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Mino et al.

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[45] **Nov. 26, 1974**

[54] **METAL SPRAYING PROCESS**

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[52] **U.S. Cl.** ..... **117/48**, 117/46 FS, 117/94, 117/105.1, 117/105.2

[51] **Int. Cl.** **B44d 1/097**, B44d 1/52

[58] **Field of Search** ..... 117/46 FS, 94, 130 R, 131, 117/105, 105.1, 105.2, 105, 4, 46 FZ, 48

[56] **References Cited**

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Primary Examiner—William D. Martin
Assistant Examiner—Shrive P. Beck
Attorney, Agent, or Firm—Wenderoth, Lind & Ponack

[57] **ABSTRACT**

A process of spraying molten metal on to an object, which is formed with a plurality of mechanical parts to be metal-coated, to form a metallic coating interlocked with the surface of the object. To facilitate the metal spraying process, the mechanical parts to be metal-coated are formed into the single object with a partition plate utilized to insulate individual mechanical parts from each other, the resultant metallic coating covering the entire peripheral surfaces of these parts and plates. A line of weakness along which brittle facture occurs is provided in the metallic coating substantially between the ends of each of the mechanical parts and the adjacent partition plate whereby separation of the object into these individual mechanical parts can be easily carried out by giving an impact to the metallic coating or the partition plate.

