On the Continuous Compaction of Metallic Powders

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The term semi-finished products refers to strips, sheets, tubes, and wires which will undergo some subsequent working before finally being used. The reason for manufacturing some of these semi-finished products by powder metallurgy is to improve their physical properties or because of economy. Reference is made especially to products made by powder rolling or powder extrusion and to the production of wires for welding purposes, stainless steels, and dispersion-strengthened materials. Recent improvements in the new powder metallurgy processes will result in increased production in the near future.

INTRODUCTION

Concerning the direct conversion of metallic powders into strip, tube, and wire, the present state of the art indicates that large-scale production will become technically possible as well as economical—at least for a limited number of products—during the next few years. Continuous compacting of metal powders was invented some time ago, but has not been applied on a large scale. The financial risk of entering an entirely new technology acted, on one hand, as a deterrent. On the other hand, economic operation of this process is dependent on preconditions which have only recently been given. In consideration of those factors that make the direct conversion of powders superior to the conventional method (i.e., starting from a melt), the following facts are of great importance:

1. Powder costs less than billets.
2. Powder costs the same as a cast billet; rolling or extruding the powder, however, gives a higher yield and requires fewer operations.
3. A cast billet cannot be rolled, extruded, or shaped in any way, whereas the same alloy in the form of powder can be compacted.
4. With powder as raw material, the final product will have entirely new properties. These properties could not be obtained when using a cast billet as raw material.

These four points represent a great challenge for the powder metallurgist. To solve the whole problem, the entire field of physical chemistry must be drawn upon, especially the area of the solid-state reactions. Furthermore, to make it work, a great deal of development in the field of control technology is required. The above-mentioned points may be elaborated as follows.

EXPERIMENTAL

1. During recent years, metallic powders became available at lower prices than before. Due to new chemical processes, it was possible to obtain copper, nickel,
and cobalt powders at reduced cost, and this particularly stimulated the production of strip from powder. A similar situation seems to be arising with our most important metal, iron. To feed our blast furnaces with pellets, we had to find out how to pulverize even very brittle types of iron ore. Surprisingly, it was found that this kind of pulverization process did not cost as much as was initially expected. The long series of attempts to reduce iron ore by a solid-state process to obtain a low-cost sponge iron, thus bypassing the blast furnace, once more became of interest. In experiments carried out at present with high-grade ores, the attempt is being made to produce sponge iron of such high purity that it can be compacted continuously. This presupposes that the grain size distribution is properly matched. During the next few years, production of mild-steel tube, wire, and especially steel sheet for deep drawing is likely to leave the experimental stage.

2. If the powder and the billet cost about the same, there is one very illuminating example of cost saving with immediate conversion of strip into powder, namely, atomizing molten aluminum, which yields a coarse powder. The best way to compact this powder into a strip proved to be to heat the powder to 400°C before compaction. If this type of processing is possible (i.e., atomizing a melt, drying the powder obtained, and compacting it), the yield is very high. With the continuous compaction of stainless steel powder into wire, Mannesmann has obtained a yield of nearly 100%, taking into account all the processing stages between melt and green rod. With alloys which are difficult to roll or to shape in any way from a cast billet into longitudinal shapes, a process making use of the pulverized state can be advantageous. By this process, saw blades have been produced from steel powder with the following analysis: 0.8% C, 4.0% Cr, 6.0% W, 5.0% Mo, 2.0% V.

3. The powder metallurgical method of producing welding rods has many possibilities. A welding rod produced by this process can produce additional chemical reactions during welding, because it is not perfectly homogeneous. Many alloys which, at present, can be cast only as rods can be shaped into rods more economically via the pulverized state. For example, a mixture of soft and easily deformable iron and a brittle alloy powder can easily be compacted into rods. However, homogenization has to be prevented during the extrusion process. The final formation of the alloy, i.e., the final homogenization, is caused by the welding process.

4. The powder metallurgist is especially interested in alloys which can be obtained only as powders and not at all as cast. Cemented carbides and ferrite magnets are examples. For example, tungsten powder doped with thoria powder is extruded as wire. Thoria prevents the formation of coarse crystallites.

In addition to tungsten, SAP (sintered aluminum powder) has been known for a long time, whereas lead and tin, both dispersion-strengthened by a finely dispersed oxide phase, have become interesting only recently. In all these cases, the mechanical properties have been surprisingly improved.

Little attention has been paid to the possibility of treating a strip or a green billet chemically before it is fed into the extrusion press. During this treatment, certain chemical reactions are going on at temperatures that are low in comparison to melting point. One example may explain this: In a given steel sheet, the concentration of contaminants can be decreased at low temperatures better than at a temperature above the melting point of iron. Thin steel sheets for transformers can be purified by thermal treatment more easily than the melt from which the sheet has been obtained. Carbon, nitrogen, and sulfur especially can be removed to a large extent by this solid-state reaction.