United States Patent [19]

Chehi

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[45] **Feb. 18, 1975**

[54] **METHOD OF MAKING CROSS-ROLLED POWDER METAL DISCS**

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[73] Assignee: **Bethlehem Steel Corporation,** Bethlehem, Pa.

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[52] **U.S. Cl.**..... **29/420.5,** 29/423, 29/DIG. 32, 264/111

[51] **Int. Cl.**..... **B22f 3/24**

[58] **Field of Search** ... 29/420, 420.5, 423, DIG. 31, 29/DIG. 32; 264/111

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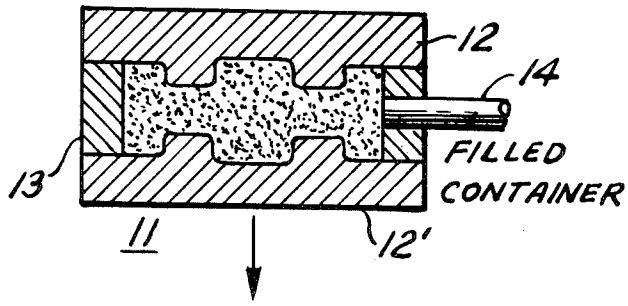
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[57] **ABSTRACT**

A method of making metal stock utilizing powder metal technology and rolling mill practices. The method described comprises filling a container having a contoured interior surface with metal powder, sealing, evacuating and heating the container and cross-rolling the containerized powder in a rolling mill to produce a predictable size and configuration of compacted metal product having properties similar to conventionally rolled or forged stock.