10 Claims, 5 Drawing Figures

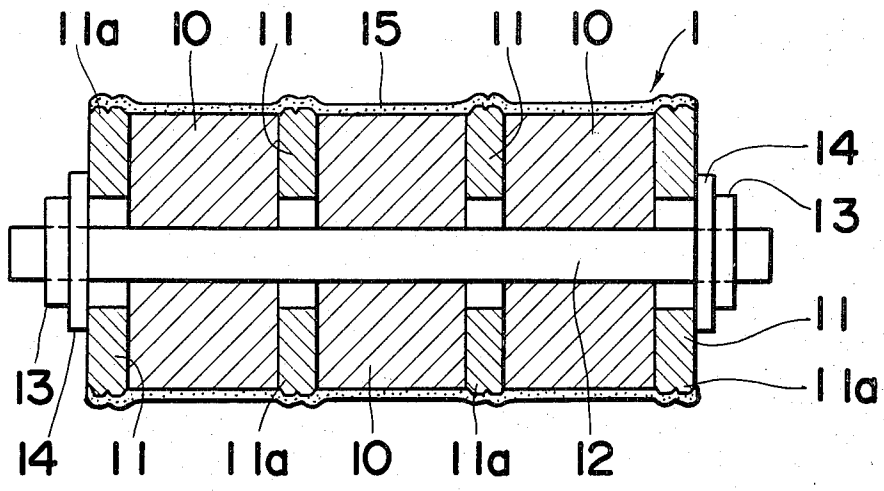


FIG. 1

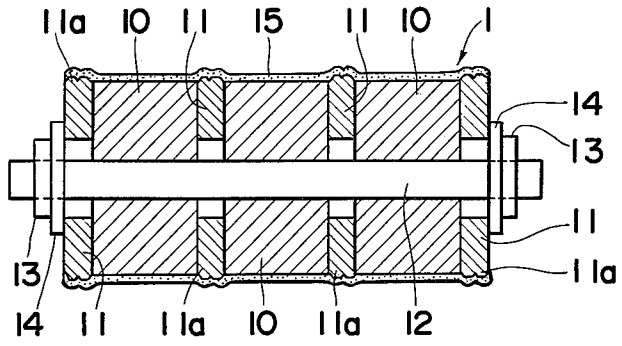


FIG. 2

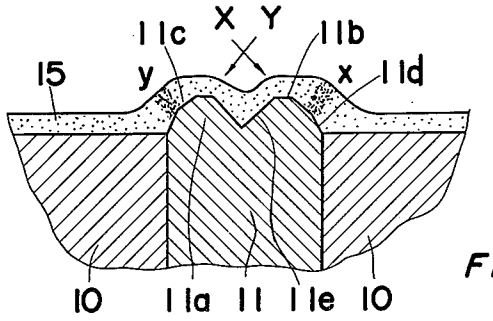


FIG. 3

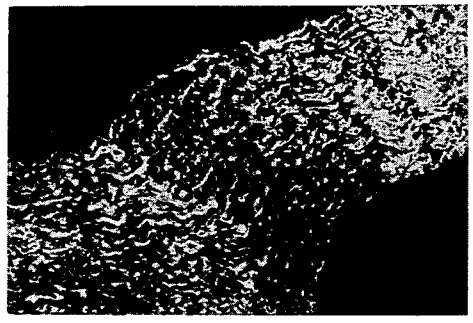


FIG. 4

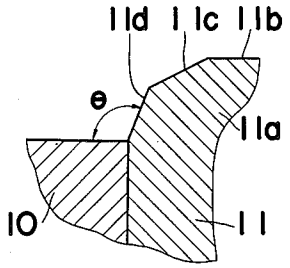
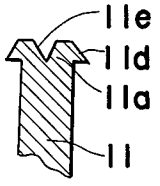


FIG. 5



METAL SPRAYING PROCESS

The present invention relates to a metal spraying process and, more particularly, to a metal spraying process for producing a plurality of metal coated mechanical parts in a single spraying operation.

The spraying of molten metal for the purpose of formation of a metallic coating is a comparatively recent development and various methods have heretofore been employed to reduce the cost and time involved in manufacturing a number of mechanical parts the surfaces of which are each metal-coated.

Of these various methods, a method is well known to those skilled in the art wherein a plurality of mechanical parts of cylindrical shape supported side by side in a horizontally suspended manner with a partition plate positioned between each two adjacent members of and at each end of the row of said mechanical parts are surface-coated with metal by means of a metal spray gun. In this known method, the partition plates are each made of copper and the peripheral edge portions thereof, which protrude radially outwardly from the peripheral surfaces of the parts to be metal-coated, are usually left uncovered with metal sprayed by the metal spray gun for the purpose of facilitation of individual separation of these mechanical parts.

Although this known method seems to be convenient in terms of the number of metal-coated mechanical parts obtainable in a single spraying operation, the fact that copper, used as the material for the partition plates, does not bond to such molten metal as is usually employed in the metal spraying process intended to produce hard surfaces has been found to cause the following disadvantages: Molten metal sprayed by the metal spray gun is hard to deposit particularly around the peripheral edge at each end of the mechanical parts where the sprayed metal contacts the corresponding partition plate, and accordingly a layer of metallic coating of substantially uniform thickness cannot be obtained from end to end over the entire length of each of the mechanical parts. In addition, experiences have shown that cracking tends to be initiated from the metal deposit formed above the peripheral edge at each end of the mechanical parts in contact with the corresponding partition plate, which cracking ultimately runs over the entire length of the metallic coating on the peripheral surface of any one of the mechanical parts during the service thereof.

Accordingly, an essential object of the present invention is to provide an improved metal spraying process capable of providing a plurality of metal coated mechanical parts in a single spraying operation with substantial elimination of the disadvantages inherent in the conventional process of a similar kind.

Another important object of the present invention is to provide an improved metal spraying process of the above mentioned character wherein a metallic coating of substantially uniform thickness is obtainable over the entire length of each of these mechanical parts in a bonded on rigidly interlocked relation between the metallic coating and the peripheral surface of each of said mechanical parts.

A further object of the present invention is to provide an improved metal spraying process of the above mentioned character which can be practised without incurring an increase of the cost and time of manufacture of the metal-coated mechanical parts.

According to the present invention, an essential feature resides in the construction of each one of the partition plates which may be made of metallic material of similar quality with respect to the metallic material used to manufacture the mechanical parts to which the metallic coating is applied. The terms "similar quality" hereinabove employed is intended to mean that, unlike copper material which lacks a bondability to other metallic material generally employed in the metal spraying process, the metallic material for the partition plates has bondability. Needless to say, the partition plates may each be of the same metallic material as employed for the mechanical parts.

In addition thereto, each of the partition plates employed in the metal spraying process according to the present invention has a peripheral face shaped such that a line of weakness or dummy joint can be formed on both sides of the peripheral face thereof as molten metal is sprayed onto the mechanical parts covering the peripheral face of said partition plate. At the time of completion of the spraying operation, although the mechanical parts and the partition plates appear to be formed into an integral unit, these can be separated in a predetermined manner to produce the individual mechanical parts which are sufficiently and satisfactorily metal-coated. This is possible because of the presence of the line of weakness or the dummy joint in the metallic coating on both sides of the peripheral face of each of the partition plates, along which cracking occurs if an impact is given thereto, for example, by means of hammering at each line of weakness or dummy joint.

