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METHOD OF CLADDING METALS

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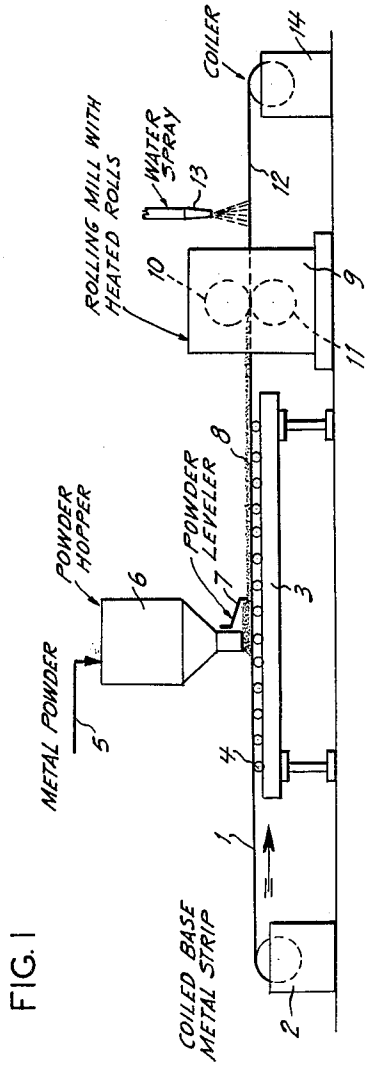

FIG. 1

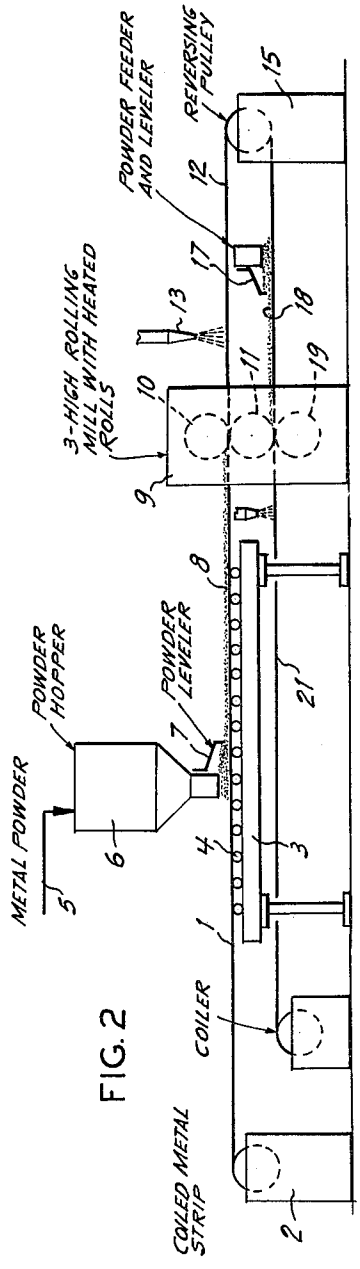

FIG. 2

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METHOD OF CLADDING METALS

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The present invention is directed to the cladding of metals and more particularly to the use of powder metallurgical techniques to obtain superior cladded metal products.

While some attempts have been made to use powder technology in cladding metals, only plating and laminating procedures have been used on a large scale. In such operations it was necessary to prepare the surface to be clad as by machining, cleaning, polishing and the like, all of which were costly. If powder was used, it was preheated as was the base metal, introducing the danger of oxidation and thus non-adherence of the coating to the base. To avoid such danger the cladding was carried out in an inert atmosphere, but this introduced additional expense of equipment and materials. In prior processes the cladding materials were considerably more expensive than the base metal which was steel or a similar metal. Also, in prior procedures there was a large reduction in the thickness of the base metal, which was undesirable in many instances, particularly when heavy gauges were employed. The present invention is intended and adapted to overcome the difficulties and disadvantages inherent in prior processes for cladding metals, it being among the objects thereof to devise a method which is simple, which utilizes low cost materials, and does not require complicated or expensive apparatus.

It is also among the objects of the invention to provide a process which does not require that the base metal be finished and in which a variety of cladding metals are applicable.

It is further among the objects of the invention to provide a process which may be conducted in the air, which results in a superior product, which may be made continuous, and wherein the apparatus is capable of realizing very high rates of production.