4 Claims, 9 Drawing Figures



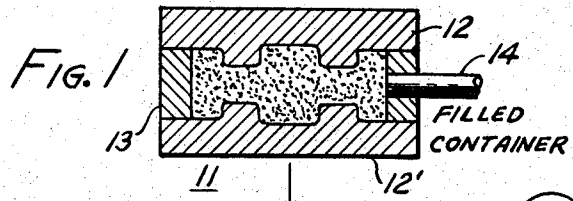


FIG. 1

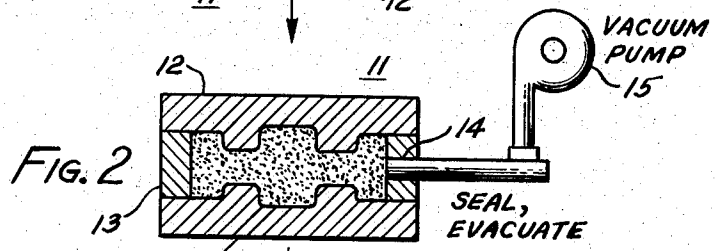


FIG. 2

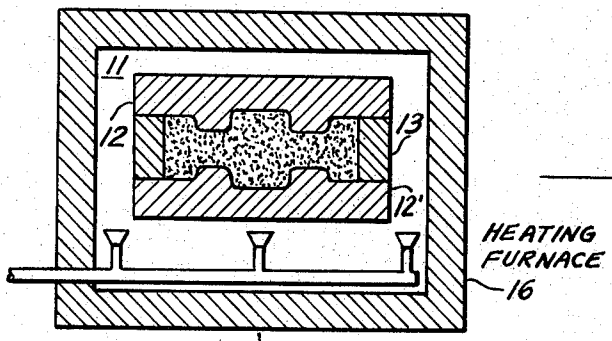


FIG. 3

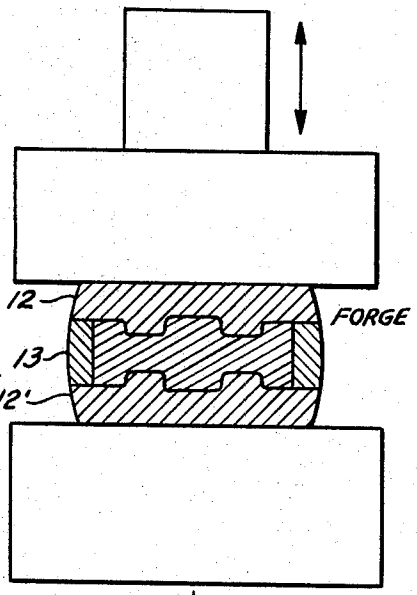


FIG. 4

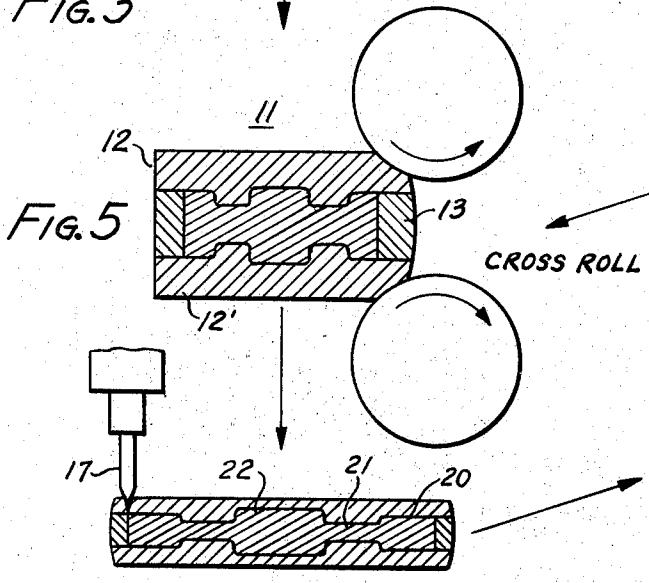


FIG. 5

FIG. 6

REMOVE CONTAINER FROM
ROLLED METAL STOCK

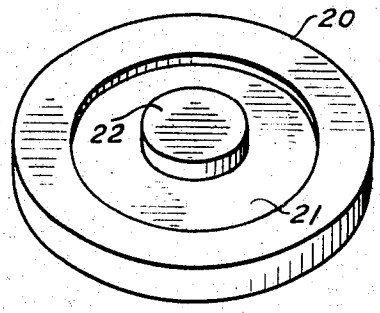


FIG. 7

METAL STOCK

FIG. 8

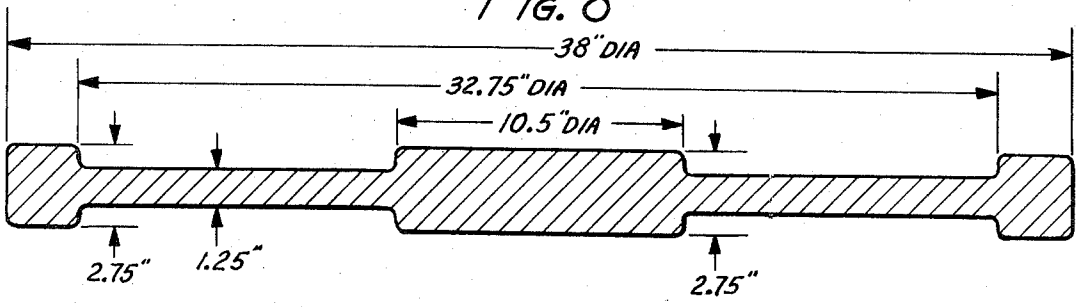
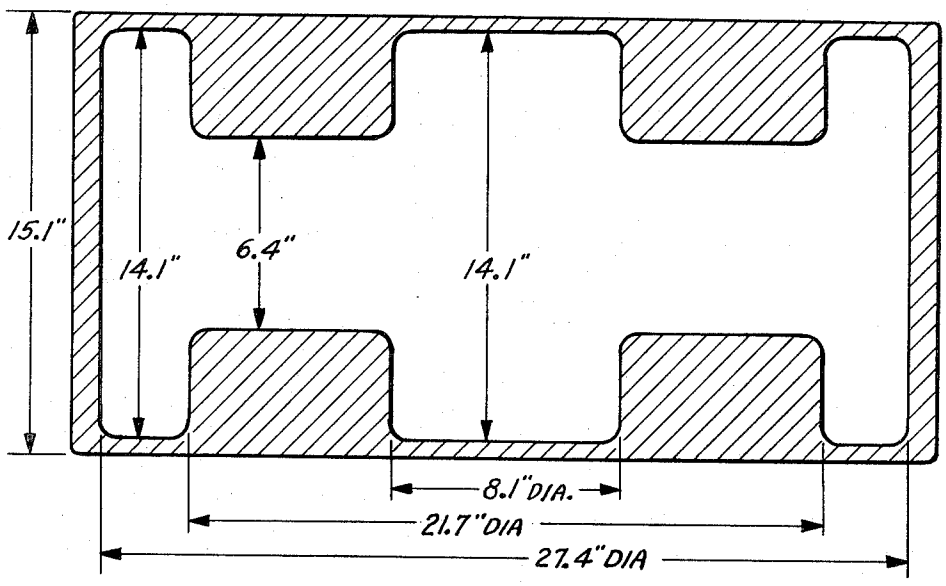

