying drawing, which comprises a flow sheet of the process.

The reduced iron supplied to the process is not suitable as iron powder for use in fabrication of articles by conventional powder metallurgy processes without some further processing. The reason for this is that in some instances at least, and depending upon the process by which the iron was reduced, it may be partially or wholly in the form of small or large chunks or porous sponge-like masses. In other instances, and particularly where quite low temperatures are used in effecting the reduction, the iron may be in powder form. In either case, the bulk density of the iron is usually substantially less than that desired. Furthermore, when the material supplied to the present process is in the form of chunks or various different size masses of sponge-like iron, this material does not have the desired flow characteristics of iron powder, which is presently required by commercial fabricators of powdered iron articles.

The first process step, therefore, is required to bring all the iron, irrespective of the shape or form in which it is received, to the form of a powder. This step is accomplished by the use of grinding equipment, which is per se known in the art. The preferred type of grinding is one where the comminution is effected by a shearing action rather than by a crushing action. Thus, the preferred type of equipment for carrying out this step is a disk-type attrition mill, or, alternatively, an air attrition mill.

Experimental work on this step of the process has shown that it is feasible to use a jaw crusher to effect an initial comminution of the larger size lumps or chunks of sponge iron and then to use a ball mill for the final comminution operation. This manner of operation is, however, quite slow; and, furthermore, unless the size of the balls is very carefully selected in respect to the hardness of the iron being handled, there results what is termed "work-hardening" of the product, which renders this product relatively less desirable from the point of view of the fabricator of the powdered metal parts to whom the product is supplied. In general, it is desired to minimize work-hardening.

Another type of comminution apparatus which has been tried and which is operative, but is relatively less desirable than the disk-type attrition mill or air attrition mill, is a hammer mill. Here again, the use of a hammer mill tends to work harden the iron powder.

The product of the first grinding operation aforesaid is an iron powder having a bulk density in the range of about 1.8 to about 2.2 grams per cc.

The next step in the operation in accordance with the present invention is to roll the powder produced by the

first grinding step as aforesaid into the form of a frangible sheet. To do this, it is usual to pass the powder between smooth surfaced rollers, located with their axes both in the same horizontal plane, and, of course, substantially parallel. In practicing this step, various size rollers have been used, for example when the step was practiced on a laboratory scale, a pair of rolls about 12 inches in diameter and with an axial length or face width of 2 inches was used to produce a sheet which was about .08 inch to about .09 inch in thickness. There has also been used a pair of 12 inch diameter rollers having an 8 inch face width, to give a sheet about 0.15 inch to about 0.25 inch in thickness. Other sizes and dimensions of rolls could be used if desired. The critical limitations on this step do not pertain to the diameter of the rollers, their face width or the spacing between the rollers at their closest approach to each other, but rather relate to the density of the rolled sheet. It has been found that the actual sheet thickness is not particularly important or critical, but is to a great extent a function of the dimensions of the rolls and the spacing therebetween. The density of the sheet, however, is quite important from the point of view of the present invention. It has been found that irrespective of its thickness, the rolled sheet should have a density in the range of about 3 to about 4 grams per cc. When such a sheet is produced, irrespective of the thickness and/or variations in thickness thereof due to possible springing of the rolls, the desired results in accordance with the present invention are attained.

The next step in the process is to grind the frangible sheet, produced by the rolling step aforesaid, to powder form. The requirements as to the type of grinding for this second grinding operation are substantially the same as those given above in respect to the first grinding step. It has been found that either or both the grinding steps may be performed using the preferred type of grinding equipment or method, i.e. attrition as distinguished from crushing; and preferably that both steps should be effected using the preferred type of grinding.

The material resulting from this second grinding step will usually have the desired bulk density, i.e. from about 2.3 to about 2.5 grams per cc. This material is usable without further treatment in the making of articles by powder metallurgy practices.

However, due to the practical requirement of measuring up to the particular specifications of individual manufacturers of powdered metal parts, there is usually employed an additional step involving screening out powder particles of greater than some particular screen size. For example, one manufacturer may require powder having a particle size of 100-mesh and finer and place a limitation on acceptable powder that it shall not contain more than one percent of material having a particle size greater than 100-mesh (standard Tyler screen). Another manufacturer may place similar limitations, but with the limit at 65-mesh and a requirement that not more than one percent of the powder particles shall exceed this screen size. It has been found that if a 90-mesh screen is used and the oversize discarded or reprocessed, the product, i.e. the material passing through a 90-mesh screen will be satisfactory to many, if not all, of the fabricators of powdered metal parts.

Whatever size limits are used as aforesaid, it is contemplated in accordance with the present invention that the over-size particles separated out by the screening step will be returned to the process at least as early as the

second grinding step and possibly to the rolling step aforesaid. The accompanying flow sheet illustrates this oversize material being returned to the second grinding step, which is a preferred manner of practicing the method of the present invention.

As a further alternative embodiment of the process of the present invention, the product of the second grinding step may be further densified, i.e. its bulk density may be further increased by additional pairs of alternate rolling and grinding steps, each pair of which is respectively similar to the rolling step aforesaid and the second grinding step, it being understood, of course, that the final step of the process or the final step prior to the screening step above referred to will be a grinding step and not a rolling step.

There is hereinabove described and there is illustrated on a flow sheet basis a preferred embodiment of the present process. There has also been set out as the description proceeded certain alternatives which are usable in respect to certain of the preferred steps or certain alternative ways of performing these steps, in addition to the preferred manner in which these steps are respectively performed. Other equivalents will occur to those skilled in the art from the foregoing description. We do not wish to be limited, therefore, except by the scope of the appended claims, which are to be construed validly as broadly as the state of the art permits.

We claim:

1. The method of treating iron, which was reduced to the metallic state from an iron compound under conditions such that the metallic iron produced was not melted or firmly sintered together, while preventing work-hardening and increasing the bulk density thereof, so as to provide an iron powder having a bulk density and flow characteristics such that it is useful in powder metallurgy, said method comprising the steps of comminuting the reduced iron solely by attrition to produce an iron powder having a bulk density in the range of about 1.8 to about 2.2 grams per cc., compacting the powder thus produced solely by rolling it between smooth surface rolls and without positively heating it to produce a frangible sheet having a bulk density of about 3 to about 4 grams per cc., and thereafter comminuting said frangible sheet solely by attrition to provide an iron powder having a bulk density in the range of about 2.3 to about 2.5 grams per cc. and which is not substantially work-hardened as compared with the iron supplied to or that at any earlier stage of the method aforesaid.

2. A method of increasing the volume weight of metal powder without substantially increasing its grain size which comprises cold rolling the powder in a layer of sufficient thickness and under sufficient pressure to form a continuous layer and comminuting said layer to a powder.

3. A method of increasing the volume weight of metal powder which comprises cold rolling the powder in a layer of sufficient thickness and under sufficient pressure to form a continuous layer and comminuting said layer to a powder.

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