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METHOD OF GALVANIZING A FERROUS METAL AND A GALVANIZING FLUX COMPOSITION THEREFOR

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This invention is a continuation-in-part of Application Serial No. 138,577, filed Sept. 18, 1961, now abandoned.

This invention relates to a novel method of galvanizing a ferrous metal and a novel galvanizing flux composition therefor. More particularly this invention relates to a novel flux composition in processes for coating or plating the surfaces of a high-melting point metal with a relatively low melting point metal. Still more particularly this invention relates to a process and composition for galvanizing ferrous metal to obtain a bright and flexible coating of maximum corrosion resistance.

In galvanizing ferrous articles it is a well-known expedient to employ ammonium compounds such as ammonium chloride or zinc-ammonium chloride in the flux composition. However even at minimum operating temperatures the ammonium compounds either sublime or decompose to produce decomposition products which sublime. Thus the visible smoke-like fumes formed are not only objectionable from an operating standpoint but also progressively reduce the effectiveness of the flux. Obviously if the metal bath temperature is further elevated the above mentioned difficulties are augmented. Further, the presence of ammoniacal compounds appears to cause a condition known as "black spotting" on the finished galvanized product which is objectionable.

The employment of ammoniacal compounds, such as those mentioned above, introduces the element hydrogen into the composition. These ammoniacal compounds tend to decompose at operating temperatures forming hydrogen chloride which in turn attacks the ferrous base metal, and aluminum if present, to form chlorides thereof. The iron chloride subsequently is reduced by the molten zinc metal forming a zinc-iron alloy which appears as dross. This perhaps explains the fact that zinc-ammonium chloride attacks the ferrous base metal more than zinc chloride. On the other hand when zinc chloride is used in the absence of ammoniacal compounds the formation of zinc-iron alloy dross is substantially avoided particularly in the flux compositions of this invention employed at operating temperatures not exceeding 890° F.

A further difficulty in galvanizing operations using fluxes containing ammoniacal compounds according to the prior art is that they tend to spatter with attending danger to the operators. Another difficulty in the use of fluxes containing ammoniacal compounds according to the prior art is that if the operating temperature of the molten bath is maintained near the minimum the resulting metal coating of the article is rough in contrast to a more desirable bright smooth coating. But if the bath temperature is elevated the flux decomposes and sublimes with its above mentioned attending objections together with a high consumption rate of the flux.

The serious disadvantages of the ammoniacal salt fluxes have long been recognized in the prior art. Thus the prior art does show many patented instances of the use of non-ammoniacal, principally zinc salt containing, fluxes which are most frequently intended for use following a conventional ammoniacal salt treatment. By such measures there is however not avoided the use of the often undesirable ammoniacal salt flux for which the non-ammoniacal blanket flux is not an effective substitute. The non-ammoniacal blanket fluxes of the prior art have not been heretofore found fully satisfactory in hot-dip galvanizing because of fuming problems, undesirable melting point ranges, and a failure to provide adequate coating of the base ferrous metal.

From the foregoing it is a prime object of this invention to provide a galvanizing process wherein there is used a non-ammoniacal metal-coating flux composition of low melting point and improved fluidity which overcomes the above mentioned difficulties and objections.

A further object of this invention is to provide a non-ammoniacal flux composition for metal-coating a ferrous article, said composition having a melting point critically within the range of 650° F. to 850° F., whereby the galvanizing process may be performed at higher operating temperatures, up to 890° F., without the production of visible fumes or smoke and with a substantial reduction in the formation of dross.

A still further object of this invention is to provide in a galvanizing process a flux composition for metal-coating a ferrous article, which does not spatter at operating temperatures and eliminates the formation of black spotting on the coated article.

A yet further object of this invention is to provide a fluxing process and composition for metal-coating an article which facilitates the production of a smooth bright metallic coating firmly adhered thereto.

Still another object of this invention is to provide a metal-coating flux composition and process according to the preceding objects which is particularly adapted to a process for galvanizing ferrous articles.

These and other desirable and important objects inherent in and encompassed by the invention will be more readily understood from the ensuing description and the appended claims.