38" DIA
32.75" DIA
10.5" DIA
2.75"
1.25"
2.75"

FIG. 9


15.1"
14.1"
6.4"
14.1"
8.1" DIA.
21.7" DIA
27.4" DIA

METHOD OF MAKING CROSS-ROLLED POWDER METAL DISCS

BACKGROUND OF THE INVENTION

The need for large contoured circular forgings of heat resistant super alloys and other high alloy and stainless material has recently emerged with the demand for superalloy turbine discs such as those used in jet engine compressor and turbine components. Prior art methods for making high alloy discs include forging the discs from conventionally cast ingots. The forging method, however, requires repeated heating and forging steps and is therefore costly. In addition, the size of the disc is limited by the capacity of currently available forging equipment. In the production of larger diameter discs the disadvantages of repeated heating and forging steps are magnified.

Powder metallurgy is defined in "Introduction to Powder Metallurgy" by Joel S. Hirschhorn published by the American Powder Metallurgy Institute, 1969, page 1, as "the material processing technique used to consolidate particulate matter, both metals and/or nonmetals, into discrete shapes." Powder metallurgy techniques are being used to design and fabricate massive materials and shaped objects to provide the exceptional properties required in the aerospace, electronic and nuclear energy industries.

It has been found that powder metallurgy techniques are also applicable for economically forming large diameter disc shapes, as e.g. by cross-rolling large contoured discs on conventional rolling mill equipment.

Circular contoured disc shapes for gas turbine compressor discs are sometimes manufactured from superalloy materials, e.g. Inconel 718 or Udimet 400. The ASM Metals Handbook 8th Edition defines a superalloy as "an alloy developed for very high temperature service where relatively high stresses . . . are encountered and where oxidation resistance is frequently required."

The current practice for forming large circular shaped components such as contoured discs and including the use of superalloys requires repetitive heating and forging steps involving the use of large forging equipment. Extensive machining of the rough forging is also necessary to arrive at the final stage.

It is an object of this invention, therefore, to provide a method of forming contoured disc shapes directly from metal powder.

It is another object of this invention to provide a method of forming contoured disc shapes from metal powder by utilizing conventional rolling mill equipment.

It is a further object of this invention to provide an inexpensive and efficient method of producing metal stock from metal powder which requires a minimum of machining.

SUMMARY OF THE INVENTION

The instant invention accomplishes these objects by providing a unique process comprising a combination of the steps of sealing a supply of metal powder in a container having a contoured interior surface, evacuating and heating the container and compacting the containerized metal powder by cross-rolling on conventional rolling mill equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a sectional view through a container filled with the metal powder;

FIG. 2 is a graphical representation showing a section through the filled container of FIG. 1 and depicting the steps of sealing and evacuating which occur in that sequence;

FIG. 3 shows a sectional view through the filled container and a heating furnace depicting the step of heating the filled container to rolling temperature;

FIG. 4 shows the step of forging the container of FIG. 3;

FIG. 5 graphically depicts the step of cross-rolling the container which was subjected to forging in FIG. 4;

