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(54) Pot roll for continuous hot-dip galvanizing

(57) A Pot roll for continuous hot-dip galvanizing used in a galvanizing bath, characterized by comprising a Pot roll surface having three spray coating layers composed of a alloy of high Co ratio or cermet of high ratio of said alloy as the first layer, a cermet containing a oxide, carbide or boride as the second layer and a ceramic of oxide group as the third layer.

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Description

Field of the Invention

The present invention relates to a pot roll for continuous hot-dip galvanizing used in a galvanizing bath of continuous hot-dip galvanizing process line.

Background of the Invention

In the previous pot roll used in a galvanizing bath of hot-dip galvanizing line, a thermal spray coating which is hard to react with molten zinc and has wear resistance was formed onto the surface of stainless steel roll substrate, that is, onto the face side contact with a steel belt. For example, Japanese Non-examined Patent Publication No.59-1,53,875 proposes a self-melting alloy of Co base, and Japanese Non-examined Patent Publication No.1-225,761 proposes a technique of spraying WC-Co cermet and the like.

The pot roll having such spray coating has given performances for the present, concerning a corrosion resistance to a zinc and wear resistance to a steel belt by controlling reaction with-the zinc and its higher hardness, as compared with the case when a stainless steel was directly used. But, problems were found that the Co component in the cermet was diffused into the zinc, and the coating was embrittled with the increase in WC ratio of the coating, and then flaking troubles of the WC-Co cermet were induced. And so, the performances thereof was not always sufficient.

A hot-dip Pot roll on the surface of which the coating, proposed by the inventors of Japanese Applied Patent Publication No.52-17,490, is formed has recently been used. This coating, composed of a silicon nitride or substituent thereof which replaced silicon with aluminum and nitrogen with oxygen respectively, is free from reaction with zinc and has a increased hardness and excellent wear resistance.

Thermal spray coating method is utilized in order to form a ceramic coating, but pores exist inside the coating which formed by spraying, some of which pass therethrough. Because such through pores never fail to exist in the coating of ceramic or cermet group, this problem is unavoidable as far as the formation of coating is dependent upon the thermal spray coating method. Also, when a ceramic coating is sprayed on a roll surface, thermal expansion difference between the ceramic and roll substrate of stainless group causes the coating to create thermal stresses and cracks inside the coating. A cermet can be sprayed as the lower layer in order to moderate the thermal stress as much as possible, but pores also exist in the cermet coating. Moreover, in case of the lower layer, sealing by chemical adhesion method or the like cannot generally be employed, in order to ensure adhesiveness to the upper layer, and so the fact was that cracks or zinc penetrations passing through pores could not be prevented.

The molten zinc which penetrated and passed inside the through pore portion of both the upper ceramic and lower cermet coating then reaches the roll surface of stainless group, and, at that contact portion, react chiefly with Fe component among the chemical compositions of stainless group to produce a alloy of Zn-Fe, or a ternary intermetallic compound of Ze-Fe-Al when Al is added into the galvanizing bath. Because the ternary intermetallic compound is accompanied with any volume expansion, both the lower and upper layer are partly flaked in the form of pushing upward. The inventors learned by their experiences that, when such troubles had occurred, a number of circular flaking of 3-5 mm diameter are created at the portion where the roll and steel belt contacted together and external stresses were applied.

Therefore, it is required that a shielding layer is located between the sprayed cermet and roll substrate in order to prevent the zinc, passed inside through pores which occurred unavoidably during ceramic or cermet spraying, from reaching the roll substrate of stainless group and further the shielding layer has a characteristic such as effect self-sealing even if the zinc should pass therethrough. The present invention is aiming to provide means to solve these problems.

The present invention intends to elongate the life of Pot roll used for continuous hot-dip galvanizing.

Summary of the Invention

The present invention provides a pot roll. for continuous hot-dip galvanizing in a galvanizing bath, characterized by comprising a pot roll surface where three spray coating layers composed of an alloy of high Co ratio (Co-based alloy) or cermet of high ratio of said alloy (cermet-based alloy) as the first layer, a cermet containing an oxide or carbide or boride as the second layer and a ceramic of oxide group as the third layer are formed in order of coating.

The reason why a spray coating composed of a alloy containing cobalt, or a alloy or cermet of high ratio of the alloy is located as the first layer of the coatings, is that the amount of pores in the coating layer is extremely reduced, because this kind of spray coatings have a melting point of about 1,500°C, which are lower in comparison with other cermets or ceramics, and so this portion melt by the heat of the spray frame.

