

PATENT SPECIFICATION

(11) 1 496 048

- (21) Application No. 29905/75 (22) Filed 16 July 1975
(31) Convention Application No. 489143
(32) Filed 17 July 1974 in
(33) United States of America (US)
(44) Complete Specification published 21 Dec. 1977
(51) INT CL² B23K 37/06
(52) Index at acceptance
B3R 32A 37A1X



(54) WELDING BACKING TAPE

(71) We, MINNESOTA MINING AND MANUFACTURING COMPANY, a Corporation organized and existing under the laws of the State of Delaware, United States of America, of 3M Center, Saint Paul, Minnesota 55101, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improved flexible tapes useful as a backing in the fusion welding of metals, especially where the material to be fusion welded must be preheated.

In the formation of fusion-welded metal articles, particularly where the weld joints extends through a thick material, it is conventional to weld or clamp a heavy steel backing bar in place to support the weld bead and lay down the bead in two or more weld passes.

The welding process causes localized heating and cooling in the materials joined, which in turn produces (1) internal stresses, (2) distortion of warpage, and (3) coarse and variable grain size, each of which lowers the strength of the weld. The problems are particularly acute when the pieces to be joined are 20 millimeters thick or greater. Without proper preheating, the multiple passes used in joining such pieces create a stress in the weld bead where the center portion is in compression and the surfaces are in tension. In order to prevent internal stress, warpage or grain size problems during the actual welding, it is common to preheat the assembly, e.g., to 150°—200°C. for from several minutes to several hours. After the weld material has been deposited, the bar is removed by chipping and grinding, a difficult and time-consuming process. The joint is then repaired and finished by welding any cracks which are present on the side formerly in contact with the bar. This repair operation often requires the welder to operate in

cramped, awkward positions while the work piece is still hot, e.g., at 115°—150°C.

To eliminate the bar removal problems and produce a sounder weld on the backing side, a flexible welding backing tape has been used as a replacement for the metal backing bars. One such tape, described in U.S. Patent 3,372,852, is formed by coating a flexible heat-resistant backing of, for example, glass cloth or metal foil with adhesive and adhering a strip of flexible heat-resistant refractory material to the central portion of the backing. The flexible refractory strip comprises inorganic particles bonded together with a minor amount of a flexible organic binder which may contain a carbon scavenger to prevent an increase in the carbon content of the weld metal due to decomposition of organic materials present.

These flexible backing tapes can be applied over one side of a joint to be welded where they readily conform to the shape of the metal articles to be joined. The refractory strip supports the molten weld material as it is deposited during the welding operation, allowing production of a smooth-surfaced, one-pass weld. These tapes substantially eliminate the need for grinding and welding the backing side to form a smooth, sound weld.

Where a backing tape is used as in the welding of thick material, e.g., greater than 20 mm thick, the preheating is carried out with the tape in position. While the prior art tapes easily take the high temperature momentarily generated by an electric arc and hold the molten weld material in place until it begins to solidify (a period of 5—10 seconds), they have not been designed to endure extended periods of preheating, and the binder in the flexible refractory strip tends to decompose if preheated, resulting in disintegration of the flexible refractory layer. This causes an irregular surface on the weld bead in contact with the tape or even inclusion of inorganic particles in a weld. While these tapes provide a better weld than the backing bars

previously used, the occasional defects require repair and have caused some concern, especially where the welds are in high strength structural or pressure vessel applications.

The present invention provides a welding backing tape which retains all the advantages of the prior art tape but which minimizes or eliminates the inclusion of refractory inorganic particles in the weld joint.

The welding backing tape of this invention includes an elongate heat-resistant flexible tape backing coated with a pressure-sensitive adhesive and provided with a strip of flexible refractory material adhered to the backing along a central portion thereof and comprising refractory inorganic particles held together by a flexible binder, the tape further including, disposed on the surface of the strip of refractory material opposite the backing, a tacky layer of film-forming adhesive which is curable when heated to at least 150°C. The flexible backing is normally metal foil or glass cloth and the pressure-sensitive adhesive normally acrylic. The refractory particles of the central strip usually have an effective diameter of about 50–4000 microns, the binder generally representing less than about 10% of the strip by volume. The strip can, if desired, incorporate a carbon scavenger, e.g., ammonium nitrate to react with carbon generated by decomposition of any organic materials present.