These and other objects and features of the present invention will become apparent from the following description made by way of example with reference to the attached drawings, in which;

FIG. **1** is a longitudinal section of an object onto which metal spraying is carried out in accordance with the present invention,

FIG. **2** is a longitudinal section, or an enlarged scale, of an essential portion of the object shown in FIG. **1**, showing a manner of formation of a metallic coating over the peripheral face of a partition plate,

FIG. **3** is a photomicrograph, magnified **16** times, of the metallic coating, showing the presence of a line of weakness or dummy joint in said coating,

FIG. **4** is a schematic longitudinal section of a portion of the peripheral face of a modified form of partition plate, and

FIG. **5** is a view to FIG. **4**, showing a further modified form of the peripheral face of the partition plate.

Referring first to FIG. **1**, in order to efficiently practice the method of the present invention, a plurality of workpieces **10**, each being of, for example, cylindrical shape and the peripheral surface of which is to be metal-coated, are collected into a single object, as generally indicated by **1**, in a manner as hereinafter described. It is to be noted that the object **1** on which the metal spraying is performed in accordance with the present invention includes a plurality of partition plates **11**, each of which has a similar shape to and somewhat greater size than that of any one of the mechanical parts **10** so that the peripheral portion **11***a* of said partition plate protrudes radially outwardly a substantially uniform distance from the peripheral surface of a mechanical part **10** positioned on one or both sides of said partition plate **11**. The number of the partition plates **11** depends on the number of the mechanical parts **10**

to be metal-coated and the former is greater than the latter by one.

In the illustrated embodiment and particularly in FIG. **1**, the object **1** is shown as comprising three mechanical parts **10** and four partition plates **11**. These parts **10** and plates **11** are supported in a row by a supporting rod **12** loosely extending therethrough, which are in turn held in position in such a way that, while two of said plates **11** are located at both ends of the row of the mechanical parts **10**, the remaining members are between each two adjacent members of said mechanical parts **10**. The parts **10** and plates **11** thus arranged on the supporting rod **12** are pressed side by side by means of a pair of fastening pieces, for example, nuts **13** through suitable washers or backing plates **14**.

The supporting rod **12** may be directly or indirectly connected with a suitable drive system (not shown) so that the object **1** can be rotated relative to a metal spray gun of conventional type (not shown) which is arranged in any known manner such as to permit atomized spray of molten metal from the spray gun to be oriented toward the peripheral surface of the object **1**. The atomized spray of molten metal is shown as formed into a metallic coating **15** covering the entire length of the object **1** to the desired thickness.

Referring now to FIG. **2** wherein portions of only one of the partition plates **11** and two of the mechanical parts **10** on both sides of said partition plate **11** are shown on an enlarged scale, the conditions necessary to achieve the optimum result in the metal spray process according to the present invention will be described. As clearly shown, the peripheral portion **11***a* of the partition plate **11** protrudes radially outwardly protruded from the peripheral surfaces of the mechanical parts **11** with the peripheral surface **11***b* of said plate **11** situated above the peripheral surfaces of said mechanical parts **11**. Each of the peripheral edges of said partition plate **11** is inwardly inclined in two steps to provide outside and inside bevel surfaces **11***c* and **11***d*. It is to be noted that the outside bevel surface **11***c* is not always necessary, but may be flush with the peripheral surface **11***b* of the partition plate **11**. However, the inside bevel surface **11***d* on both peripheral edges of said partition plate **11** is, as shown in FIG. **4**, inclined with respect to the surface of the adjacent mechanical part **10** at an angle θ within the range of 90° to 170°, preferably, within the range of 110 to 150°, the reason for which will be described later.

Furthermore, the distance which the peripheral portion **11***a* of the partition plate **11** projects radially outwardly from the peripheral surface of each mechanical part **10** must be within the range of the value one-third of the thickness of the resultant metallic coating **15** to a value five times, preferably, three times, of said thickness of said resultant metallic coating **15**.

