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METHOD OF MAKING TRIMETALLIC PLATE

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1 Claim. (Cl. 29—189)

This invention relates to a metal article, and the method of making it, wherein the metal of one face has physical and chemical properties different from those of an opposite face capable of use under conditions for which the properties of either one would be unsuitable. In one application of the invention the article may be a metal plate, the major thickness of which has one set of properties and the minor thickness another set, but with a transition zone as to properties making separation impossible and making the plate a unitary structural element in resisting use forces.

The invention is especially suitable as an element of a stressed structure subject to corrosion influences on a face, particularly such as the wall of a pressure vessel to contain corrosive chemicals, and more particularly when subject to changes of temperature in use, in addition the stresses due to pressure and the internal face corrosion.

Metals resistant to corrosion or attack by various chemicals of acid or alkaline character are well known but many of them are of high cost, and may be otherwise unsuitable as stressed members in large structures subject to variable temperature, and numerous attempts have heretofore been made to provide an article having a face of such metal on the side or sides subject to attack, and with a foundation body of less expensive material and suitable otherwise for the desired structure.

One such attempt is apparent in the United States patent to A. E. Gillespie 1,306,690, issued June 17, 1919, wherein chrome alloy steel and mild steel are united by rolling, hammering or forging when hot. Another process or method is that wherein a clad plate is formed with corrosion resistant material on one side by first forming a sandwich of two corrosion resistant alloy plates permanently separated by a suitable intervening compound, casting base metal on either side of the sandwich, rolling a billet thus formed into plate thickness at a forging heat, separating it at the original permanent division between the alloy plates and thus arriving at two sheets, each composite with its respective cladding of corrosion resistant metal.

By still another method a sandwich is formed from a low priced steel base metal and an alloy cladding metal with an intervening thin uniting sheet of low carbon steel; the peripheral edges of the sandwich are then first united by fusion welding and the whole then rolled under forging heat and pressure until a composite plate is formed.

However, all of these clad plates made by the methods heretofore known have failed in use by local ruptures of the bond between the cladding and the base metals with consequent deterioration and loss of utility. The present invention does not fail in service and retains its utility indefinitely because it is an integral metal mass which while different as to properties on opposite faces is insured, by the method of making, against too abrupt a change in these properties in a juncture zone, earlier ones having failed because one metal composition changed to the other too abruptly without an adequate transition zone.

Another object is to select two different metals of such commensurate physical, chemical and other metallurgical properties, for example one for resisting stress, and the other for resisting corrosion, that when combined according to this invention a tough, ductile product with a minimum of local stress at the junction is the result, whereby, in subsequent working, forming and the like, or in service, there is no separation or cracking of the one with respect to the other due to local over-stress failure.

A further feature of this invention is that the different metals are so selected and combined originally that subsequent rolling action under heat only serves to increase the integrality of the union between the different metals, and to preserve the width of the transition zone sufficient to avoid local stresses that the metal carriers resist, especially those due to unequal expansion.

Additionally, by reason of the method employed, the amount of expensive corrosion resisting metal used for the surfacing of the article is much less than with other methods due to the fact that rolling to ultimate form may be carried to such an extent, by reason of the integrality of the bond and consequent lack of stress at the junction with elimination of liability to cracking and separation, that the final cladding may be of only just sufficient thickness of the cladding metal as to afford resistance to chemical action.

Another feature of the invention is the uniting of the different metals at a temperature for each which represents superheating the same, namely, a temperature above the melting point and under conditions producing a junction free of porosity and non-metallics initially in the molten state at the junction.

In executing the method of the invention one article which may be made, and from which other articles may then be formed, is a flat plate having one face of one metallic composition and the opposite face of another metallic composition with a gradation at the juncture between the different metals of the composition and properties of the metal of one face to the composition and properties of the metal of the other face in the zone between the two faces, and which holds true whether opposite faces are of like or different metals and the depth of which gradation zone is never zero but always adequate to avoid such excessive local stresses as might cause fracture.

A feature of the invention is the combination of different metals into an integral plate such that the gradation of metals and the corresponding gradation of physical properties, like coefficients of expansion, are so related as to avoid locally high concentration of stresses, a condition which accounts for the disintegration of the unity of the hereinbefore referred to composite plates and cracking of the resistant metal.

In detail, the invention, irrespective of the different types of metals combined, embraces the selection of a starting or foundation piece of base metal of adequate size and thickness for the ultimate article, which ultimate article in the present instance I shall assume to be a finished plate of metal to be protected on one side with a resistant metal suitable for the wall of a pressure vessel, and the selection of a resistant alloy, of commensurate physical and chemical properties to resist corrosion attack of the vessel's contents, for fusion welding thereto.