According to the invention, a wide variety of metals such as tin, zinc, aluminum, lead, copper, titanium and many others can be clad to a base metal such as carbon steel on a continuous basis at low cost. The cladding material in powder, granule, fiber, etc. form is deposited uniformly on the base metal which is in the form of strip or plate, and the assembly of strip and powder are passed between heated rolls of a rolling mill. The strip and powders are heated by the rolls above the recrystallization temperature of the powders so that the powders are simultaneously consolidated and bonded to the base. It is important to the process that the powders are simultaneously heated, consolidated, bonded and hot rolled during the interval in which they are under pressure between the rolls.

All process heat is furnished by the heated rolls and by the heat evolved by virtue of the work expended in compression of the powders and base metal. The process differs from existing powder metallurgical processes in that neither powder nor base metal is heated before the rolling operation, yet the base metal leaves the rolling mill with the clad fully consolidated and bonded to the base metal, or at least in a condition such that one or more additional rolling passes will complete the consolidation.

The invention is more fully described in connection with the accompanying drawing constituting a part hereof

and in which like reference characters indicate like parts, and in which:

FIG. 1 is a diagrammatic side elevational view of a continuous system for the cladding with metal powder of metal strip on one side using heated rolls according to the invention; and

FIG. 2 is a view similar to FIG. 1 showing the powder cladding of metal strip on both sides in a single operation.

Steel plate has been cladded with a wide variety of materials by the new powder metallurgical technique described. The cladding of tin, zinc, lead and aluminum on steel has been demonstrated. Virtually any other type of metal clad is possible, the only limiting factor appearing to be the maximum operating temperature of the rolls.

A plant for producing strip clad on one side on a continuous basis is shown in FIG. 1. The base metal strip 1 to be clad is carried on a coil 2 which is unwound so that the strip passses over table 3 having a series of free running rollers 4. Metal powder 5 from hopper 6 is fed through a slot in the bottom thereof onto the moving strip 1 and a leveling blade 7 insures a uniform distribution 8 of the powder on the strip. It enters mill 9 and is pressed between heated rolls 10 and 11 at a temperature above the recrystallization temperature of the metal powder, whereby close adherence of the powder to the base metal is obtained.

Immediately upon leaving mill 9 the clad strip 13 is met by a cooling medium, such as a spray 13 of water, thus preventing oxidation. The product is rolled up in coiler 14.

During the operation the powder is deposited on the strip as a uniform layer, the thickness of which can be varied by means of the leveling gate 7. Strip and powder are then passed between heated rolls where the clad is consolidated and firmly bonded to the base metal. The rolls may be heated by internal electric resistance heating elements, by high frequency induction coils, or by direct flame impingement.

If both sides of the strip are to be clad, the strip clad on one side can be reversed over an idler pulley, loaded with powder on its unclad side and passed between the lower set of rolls of a three-high rolling mill as shown in FIG. 2.

The apparatus is basically the same as in FIG. 1 except that mill 9 is three-high. In place of coiler 14 of FIG. 1 a reversing pulley 15 is provided, around which the clad metal strip 12 passes. Powder metal from hopper 16 is deposited on the reversed side of strip 12 and leveler 17 provides uniform distribution 18 of the powder. The strip continues between heated rolls 11 and 19 where the consolidation takes place, then being quenched by water spray 20. It passes as shown at 21 to coiler 22.

Alternatively the strip may be passed through rolls arranged to accept a vertical feed and then dumping powders on either side of the base metal strip as it is drawn between the rolls.

For cladding base metal in plate form, the plates are carried under the powder hopper by means of a conveyor belt and rolled individually. The plate can be clad on both sides by sending it through two mills in series. It is clad on one side after being passed through the first mill; and it is then turned over and clad on the reverse side by being passed through the second mill.

Aluminum clad steel and lead clad steel were fabricated by abrading a 1/16" steel plate and depositing on the plate a 1/8 to 1/4" thickness of powder. The unheated compacts were then passed through the rolls of a 5" x 8" rolling mill operating at 40 to 50 f.p.m. (feet per minute). Rolls were preheated to 400° to 450° C.