FIG. 6 is a section through the container of FIG. 2 after it has been subjected to the steps of sealing, evacuating and heating, as shown in FIG. 3, forging as shown in FIG. 4, and cross-rolling in FIG. 5 resulting in a containerized contoured metal disc prior to removal of the container;

FIG. 7 is an isometric view of a metal disc formed by the method of the instant invention;

FIG. 8 is a section through a contoured metal disc formed by the method of the instant invention; and

FIG. 9 is a section through the container required to form the disc shown in FIG. 7 and in cross-section in FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The specific examples hereinafter referred to will describe in detail the use of some specific metals in making metal stock by the method of this invention. The term metal powder as used herein includes alloys.

Referring now to the drawings, FIG. 1 shows a sectional view through a metal container **11** for encapsulating a supply of loose metal powder **10.** Metal powder is defined as metallic elements or alloys in finely-divided or powder form. The container **11** comprises a circular top or first portion **12,** a circular bottom or second portion **12'** and a peripheral side or third portion **13** which portions are joined together, as e.g., by welding. The portions **12** and **12'** are contoured on their inner surfaces to be registered opposite one another to produce a contoured disc shape. In the fabrication of container **11** the bottom or second portion **12'** and side or third portion **13** are welded together to form a container which is open at the top. Loose metal powder **10** is placed in the partially fabricated container and tamped or vibrated. The top or first portion **12** is then placed on the partially fabricated container and sealed thereto completing the assembly of a container having contoured interior surfaces and filled with metal powder. A parting compound may be applied to the inside of the container prior to filling with metal powder to facilitate the removal of the container from the metal stock. An opening **14** is provided in the container **11** and equipped with a pipe nipple registered therewith and welded to the container for the purpose of attaching a vacuum pump to evacuate the filled container. The filled, sealed and evacuated container is depicted graphically in FIG. **2.**

The next step is to heat the filled and sealed container **11** to rolling temperature, as e.g. in heating furnace **16.** The temperature will vary with the materials.

tainer is then preheated to 2090° F. and forged to a height of 9.8 inches from the starting height of 15.1 inches. Cross-rolling of the container is then commenced, taking a reduction of approximately 10 % per pass until the thickness of the container is 4.9 inches. Reheating during the cross-rolling may at times be necessary depending on the powder material and its hot-working range.

The above description and examples illustrate the practicability of forming large contoured discs by filling a container with metal powder and cross-rolling the filled container utilizing conventional rolling mill equipment.

The microstructures of the disc produced by utilizing Type 304L stainless steel powder and a normal as-rolled Type 304L stainless steel disc were compared. The austenitic grain size in the disc produced by utilizing powder was found to be significantly smaller than in the as-rolled stainless steel. "For a specific type of steel and strength level, fine-grained steels have higher notch toughness than coarse-grained steels."(Metals Handbook, 8th Ed., Vol. 1, p. 234, 1961).

This invention provides an efficient process capable of combining the advantages of high purity powdered metals, with the application of the very large forces available in a rolling mill utilizing the concentration of forces which results from the line contact of the rolls with the workpiece. The principal of encapsulating metal powder in a container which has been precisely tailored by precalculation of size and contour can result in metal stock of predictable size and shape.

The invention provides a novel and economical technique with no new major capital equipment requirements.

I claim:

1. A method of making contoured metal disc shapes by hot-rolling comprising the sequential steps of:

a. providing a container having an integral contoured interior surface filled with metal powder,

b. sealing, evacuating and heating the container,

c. rolling the container in a rolling mill in a plurality of rolling steps with the direction of each rolling step relative to the workpiece changed from the direction of rolling of the preceding step to reduce and compact the powder filled container, and

d. removing the container from the metal stock.

2. The method described in claim **1** further including a forging step between steps (b) and (c) to initially compress the filled container.

3. The method described in claim **1** wherein the inside surfaces of the container are coated with a parting compound before filling the container with metal powder.

4. The method described in claim **3** further including a forging step between steps (b) and (c) to initially compress the filled container.

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