In galvanizing processes the essential function of a flux is to prepare the base metal, such as iron and steel surfaces by cleansing them of foreign matter, e.g. rust, corrosion, and other foreign material or impurities, immediately prior to the application of the metal coating. Another function of the flux often used is to pre-heat the base metal prior to immersion in the coating metal bath. The term "base metal" employed herein is intended to mean the solid metal article to be coated and therefore it must obviously possess a melting point substantially higher than the flux composition used as well as the operating temperature of the molten bath of the coating metal. One known continuous galvanizing process employs a pot containing a molten zinc or zinc alloy metal bath. The pot is provided with a partition in the central portion thereof which extends below the surface of the molten metal bath. On the one side of the partition there is provided a flux blanket on the surface of the molten metal consisting of, for example, zinc-ammonium chloride, of an appreciable depth or thickness while on the other side is a relatively thin layer of the flux which serves to protect the bath metal from atmospheric oxidation. The base metal such as thin gauge steel is fed through the thick flux layer and immersed in the molten coating metal bath and thereafter emerges on the other side of the partition through the thin flux layer. As mentioned previously the use of zinc-ammonium chloride or any ammonium containing flux in such operations presents objectionable diffi-

culties, while the prior art non-ammoniacal fluxes are unsatisfactory at higher galvanizing temperatures.

Broadly, the flux composition of this invention consists of the following ingredients in terms of percentages by weight.

	Percent
Zinc chloride	55 to 70
Potassium aluminum fluoride	10 to 15
Potassium chloride	10 to 15
Sodium Chloride } Barium Chloride } Calcium Chloride }	10 to 15

The sodium chloride, barium chloride and calcium chloride are interchangeable with each other or alternately may be mixtures of any two or all three of these salts provided that the aggregate amount is within the above indicated specified range.

Any flux composition within the above specified proportional limits has a melting point of approximately 650 to 850° F., and may be used at higher temperatures without producing visible fuming or smoking and provides excellent fluxing properties. Thus in galvanizing, the metal bath may be successfully elevated to temperatures exceeding 850° F., if desired, resulting in a much smoother, brighter and uniformly applied metal coating than that obtained by known methods employing lower operating temperatures with non-ammoniacal as well as with ammonium-containing fluxes.

The function of each of the above mentioned ingredients other than to provide a non-fuming or non-smoking composition is not too well understood. It is believed, however, that the zinc chloride acts as a cleansing agent while the potassium aluminum fluoride improves fluidity or lowers the viscosity of the molten flux composition. The fluoride salt is believed to assist in preventing the zinc chloride from decomposing or converting to other zinc compounds (e.g. hydrate or oxide) such as, for example, by reaction with atmospheric constituents. In addition it is believed to act between the base metal and the molten metal of the galvanizing bath to result in a more firm adherence or coherence of a uniform metallic coating; and to prevent oxidation of aluminum metal, if any, in the molten zinc metal bath. The sodium chloride and its alternates barium chloride and calcium chloride are believed to assist in the obtaining of a true solution of the composition in the molten state or liquid phase. The over-all result, however, is a flux composition which in use will function efficiently for at least a week without change or renewal, needing only the addition of more of the composition to maintain the necessary blanket depth. On the other hand, the former zinc-ammonium compounds, must be changed or renewed at least once or more times daily to function properly.

The above mentioned proportional limits are critical because compositions outside these ranges have melting points outside the range of 650° F. to 850° F. Furthermore compositions outside the above mentioned proportional limits results in a deficiency of one or more of the above discussed functions of the specific ingredients. Thus in order to obtain satisfactory results the proportional limits of each ingredient must be strictly adhered to in accordance with the above stated critical limits. In galvanizing operations the temperature of the flux composition of this invention should in no event exceed a maximum critical temperature of 890° F. From this it can be seen that the melting point of the flux composition must not exceed 850° F. as otherwise solidification of the flux composition on the base metal may occur and thus prevent the flux from functioning and at the same time inhibit galvanizing. For example a known composition, for coating base metal with aluminum, consisting of equal proportions of sodium fluoride, zinc chloride, sodium chloride, and potassium chloride has a melting point of about 950° F. which is too high for galvanizing operations. Further if the operating temperature of the galvanizing bath is elevated sufficiently for melting such flux, the resulting coating is of poor adherence and very unsatisfactory. If the temperature of the flux composition of this invention exceeds the critical maximum temperature of 890° F. the quality of the galvanizing coat deteriorates and also increased dross formation.

From my experiments it appears that the presence of potassium and fluorine are essential in this invention and may not be substituted. Apparently the combination of elements present produces a synergistic effect not only from the reduced or low melting point property but also as to the improved fluxing properties.