The resultant clad steel strip could be bent 180° without having the clad crack or break away from the base metal. On the basis of the aluminum and lead cladding, it appears that the roll temperature should be about 100° C. higher than the actual required cladding temperature. The recommended cladding conditions are given in the table below:

Cladding of Carbon Steel With Various Materials Through Use of the Hot Roll Cladding Process

Cladding Material	Cladding Temperature, ° C.	Roll Temperature, ° C.
Aluminum	450–600	400–700
Lead	200–300	300–400
Zinc	300–400	400–500
Tin	100–200	200–300
Copper	600–800	700–900
Titanium	1,000–1,100	1,110–1,200

Plate or strip clad by the process of this invention has highly desirable properties and advantages, some of which are as follows:

(1) Steel can be clad at lower cost than by processes conventionally used for cladding because of the low cost of the materials used and the simplicity of processing. Whereas conventional cladding processes utilize base metal and clad in finished strip or plate form, the subject invention requires only that the base metal be in strip or plate form. The cladding, which is ordinarily more costly than the base metal, is by relatively low cost powders to be processed by the technique described by this invention. Processing, too, has been simplified.

(2) In conventional cladding of plate, the base metal, say steel, must be carefully machined and cleaned and then mated to the cladding, say copper. After this, the edge seam between the two plates must be welded to prevent infiltration of air between mating surfaces during rolling. The assembly is then hot reduced considerably to ensure metallurgical bonding between clad and base metal. By means of this invention, it is possible to clad steel with a minimum of surface preparation, light abrasion of the surface usually being adequate. Metallurgical bonding of clad to core can usually be achieved in one or two passes and with a minimum of base metal reduction, usually less than 50%, so that processing and handling costs are kept at a minimum.

(3) The process is continuous so that very high production rates are achieved. The length and width of clad plate or strip which can be produced is limited only by the length and width of the base metal or the width of the rolls on the mill.

(4) Clad plate or strip of almost any thickness can be produced simply by varying the initial thickness of the base metal. The process is advantageous in the fabrication of clad materials in lighter gauges because it eliminates the need for pickling, electroplating or hot dripping equipment. It is advantageous in the fabrication of thick clad plate because it requires lesser thicknesses for the starting materials and eliminates the costly equipment needed to satisfactorily prepare the surfaces of heavy plate.

(5) The cladding of steel can be carried out in air even where the clad material is prone to oxidation at the temperatures used in rolling. Since the heated powders are compacted so rapidly, there is little opportunity for them

to oxidize before they are fully consolidated. Once consolidated, they may be quenched rapidly so as to avoid oxidation after rolling. Quenching may be accomplished by water sprays at the point where material leaves the rolls.

(6) In prior cladding processes employing powder preheating or post-heating techniques, protective atmospheres usually must be used in order to avoid oxidation of the powders during processing. This requires equipment of greater complexity and results in higher operating costs than in the case of the subject invention.

Although the invention has been described setting forth several specific embodiments thereof, the invention is not to be limited thereto as changes in the details are considered to be within the broad concept of the invention. For instance, quite different types of apparatus are available for carrying out the process. Other cladding and base metals are applicable. Various quenching means may be used other than water spray. These and other changes may be made within the spirit of the invention which is to be broadly construed and to be limited only by the character of the claims appended hereto.

What is claimed is:

1. A method of cladding a strip of base metal, comprising the steps of covering an unheated strip of the base metal with a layer of unheated oxidation-sensitive metal in powder form, conveying the unheated combination in air through pressure rolls which are heated to a temperature imparting sufficient heat to the metal powder to raise it above its recrystallization temperature and which subject the heated metal powder to sufficient pressure to consolidate the layer of powder and simultaneously bond it to the base strip, the temperature of the rolls being higher than the temperature of the powder.

2. A method according to claim 1 characterized in that the operation is conducted with the continuous feeding of said metal strip.

3. A method according to claim 1 characterized in that the product is cooled immediately following said heat and pressure treatment.

4. A method according to claim 1 characterized in that said layer is leveled prior to the heat and pressure treatment.

5. A method according to claim 1 characterized in that after said treatment the opposite side of said metal strip is similarly treated.

6. A method according to claim 1 characterized in that both sides of said metal strip are simultaneously coated with said metal powder.

7. A method according to claim 1 characterized in that after said treatment the opposite side of said metal strip is similarly treated, and said heat and pressure are applied in both of said treatments by passing said assembly between two rolls of a three-high mill.

8. A method according to claim 1 characterized in that the roll temperature is about 100° C. higher than the recrystallization temperature of the powder.

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