The tape of this invention attains improved resistance to degradation during preheating by virtue of a layer of heat-curable adhesive on the exposed surface of flexible refractory material and preferably also incorporates a layer of glass cullet or other inorganic particles on the exposed surface of the adhesive layer.

The heat-curable adhesive used in this invention can be formed of numerous materials which at room temperatures are in a solvent-free state but which at elevated temperatures, of at least 150°C., heat cure to provide a continuous layer of resin across the top of the flexible refractory. This layer will hold the inorganic particles of the flexible refractory in position. One heat-curable adhesive which fits the requirements of this invention is a blend of nitrile rubber and a thermosetting resin system, at least 1/2 to 1/3 the weight of the resin system constituting a liquid epoxy resin. The liquid epoxy resin should be at least slowly pourable at room temperature and the thermosetting may contain in addition to the pourable epoxy resin, a reactive phenol formaldehyde resin, a resorcinol formaldehyde resin or other thermosetting materials which are

compatible with nitrile rubber and the pourable epoxy at the cure temperature. The resin system will contain means for curing the resins present, for example, where phenolic resin is present in substantial amounts the epoxy present will react with phenolic and no further curing agent will be necessary. However, if the entire system consists essentially of epoxy, a separate curing agent effective at the elevated curing temperature is included. The curing agent chosen should have little effect at room temperature so that the epoxy resin:nitrile rubber blend has a long shelf life at room temperature. One example of such a curing agent is a dicyandiamide. The resins present are preferably mutually soluble and compatible at room temperatures; however, it is essential that they be mutually soluble at the cure temperature to insure an intimate reaction between the various ingredients present.

The welding tape of this invention is placed at the back of the joint to be welded prior to preheating. As the joint is heated at 150° to, typically, 175°C. for one hour, the heat-hardening adhesive layer cures to form a thin continuous film material which holds the refractory particles in position.

A top coating of glass cullet or other inorganic particles, e.g., metal oxide spheres or pieces, can be disposed as a layer of particles on the heat-curable adhesive. The top coating protects the tacky heat-hardenable adhesive and permits easy rolling and unrolling of the tape. The particles form a smooth glaze during welding, imparting a fine finish to the weld. They also space the organic materials of the tape away from the weld, reducing the possibility that any carbon will be absorbed by the weld metal.

The inorganic particles of the top coating will generally be about 0.25–1.6 mm in size. Particles larger than about 1.6 mm are difficult to adhere to the tape, and particles smaller than about 0.25 mm provide minimal spacing between the carbon caused by decomposition of the tape in the presence of the molten weld material. A more preferred size range is about 0.4–0.8 mm particles of this size being easily adhered to the heat-curable adhesive layer and providing adequate spacings between the weld metal and refractory material. Where small particles or no particles are used, a carbon scavenger can be added to the heat-curable adhesive layer to prevent carbon transfer to the weld material.

A further understanding may be had by referring to the accompanying drawing in which:

Figure 1 is a cross-sectional view of one

embodiment of the tape of this invention; and

Figure 2 is a cross-sectional view of a joint, prior to welding, showing the tape of Figure 1 in position.

Composite tape 10 comprises backing 11 coated on one side with pressure-sensitive adhesive 12, which is protected by removable release liner 13. A self-supporting flexible strip of refractory material 14 is disposed medially along the length of the tape. A layer of a tacky, heat-curable resin 16 is disposed on the surface of refractory material 14 opposite backing 11, a layer of particulate material 17 being adhered thereover.

Figure 2 shows two pieces of metal 18 in position to be joined by welding. The tape 10 is attached to pieces 18 by positioning refractory strip 14 over the gap to be filled and adhering adhesive 12 to the pieces.

A further understanding can be had by referring to the following Example in which all parts and percentages are by weight unless otherwise noted.

Example

A pressure-sensitive adhesive was formed by mixing 62.4 parts of 1:3 styrene:butadiene rubber and 37.6 parts of 95.5:4.5 *iso*-octylacrylate:acrylic acid copolymer.