The preferred composition of the flux of this invention is in accordance with the following proportions of ingredients expressed in terms of weight percentages.

	Percent
Zinc chloride	70
Potassium aluminum fluoride	10
Potassium chloride	10
Sodium chloride	10

The above ingredients were mixed together and heated to establish a liquid phase state. This composition melts into a liquid phase solution at about 650° F. The molten flux composition thus obtained was placed on the surface of a molten galvanizing bath forming what is commonly known as a "flux blanket" in a galvanizing pot of the kind previously described. The galvanizing bath metal consisted of an aluminum-zinc alloy, comprising about 93% by weight of zinc metal with the balance being substantially aluminum metal, which has a melting point of about 720° F. as compared with pure zinc melting at about 788° F. The galvanizing bath was maintained at an operating temperature of about 840° F. Thin gauge steel sheet as a base metal article was fed through the flux blanket of the above described composition into the molten metal galvanizing bath and emerged through a relatively thin layer of the same flux composition. The steel sheet as a result thereof, was coated with the galvanizing metal uniformly, and the coating, which was extremely bright and smooth and firmly bonded, was accomplished without the occurrence of any visible fumes emanating from the bath and with minimal dross formation. Barium chloride or calcium chloride when substituted for the sodium chloride gave similar results to that described above. Likewise a mixture of equal quantities of sodium chloride, barium chloride and calcium chloride, substituted for sodium chloride in the flux composition, gave comparable results. It was also observed that in the course of a typical galvanizing run the flux consumption was only 1.8 pounds when the above described composition was used for the flux blanket whereas in the case of the conventional zinc-ammonium chloride flux used for a like galvanizing run slightly more than 3 pounds of the flux was consumed. This indicates a reduction of about 40% in the amount of flux consumption when my improved composition is employed.

It will be noted that in the above described galvanizing process, an operating temperature considerably higher than that customarily used in the prior art was employed. It was also found that the rate of movement of the sheet steel could be substantially increased if it is heated immediately prior to its entry in the flux blanket. Furthermore since higher operating temperatures are employed desirably with the flux composition of this invention, it is often desirable to employ a heating insulating material which floats upon the surface of the flux blanket. The insulating media should of course be selected from materials which possess a density less than the flux composition, chemically unreactive therewith and be substantially insoluble therein. Such an insulating media also prevents adverse effects of the atmosphere on the galvaniz-

ing metal and the flux composition. For this purpose I have successfully employed fuller's earth in amounts up to 20% by weight of the flux composition used. Clays or the like having similar characteristics to fuller's earth, or talc may likewise be employed for such purpose.

Particularly at higher operating temperatures but not exceeding 890° F. it is sometimes found that the viscosity of the flux composition is too low. When this occurs it was found that for each pound of flux composition of this invention up to 0.16 pound, or up to about 16% of the flux composition, of magnesium chloride could be added thereto for increasing the viscosity thereof without substantially reducing the efficiency of the flux composition. The amount of magnesium chloride added of course depends upon the operating temperatures and the desired viscosity.

Having now described a preferred embodiment of the process of the invention it can be seen that the objects thereof have been fully achieved and it must be understood that changes and modifications may be made which do not depart from the spirit of the invention nor from the scope thereof as defined in the appended claims.

What is claimed is:

1. A method of galvanizing a ferrous metal article which comprises the steps of introducing the article into a molten intimately mixed inorganic composition comprising about 55% to about 70% by weight of zinc chloride, from about 10% to about 15% by weight of potassium aluminum fluoride, from about 10% to about 15% by weight of potassium chloride, and from about 10% to about 15% by weight of a halide salt of at least one metal selected from the group consisting of alkali metals and alkaline earth metals, said composition having a melting point between 650° F. and 850° F., withdrawing the article from the molten inorganic composition, introducing the article into a bath of molten zinc and withdrawing the article from the zinc bath.

2. A process for galvanizing a solid ferrous metal article at temperatures in excess of 720° F. and not exceeding 890° F. with fused metal-containing metallic zinc as a major constituent thereof comprising the introduction of the article into a bath of molten zinc through a molten salt blanket floating thereupon, said molten salt blanket comprising about 55% to about 70% by weight of zinc chloride, from about 10% to about 15% by weight of potassium aluminum fluoride, from about 10% to about 15% by weight of potassium chloride, and from about 10% to about 15% by weight of at least one salt selected from the group consisting of sodium chloride, barium chloride, and calcium chloride, said composition having a melting point between 650° F. and 850° F., and withdrawing the article from the fused metal bath.

