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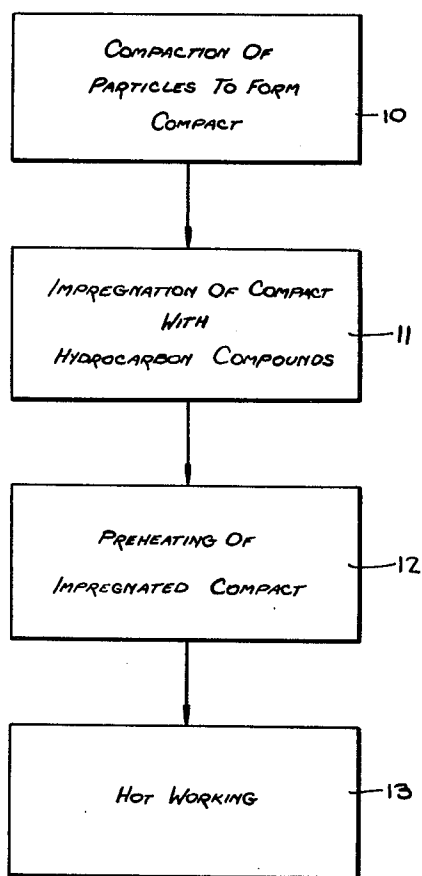
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PROCESS FOR PREVENTING OXIDATION OF HOT WORKED PARTS

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OF HOT WORKED PARTS*



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PROCESS FOR PREVENTING OXIDATION OF HOT WORKED PARTS

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This invention relates generally to the hot working of metals and more particularly to an improved method for inhibiting the oxidation of metal parts being hot worked.

In hot working certain oxidation-sensitive metals, it is conventional to use protective atmospheres when preheating the metal part and also when hot working the part. This practice is essential in order to preclude excessive scaling and to avoid contamination with the nitrogen and oxygen in the air. Such contamination is ordinarily encountered with cast-wrought materials, but it is particularly acute in the case of powder-fabricated metal parts.

In fabricating metal parts by powder metallurgy techniques, the parts normally possess some degree of porosity during certain phases of the operation, as for example, after cold compaction. Because the pores may be partially interconnecting, even the innermost regions of the powder fabricated part can be penetrated by contaminants such as oxygen and nitrogen. By reason of this fact and because a porous metal compact presents a greater amount of exposed surface area to the heating atmosphere, the extent of contamination arising in porous metals may be severe as compared to that occurring in cast wrought materials exposed to an oxidizing atmosphere.

The extent of oxidation is also affected by the nature of the furnace used. In fuel furnaces, the main constituents of combustion gases are CO₂, nitrogen, water vapor and CO or O₂. The relative amounts depend upon the degree of mixing and the quantities of fuel introduced into the burners. In general, it has been found that the scaling or oxidizing gases in a furnace atmosphere are CO₂, water vapor and O₂, while the reducing constituents are CO and H₂ and unburned hydrocarbons from the fuel. The scaling action of the atmosphere at any temperature and for any time of contact depends upon the relative proportions of these gases in the atmosphere. In electric or muffle furnaces, on the other hand, the atmosphere is normally air which in the case of steel, for example, forms a heavy free scale at all temperatures above 1200° F., the amount of scale increasing with temperature.

It has therefore been the practice to pre-heat porous compacts in protective atmospheres, and also when transferring the compact to hot working equipment, to make use of shielded transfer ducts. The need for such expedients obviously complicates the handling and processing of oxidation sensitive metal parts, and it adds materially to the cost of the operation.

Accordingly, it is the principal object of this invention to provide a method for preheating metal parts in air prior to hot working them and yet prevent their oxidation and nitrogenation even during transfer from the pre-heating source to the hot working equipment.

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It is also an object of the invention to provide a method of the above type which makes it possible to use relatively inexpensive heating equipment and to effect a transfer of the heated part in air. While the method is of particular value with powder-fabricated parts, it is also useful with cast wrought materials.

Briefly stated, these objects are accomplished by a low cost technique utilizing thermal decomposition or combustion of hydrocarbon compounds which are impregnated in the body being processed or are contained on the surface thereof to prevent their oxidation during pre-heating and hot working. The metals being processed may consist of powder or particulate-fabricated or cast-wrought materials in the form of discontinuous billets, ingots or continuous slabs.