Alternatively, the peripheral portion of each partition plate **11** may be shaped as shown in FIG. **5** wherein the inclined surfaces **11***d* are located outwardly in the opposite directions with respect to the body of the partition plate **11**.

The reason for formation of each dummy joint, as generally indicated by *x* and *y* in FIG. **2**, will be hereinafter described. However, for the sake of brevity, reference is only made to the formation of the dummy joint *y* which is shown in the photomicrograph of FIG. **3**. As clearly shown in FIG. **2**, the dummy joint *y* formed in the metallic coating **15** in the vicinity of the inside bevel surface **11***d* extends below the outermost surface of the metallic coating **15** down to the bevel surface **11***d*. It may be said that the direction of extension of said dummy joint *y* is substantially in conformity with the bisector of the angle θ. This is evidenced by the photomicrograph of FIG. **3** showing a sharp contrast between the metallic coating above the peripheral surface of the mechanical part and that above the bevel surface **11***d*, the former being less dark than the latter. The formation of the dummy joint represented by the darker portion of the metallic coating shown in FIG. **3** is based on the difference in the direction of blowing of molten metal from the metal spray gun the spraying nozzle (not shown) of which is oriented at right angles to the longitudinal axis of the object **1** to be metal-coated. In other words, as the spraying operation proceeds during rotation of the object **1**, it has been observed that sprayed particles of molten metal tend to deposit substantially at right angles to the surface of the object, i.e., the surface of the mechanical part **11** and also the bevel surface **11***d* and, during this course deposition, depositin, impurities such as metallic oxides are enveloped in the sprayed metal at the boundary between the coatings above the surface of the mechanical part and the bevel surface **11***d*, thus forming a brittle structure in the metallic coating which is herein referred to as the dummy joint. This dummy joint thus formed is easy to crack by an impact at any position on the metal-coated object, because of the mechanical strength being lower than in the other portion of the metallic coating. However, it is advisable to apply the impact in a manner as will be described later.

Each of the partition plates **11** has formed on its peripheral face **11***b* a groove **11***e* extending around the entire peripheral edge of said partition plate **11**. This groove **11***d* may be of any shape, preferably, U- or V-shape in cross-section, and is designed such that brittle fracture is reliably initiated along the dummy joints *x* and *y* when impacts are given by, for example, hammering, through the resultant coating **15** to respective groove faces of the groove **11***e* in the direction as indicated by the arrows X and Y. This hammering procedure is most advisable in view of the fact that the metal-coated mechanical parts can thus be individually separated without being damaged. In any event, depending upon the shape of each of the mechanical parts to be metal-coated, hammering may be effected on the inner peripheral surface of each bore of the partition plates through which the supporting rod **12** extends. In addition, this hammering may be effected with or without the use of an anvil.

A process for applying the impact to produce the individual metal-coated mechanical parts may be effected either prior to the removal of the object **1** from the supporting rod **12**, or after the metal-coated object **1** has been removed from the supporting rod **12**. In the case where the object **1** is heavy, it is recommended to carry out the hammering process prior to the removal of the object from the supporting rod **12** after either or both of the fastening members **13** have been loosened.

In practice, as is well known to those skilled in the art, prior to the spraying operation, but either before the mechanical parts **10** and the partition plates **11** are mounted on the supporting rod **12** in the predetermined manner or after they have been mounted thereon, the whole peripheral surfaces of these parts **10**

and plates **11** are preferably surface treated, for example, by sandblasting, cleaning or pickling as is normally carried out in the execution of the metal spraying process. This is because, if the surfaces are treated as described above, bonding or rigid interlocking between the deposited metal and the treated surfaces can be advantageously ensured as well understood by those skilled in the art.

Referring back to FIG. **4**, if the angle θ is smaller than 90°, it is clear that the metal spraying process according to the present invention cannot be performed due to the overhang of the peripheral portion of the plate over the end extremity of the adjacent mechanical part **11**. On the other hand, if the angle θ is greater than 170°, no dummy joint will be formed. More specifically, if the angle θ is 90°, the amount of the radially outward extension of the peripheral portion **11***a* of the partition plate **11** must be smaller than three times the thickness of the resultant coating **15** and, as the angle θ increases, said amount may be increased. However, the amount of the radially outward extension of the peripheral portion **11***a* of the partition plate **11** should not exceed five times the thickness of the resultant coating **15**, or a spray gun of relatively large size will be required. An increase in the amount of the radially outward protrusion of the peripheral portion **11***a* while the angle θ is 90° will result in the coating **15** becoming discrete rather than continuously covering the whole surfaces of the mechanical parts and partition plates **11**.