Upon the face of the foundation piece or base metal there is deposited a coextensive covering of the corrosion resisting metal, the deposit being made by fusion welding, preferably with the electric arc, and preferably from a bare electrode with the arc shielded either by powdered flux, a gaseous envelope, or both developing a shield, or a properly coated rod might be used. The deposit is made in such a manner as to produce intersecting beads side by side from either a gang head with properly spaced weldrod holders, or with any other suitable arrangement, and if single beads are not sufficient, with a high rate of deposit, to give the desired thickness of resistant metal, the first deposit may be followed by another overlying deposit of intersecting beads perhaps advantageously before the first have had an opportunity to cool below a critical temperature. With some metals, and with some sizes of electrodes and current values for the rate of deposit employed, it has been found desirable to maintain the whole base metal plate in a heated condition but below fusion temperature. The beneficial result is believed to be due to an increased solution of the one metal into the other when the face of the base metal plate is locally melted by the arc and in contact with molten weld metal. Other possible causes of the beneficial result are lessened surface tension, a consequent spreading of the deposited metal over a larger area for each bead, a higher rate of deposit for lower current densities and less irregular biting into the base metal, and a minimum vaporization of metal. In all instances the weld metal deposit is so made that there is a superheating of the metals at the juncture with consequent solution of the one into the other to the degree necessary for union; and a gradation zone of sufficient depth to avoid rupture stresses is formed. The term "superheating" as here used means heating to a temperature in excess of that at which melting occurs and at which temperature the metals themselves are both molten at the zone of contact, the weld metal being wholly melted, and the base plate metal melted only at the welding face for a limited depth.

One specific manner in which the invention has already been carried into practice, but which is only one of many which I consider within the scope of the invention, is as follows:

An 8" x 8" carbon steel billet (carbon range 0.18 to 0.25%) was rolled into a plate 4¾" thick. A section 60" long x 9" wide x 4¾" thick was cut from this billet and machined on one side in order to clean it up for fusion deposit of metal thereon.

The plate was then heated to approximately 1000° F. and layers of resistant weld metal of the following composition were fusion arc deposited in parallel intersecting beads on the machined surface, carbon .10 max., manganese .75 max., silica .50 max., chrome 17.0 to 19.0; the plate was maintained at a minimum temperature of 900° F. at all times during the welding. Deposition of the weld metal on the heated plate was by the metal arc method, using $\frac{5}{32}$" electrodes having a covering or coating producing an envelope of reducing gas shielding the arc.

When the welding had been completed the thickness of the alloy deposition was ¼" to ⅜", which required three bead thicknesses in depth. Immediately after welding the resulting plate was heat treated at 1450° F. followed by furnace cooling. The alloy side of the plate was then sand-blasted and defects removed by grinding and re-depositing wherever necessary.

The plate was then rolled hot at a forging temperature and thus reduced in thickness from 4¾", plus the thickness of the alloy deposited, to a finished rolled thickness of ⅝" and a total outside dimension of 8 ft. long x 3 ft. wide; the reduction in thickness from the original alloy clad plate being 87½% with an alloy thickness ranging between .03" and .04", with no cracks through the alloy, and a quite apparent solution of the one metal into the other at the junction, thus producing a gradation, however thin, at the junction, from the metal of one face to the metal of the other in the intermediate zone.

As previously stated the weldrods used in deposition contained 17.26% of chromium and a sample section of the deposited alloy upon analysis showed the following:

Carbon	Manganese	Silicon	Chromium
.12	.62	.22	13.27

It is to be noted that there was a loss of 4% chromium from weldrod to deposited weld metal due, in part, to oxidation, and in part to dilution with steel at the juncture. The plate described was made by a hand method of deposition with consequently wide variations in the arc length, whereas it is a part of this invention to deposit this weld metal by the automatic arc method in general use and from gang heads carrying multiple weldrods either in a single row normal to the direction of deposit, or combined with weldrods in tandem in the direction of deposit and laying one bead upon another, or with weldrods oscillated in their path of travel, but in every instance with automatic arc length regulation, and with

high enough rates of deposit to insure superheating of the metals at the junction.

The finished plate may be subjected to another heat treatment for annealing if desirable.

At the junction between the weld deposited metal and the steel of this plate described there is perfect fusion throughout and freedom from non-metallics. Decarburization of the carbon steel in the juncture is due to a migration of the carbon into the higher chromium region. Physical tests demonstrated that when a 15'' x 6'' sample of this plate is heated to 950° F. and held there for a minimum period of one hour and then water quenched, this being repeated for 18 times, and a similar sample so treated and air quenched 9 times, there is no indication of any separation between the alloy surface and the body steel, and no growth or cracking of the alloy occurred.

The heating of the base metal or foundation plate may be performed in any suitable manner as, for instance, by induction currents, and in some cases it may, advantageously, even be carried to the degree of plasticity of the metal, or it may be eliminated altogether.

With plate made according to the method of this invention there is no tendency to curl after the final rolling, as is the case with composite plates of the character referred to in the forepart of this description.

While, in the foregoing, I have described the invention as to one method of practicing it to produce the article, it is nevertheless to be considered that what is claimed as new is the combination of method steps by which an integral resistant clad metal plate is produced as against the composite plates known in the prior art, and I also claim as new the article made by such method.

I claim:

The method of forming a metal plate which consists in starting with a base metal plate and a surfacing metal each having different metallurgical properties, dissolving the surfacing metal onto the surface of the plate by the electro-fusion well depositing of the surfacing metal to form an alloy, permitting the alloyed surface material to freeze, successively repeating similar depositions of layers of the surfacing metal, with intermediate freezing until the surface layer is built up and diluted to substantially the purity of the surfacing metal, then stress annealing the tri-metallic plate thus formed and pressure reducing the plate to a selected area and thickness of the different metals, and then again stress annealing the plate.

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