Also, because these alloys have lower reactivities with zincs in themselves and formation velocities of intermetallic compounds formed with zincs are slower, the intermetallic compounds formed inside pores may effect selflocking as a sealing material even if the through pores exist.

The reason why a cermet containing a oxide, carbide or boride is located as the second layer is that there are less deformations against external stresses during contacting with a steel belt and the strain of a ceramic coating layer as the third layer is minimized, because this kind of cermets have thermal expansion coefficients intermediate stainless steels and ceramics and the coating is higher in its hardness and mechanical strength.

The reason why a ceramic of oxide group is located as the third layer is that reaction rate of ceramic itself with a zinc is extremely slow and protect the spray coating of the cermet or alloy of the first and second layers.

Table I

Thermal expansion coefficient of coating of each layer according to the present invention at normal temperature	
Name of layer portion	Thermal expansion coefficient
Roll substrate of stainless group	11 - 18 x 10^{-6}
Alloy containign Co (the first layer)	11 - 16 x 10^{-6}
Cermet of high ratio of alloy containing Co, cermet containing oxide or carbide (the second layer)	5 - 15 x 10^{-6}
Cermet composed chiefly of oxide (the third layer)	5 - 9 x 10^{-6}

Examples

After spraying a alloy containing Ni-Co-Cr as the first layer, Mo cermet was sprayed as the second layer, and then a ceramic coating composed chiefly of partly stabilized ZrO_2 was sprayed as the third layer (Each thermal expansion coefficient at that time is shown in Table 2.), in order to form a bar-shaped test piece of 20 mm∅ x 200 mm length. Then, the test piece was dipped by 100 mm length thereof for a long period of time into the experimental molten zinc bath which added with 0-2% Al at 450°C. And the result was that only the flaking of about 1 mm had occurred for 180 days' dipping.

In contrast thereto, in the case of a test piece as a comparative example, associated with Japanese Non-examined Patent Publication No.1-225,761 mentioned above, which formed a spray coating of ZrO_2 group as the upper layer after spraying directly a cermet as the lower layer, 3 - 4 circular flaking of about 3 mm in diameter were created on the surface layer.

Also, as the result of actual use of a pot roll according to the present invention which applied three coating layers in a continuous hot-dip galvanizing line, it was recognized that although the durability was short in comparison with the result of the experimental dipping test because of external stresses by a steel belt, still, the value showed 120 days or more.

The test result of a pot roll which applied coating layers of the comparative example mentioned above by the same continuous hot-dip galvanizing line showed that circular flaking created after 24 days, and the advantage of the present invention was also recognized.

Thermal expansion coefficient of coating of each layer according to the example at normal temperature is shown in Table 2.

Table 2

Thermal expansion coefficient of coating of each layer according to the example at normal temperature	
Name of layer portion	Thermal expansion coefficient
Roll substrate of stainless group	17.5×10^{-6}
Alloy contianing Ni-Co-Cr (the first layer)	15.5×10^{-6}
Mo cermet (the second layer)	8.0×10^{-6}
Ceramic composed chiefly of partly stabilized ZrO_2 (the third layer)	5.6×10^{-6}

As mentioned above, according to the present invention the improvement in operation rate of process line become possible, because of a largely elongated life of the pot roll for a galvanizing bath, a reduced maintenance cost by reduced frequency of roll exchanges and a reduced shutdown of the line accompanied with the reduced frequency of roll exchanges.

Furthermore, exchange works of rolls performed around the molten zinc bath are dangerous because instruments are heated by heat radiation from the bath and so the atmospheric temperature becomes higher, and further it is unsteady to walk around the bath, but by the reduced frequency of roll exchanges the safety during the works may be ensured.

The improvement in operation rate of process line become possible, because of a largely elongated life of the Pot roll for a galvanizing bath, a reduced maintenance cost by reduced frequency of roll exchanges and a reduced shutdown of the line with the reduced frequency of roll exchanges.

Claims

1. A Pot roll for continuous hot-dip galvanizing used in a galvanizing bath, characterized by comprising a Pot roll surface where three spray coating layers composed of a alloy of high Co ratio or cermet of high ratio of said alloy as the first layer, a cermet containing a oxide, carbide or boride as the second layer and a ceramic of oxide group as third layer are formed in order of coating.

2. The Pot roll of Claim 1 wherein the first layer comprises Ni-Co-Cr, the second layer comprises Mo cermet and the third layer comprises ceramic containing stabilized ZrO_2.