A binder was prepared by mixing 100 parts of a 60% solids rubber latex, 2 parts of a 50% aqueous solution of a 2:1 zinc dibutyldithiocarbamate:2,2'-methylene bis(4-methyl-6-tert butylphenol) blend, 165 parts of a 55% aqueous ammonium nitrate solution, 3 parts sodium sulfonate, 15 parts casein, and 9 parts NH_4OH .

A heat-hardenable adhesive was made. First, a base was formed by blending 5 parts of a 57:43 butadiene:acrylonitrile copolymer (commercially available under the registered trademark designation "Hycar" 1001X), in a Banbury mixer for approximately one minute and sheeting the blend on a mill until a smooth homogeneous mixture having a Mooney viscosity of approximately 85-90 was obtained. Five parts of the base was placed in a paddle type churn, 7.5 parts of "Epon" 828, 2.5 parts "DER-511", 25 parts fumaric acid curing agent and 19.5 parts methyl ethyl ketone added, and the mixture blended to a viscosity of about 5,000-10,000 cps. "Epon" 828 is a condensation product of epichlorohydrin and bisphenol "A" having a specific gravity of 1.16, an average molecular weight of approximately 340 and an epoxy equivalent of 170 grams per 16 grams of oxirane oxygen. DER-511 is a brominated epoxy resin having a specific gravity of 1.4, an average molecular weight of approximately

960 and weighing 480 grams per gram equivalent of oxirane oxygen.

The resultant uniform adhesive composition was coated on a silicone-treated paper liner in an amount sufficient to provide 31 g/m². The solvent was evaporated by heating for about 20 minutes in a warm air oven at about 65°C. and a non-woven web formed from 60% 3-denier rayon fibers, 20% 1-1/2-denier rayon fibers, and 20% nitrile rubber binder having a thickness of 75-100 microns and weighing 21 g/m² laminated to the tacky surface. The exposed surface of the non-woven web was then coated with the uniform adhesive composition in an amount sufficient to provide a total coating of 63 g/m² and the solvent again evaporated to form a heat-hardenable tacky adhesive film.

A strip of soft aluminum foil about 5 cm wide and 75 microns thick was coated on one side with a layer of the pressure-sensitive adhesive about 50 microns thick.

One hundred parts of glass cullet, 150 to 1000 microns in size having an average particle size of about 800 microns, and 5 parts of the latex binder were mixed, cast into a strip about 6 mm. thick about 19 mm. wide and dried. The resulting flexible refractory strip was adhered to the central portion of the pressure-sensitive adhesive coated aluminum foil, leaving a strip of adhesive along each edge of the tape. The exposed pressure-sensitive adhesive was covered with a strip of treated crepe paper release liner to protect it from contamination.

The tacky, heat-hardenable adhesive film was superposed over the flexible refractory layer and pressed lightly to form a laminated structure.

The exposed tacky adhesive surface was detackified to improve handling properties by dropping glass cullet having a diameter range of about 0.4-0.8 mm., onto the heat-hardenable resin and blowing the excess of the strip. The final tape was similar to that shown in Figure 1 and was surfaced with a layer of cullet weighing about 13 grams per running meter of tape.

The tape of this example was placed at the back of a butt weld joint in about 19 mm. thick mild steel plates and the assembly heated to 175°C. for about one hour. The plates were welded using conventional arc welding techniques, producing sound welds free from inclusions of refractory particles.

WHAT WE CLAIM IS:-

1. A welding backing tape including an elongate heat-resistant flexible tape backing coated with a pressure-sensitive adhesive and provided with a strip of flexible refractory material adhered to the



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backing along a central portion thereof and comprising refractory inorganic particles held together by a flexible binder, the tape further including, disposed on the surface of the strip of refractory material opposite the backing, a tacky layer of film-forming adhesive which is curable when heated to at least 150°C.

2. A tape according to Claim 1, wherein the backing consists of a sheet of glass cloth or metal foil.

3. A tape according to Claim 1 or Claim 2, wherein the film-forming adhesive has a layer of inorganic particles disposed thereon.

4. A tape according to Claim 3, wherein

the refractory particles of said layer are 0.25 to 1.6 millimetres in diameter.

5. A tape according to Claim 4, wherein the refractory particles of said layer are 0.4 to 0.8 millimetres in diameter.

6. A welding backing tape according to Claim 1 and substantially as herein described.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1977.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