3. A process according to claim 2 wherein the molten salt further comprises magnesium chloride in an amount not greater than about 16% by weight of the said composition.

4. A process for galvanizing a solid ferrous metal article at temperatures in excess of 720° F. and not exceeding 890° F. with fused metal containing metallic zinc as a major constituent thereof comprising the steps of introducing said article into a molten intimately mixed inorganic flux composition comprising about 70% by weight of zinc chloride, about 10% by weight of potassium aluminum fluoride, and about 10% by weight of potassium chloride, said composition having a melting point between 650° F. and 850° F., and introducing said article from the molten salt bath into a bath of the fused metal, and withdrawing the article from the fused metal bath.

5. A process according to claim 4 wherein the molten salt further comprises a quantity of magnesium chloride in an amount not greater than about 16% by weight of the said composition.

6. A galvanizing bath for galvanizing a solid ferrous metal article at temperatures not exceeding 890° F., with fused metal containing metallic zinc as a major constituent thereof, said bath comprising said fused metal and as a separate layer of density less than said fused metal an intimately mixed inorganic composition comprising about 55% to about 70% by weight of zinc chloride, from about 10% to about 15% by weight of potassium aluminum fluoride, from about 10% to about 15% by weight of potassium chloride, and from about 10% to about 15% by weight of a halide salt of at least one metal selected from the group consisting of alkali metals and alkaline earth metals, said composition having a melting point between 650° F. and 850° F.

7. A bath for galvanizing a solid ferrous metal article at a temperature of at least 720° F. and not exceeding 890° F. with fused metal containing metallic zinc as a major constituent thereof, said bath comprising said fused metal and as a molten separate layer thereupon a molten intimately mixed inorganic flux composition comprising about 55% to about 70% by weight of zinc chloride, from about 10% to about 15% by weight of potassium aluminum fluoride, from about 10% to about 15% by weight of potassium chloride, and from about 10% to about 15% by weight of at least one salt selected from the group consisting of sodium chloride, barium chloride, and calcium chloride, said composition having a melting point between 650° F. and 850° F.

8. A galvanizing bath according to claim 7 further comprising magnesium chloride in an amount not greater than about 16% by weight of said flux composition.

9. A galvanizing bath for galvanizing a solid ferrous metal article at temperatures in excess of 720° F. and not exceeding 890° F. with fused metal containing metallic zinc as a major constituent thereof, said bath comprising said fused metal and as a molten layer thereupon a molten intimately mixed inorganic flux composition comprising about 70% by weight of zinc chloride, about 10% by weight of potassium aluminum fluoride, and about 10% by weight of potassium chloride, said flux having a melting point between 650° F. and 850° F.

10. A galvanizing bath according to claim 9 further comprising magnesium chloride in an amount not greater than about 16% by weight of said flux compostion.

11. A flux for galvanizing a solid ferrous metal article at temperatures not exceeding 890° F. with fused metal containing metallic zinc as a major constituent thereof, said flux being an intimately mixed inorganic composition comprising about 55% to about 70% by weight of zinc chloride, from about 10% to about 15% by weight of potassium aluminum fluoride, from about 10% to about 15% by weight of potassium chloride, and from about 10% to about 15% by weight of at least one salt selected from the group consisting of sodium chloride, barium chloride, and calcium chloride, said composition having a melting point between 650° F. and 850° F. and being substantially non-fuming at temperatures not exceeding 890° F.

12. A flux according to claim 11 having an increased viscosity through the addition of magnesium chloride in an amount up to about 16% by weight of said flux composition.

13. A flux for galvanizing a solid ferrous metal article at temperatures not exceeding 890° F. with fused metal containing metallic zinc as a major constituent thereof, said flux being an intimately mixed inorganic flux composition comprising about 70% by weight of zinc chloride, about 10% by weight of potassium aluminum fluoride and about 10% by weight of potassium chloride, said flux having a melting point between 650° F. and 850° F. and being substantially non-fuming at temperatures not exceeding 890° F.

14. A flux according to claim 13 having an increased viscosity through the addition of magnesium chloride

in an amount of up to about 16% of weight of said flux composition.

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