From the foregoing, it has now become clear that the various objects can be satisfactorily achieved by the process of the present invention. It is to be noted that the individual mechanical parts **10** that have been metal-coated may be used either as a final product or as an intermediate product which may be subjected to a subsequent machining process.

Although the present invention has been fully described by way of example, it is to be noted that various changes and modifications will be apparent to those skilled in the art. For example, although the present invention has been described as being carried out on mechanical parts of cylindrical shape, it is equally applicable to those of any shape. In this case, it is, of course, necessary to prepare the partition plates so that they have a shape similar thereto. Therefore, those changes and modifications should be, unless otherwise departing from the scope of the present invention, construed as included therein.

What is claimed is:

1. A metal spraying process which comprises the steps of :

mounting a plurality of mechanical parts in a row side by side on a supporting structure;

placing a partition plate between each two adjacent members of and at each end of the row of said mechanical parts, with the peripheral portion of said partition plate extending radially outwardly from the peripheral surface of each said mechanical parts, said partition plate being made of metallic material of similar bondable quality as said mechanical parts and having a peripheral edge on both sides of said partition plate, at least one of said peripheral edges being a bevel surface which is substantially obliquely outwardly inclined relative to the peripheral surface of the adjacent mechanical part;

spraying a molten metal which is capable of being sprayed and which will bond to the metallic material of said mechanical parts and said partition plates on the entire peripheral surfaces of said mechanical parts and said partition plates by effecting relative movement between said mechanical parts and partition plates and a spraying device, whereby a metallic coating is formed which is bonded tightly to each peripheral surface of said mechanical parts and the bevel surface of said partition plate, said resultant metallic coating having a dummy joint portion substantially along the boundary between each mechanical part and the partition plate adjacent thereto,

giving an impact to said resultant metallic coating for causing brittle fracture thereof along said dummy joint portions; and

separating said mechanical parts with said metallic coating thereon from said partition plates to produce individual metal coated mechanical parts.

2. A metal spraying process as claimed in claim **1** in which said bevel surface has a radially inner portion and a radially outer portion, the radially inner portion being inclined relative to the peripheral surface of the adjacent mechanical part at an angle of from 90° to 170°.

3. A metal spraying process as claimed in claim **2** in which said radially outer portion is obliquely inclined relative to said peripheral surface at an angle greater than the angle at which said radially inner portion is inclined, and at an angle less than an angle at which said radially outer portion is flush with the peripheral surface of the partition plate.

4. A metal spraying process as claimed in claim **3** in which said radially outer portion is flush with the peripheral surface of the partition plate.

5. The method as claimed in claim **1**, further comprising a step of roughening all the peripheral surfaces of said mechanical parts and partition plates to ensure a rigid bonding between the sprayed molten layer and said treated surfaces, which said step is carried out prior to said spraying step.

6. The method as claimed in claim **5**, wherein said roughening step is carried out prior to said mounting step.

7. The method as claimed in claim **1**, wherein said bevel surface is inclined with respect to the adjacent peripheral surface of the mechanical part at an angle within the range of from 110° to 150°.

8. The method as claimed in claim **1**, wherein the amount of the peripheral portion of the partition plate extending radially outwardly from the peripheral surfaces of the mechanical parts on both sides thereof is within the range of one third of the thickness of said metallic coating and five times the thickness of said metallic coating.

9. The method as claimed in claim **9**, wherein said partition plates have a peripheral surface with a groove therein having a pair of opposite groove faces to which said impact is imparted to facilitate the brittle fracture.

10. The method as claimed in claim **9**, wherein said groove is a V-shaped notch.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,850,669 Dated September 25, 1972

Inventor(s) HIROSHI MINO, SHOZO MIYANISHI

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 1, Line 9: for "each said" read -- each of said--;

Claim 4, Line 1: for "claim 3" read --claim 2--;

Claim 9, Line 1: for "claim 9" read --claim 1--;

Signed and sealed this 1st day of April 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

FORM PO-1050 (10-69)

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