Whereas pre-heating and hot working of oxidation-sensitive materials is usually carried out in protective atmospheres, the technique in accordance with the invention acts to generate a protective gaseous blanket about the part being worked and thereby permit the operations to be conducted in air.

For a better understanding of the invention, as well as other objects and further features thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawing whose single figure is a flow sheet illustrative of the process in accordance with the invention.

Compaction

Referring now to drawing, the first step 10 in the process, involves compaction of oxidation-sensitive metal powder or finely divided particles above powder size to form a compact. Such particles may be formed in the conventional way by atomization of molten metal by the use of air, steam or an inert gas, or by centrifugal spinning, shooting, graining or machining.

The compacts may be prepared in various ways, as by cold pressing, hot pressing or by sintering. In cold pressing, the powders are placed in a die and then subjected to pressure at room temperature, this resulting in partial consolidation and conversion into handleable compacts having up to 98% of the density of the cast-wrought metal. Cold pressing may be effected by such methods as forging, rolling or explosive compacting.

In hot pressing, hot powders are placed in a die or suitable container and subjected to pressure. This technique has the advantage of requiring less pressure than cold compaction to produce a useable compact. Alternatively, the powder may be heated within the die, this being more feasible where the powders are highly sensitive to oxidation.

The use of compacting dies may be avoided by sintering loose powders for a period of time and at a temperature appropriate to the metal, to produce a sinter cake through inter-particle bonding, the sinter cake being equivalent to a handleable compact.

Impregnation

In the second step 11, the powder compacts are impregnated with a hydrocarbon liquid or solid having the property of evolving protective vapors during pre-heating. The protective vapors are generated either through thermal decomposition of the impregnant or by its combination with the oxygen in the air to form carbon dioxide, carbon

monoxide, hydrogen, finely divided carbon particles or mixtures thereof. Among the useful low cost impregnants for this purpose are petroleum oils, both distillates and residuums, petroleum waxes and greases, and such hydrocarbon compounds as camphor, coal tars, pitches and various distillates.

The choice of impregnant must be such as to have a suitable boiling range relative to the temperature used for preheating the metal compact, and that it contain low concentrations of such contaminants as sulfur, phosphorus and ash.

Impregnation of the compact may be accomplished by mixing the impregnant with the powders prior to their cold compaction, in which event the impregnant also acts as a die lubricant for the cold compacting operation. One may alternatively impregnate the compact after the powders have been consolidated, this being accomplished by soaking the compact in oil to cause the oil to fill the pores by capillary action.

Another technique which results in deeper impregnation is to first immerse the compacts in oil, the vessel containing both the oil and compact being evacuated to drive the oil under pressure into the voids of the compact and into the interconnected pores thereof. Thereafter, the pressure in the vessel is returned to atmosphere.

It is also feasible merely to spray the impregnant onto the compact immediately before it enters the pre-heated furnace so that only the outer surfaces thereof are coated, the depth of oil penetration depending on the volume of oil relative to the volume and surface area of the compact and the time interval between spraying of the compact and its entry into the furnace. The amount of impregnant used will of course be determined by the amount of time the heated body is subject to an oxidizing atmosphere.

Subsequent to impregnation, the powder compacts are heated in air or reducing atmospheres, using conventional heating apparatus 12. Heating may be carried out in gas-fired furnaces, induction heated or electric resistance furnaces or in special electrode arrangements wherein an electric current is conveyed through the compact to produce internal heating by virtue of the resistivity of the compact.

The heating acts not only to bring the metal to its hot working point but it also results in the thermal decomposition or combustion of the impregnant, with the result that protective vapors are evolved from the pores which envelop the compact with an air excluding blanket. The heated compact is transferred as rapidly as possible by means of conveyor belts or rollers or other means to the hot working equipment. By this technique it is possible to protect the compact from oxidation during the transfer operation.

The pre-heat time to ensure protection of the compact from oxidation during preheating and transference may be determined visually, that is by observing the size of the flame occurring from oxidation of the protective vapors. It may also be determined empirically, that is by preheating the compacts for varying periods and measuring the mechanical or physical properties of the end product to arrive at optimum conditions.

Hot Working

The technique described herein can be used in conjunction with any type of oxidation-sensitive material, but its greatest applicability is with respect to the processing of materials which oxidize readily at temperatures above their recrystallization temperatures.

Such materials include iron, steel and ferrous alloys, as well as titanium and the refractory metals such as tungsten, molybdenum, columbium and their alloys. The method is also useful for non-ferrous metals and their alloys. The reason the method is most applicable to metals which oxidize rapidly at temperatures above their

recrystallization temperatures is that it is in this very range that metal is hot worked.

The pre-heated compact may be hot worked by any known process 13, such as rolling, swaging, extrusion and forging.

While the technique has been described herein in connection with protecting powder-fabricated materials from oxidation during various processing stages (i.e., pre-heating after cold pressing, pre-heating after hot pressing or pre-heating after forming a sinter cake in a protective atmosphere), the technique is not limited to powder or particle fabricated materials and may be employed to protect small cast wrought forging billets from contamination and scaling during pre-heating as well as during transfer from the pre-heating furnace to the forging press.

Thus the technique in accordance with the invention has the same objective as conventional techniques making use of protective atmospheres; namely it seeks to prevent oxidation and nitrogenation of powder fabricated or cast wrought materials when pre-heating the material and transferring it to hot working equipment. However the instant technique has many advantages, among which are:

(1) It eliminates the use of protective furnace atmospheres, so that the material to be hot worked may be pre-heated in air with a consequent reduction in the cost of furnace operation.

(2) It requires a less expensive furnace, for no provision need be made for the furnace to contain a protective atmosphere.

(3) It permits the use of low cost heat sources, such as gas or oil operated furnaces rather than the more expensive electrical types.

(4) It does away with the need for shielded conveyors to transfer the pre-heated work, for the transfer may be carried out in air.

(5) It eliminates the hazards incident to the use of combustible protective atmospheres, such as hydrogen, during pre-heating and transfer operations.

(6) It is a low cost process for the impregnants contribute very little to the overall cost of processing.

While there have been disclosed preferred processes in accordance with the invention, it will be obvious that many changes may be made therein without departing from the essential spirit of the invention as set forth in the appended claims.

What is claimed is:

1. The method of hot working metals comprising the steps of forming a coherent body of oxidation sensitive materials, coating at least the surface of said body with a hydrocarbon compound, preheating said coated body to a hot working temperature, said compound having the property of evolving a protective atmosphere at said hot working temperature and hot working said preheated body while said protective atmosphere is being evolved.

2. The method set forth in claim 1 wherein said body is formed by cold rolling powder into a compact.

3. The method set forth in claim 1 wherein said body is cast wrought.

4. The method set forth in claim 1 wherein said body is formed by hot rolling powder into a compact.

5. The method set forth in claim 1 wherein said body is formed by sintering metal particles into sinter cake.

6. The method of hot working an oxidation sensitive metal comprising the steps of cold compacting particles of said metal into a porous compact, impregnating the pores of said compact with a hydrocarbon compound which evolves into a protective vapor at the hot working temperature of said metal, preheating the impregnated compact to said hot working temperature and hot working said impregnated compact while said protective atmosphere is being evolved.

7. The method of hot working a metal, as set forth in claim 6, wherein the impregnant is mixed with said powders prior to their compacting.

8. The method as set forth in claim 6, wherein the compact is soaked in a fluid impregnant which fills the pores thereof by capillary action.

9. The method, as set forth in claim 6, wherein the compact is immersed in said impregnant and is introduced by pressure into the pores of said compact.

10. The method, as set forth in claim 6, wherein said impregnant is sprayed on the surface of said compact.

11. The method, as set forth in claim 6, wherein said impregnant is a petroleum product.

12. The method, as set forth in claim 6, wherein said impregnant is camphor.

13. The method, as set forth in claim 6, wherein said impregnant is coal tar.

14. The method, as set forth in claim 6, wherein said impregnant is pitch.

15. The method as set forth in claim 1, wherein said hot working is effected by forging said body.

16. The method as set forth in claim 1, wherein said hot working is effected by extruding said body.

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