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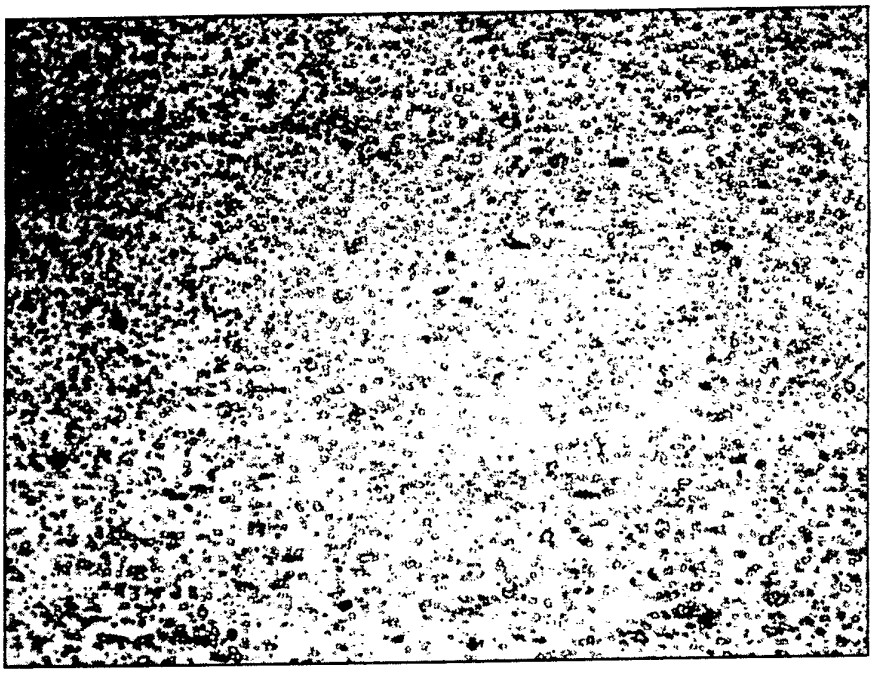

(57) Abstract

A method of joining materials by causing relative, frictional movement between respective surfaces of the materials while the materials are urged together, for example friction welding or friction surfacing. In this method, at least one of the surfaces is treated with an agent, either an active agent or a scouring agent, to remove contaminants.

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JOINING MATERIALS

The invention relates to methods of joining materials by causing relative, frictional movement between respective surfaces of the materials while the materials are urged together. Such methods are involved in friction welding and friction surfacing in which a first component in relative motion either rotary (including orbital) or oscillatory (eg.linear) is caused to bear against a second component so as to join to it via a plasticised intermediate layer which is developed due to the relative motion under applied load. The two components may be of similar or different metals or alloys. The invention applies for example to both continuous drive and so-called inertia friction welding processes as utilised for joining materials together in well known rod or tube form, or in a stud to plate configuration (including friction surfacing), or in a ring to cylinder format as in radial friction welding.

Friction welding is well known as a solid phase process in which a plasticised layer is developed (between the components to be joined), which layer is maintained at an elevated temperature less than the melting point by the work done in rapid shear within the plasticised layer. Therefore unlike fusion welding there is less opportunity for surface contaminants and oxides to be dispersed (as occurs nevertheless in arc welding with a molten pool). However in friction welding of similar components of similar materials there is deformation of the mating surfaces such that surface contamination is largely eliminated, especially in friction welding bars or rods where on arrest the components are forged further displacing the original interfaces.

However with dissimilar materials, particularly where one material does not flow appreciably, there is less opportunity for removal of contaminates or oxides from the material for which displacement is negligible. Frequently this limits the range of operating conditions which are

found to be suitable for joining dissimilar metals or alloys. This problem is particularly evident in friction surfacing, where virtually no material is displaced from the surface of the component on to which the consumable member or other component is being deposited.

In the past, surfaces have been degreased or machined which reduces certain contaminations but does not for example eliminate the oxide layer which forms naturally on metals and their alloys. In other proposals one of the surfaces has been plated with a suitable intermediary material to which the deposited material or component to be friction welded is joined. This is also unsatisfactory in introducing yet another material into the joint.

In accordance with the present invention, a method of joining materials by causing relative, frictional movement between respective surfaces of the materials while the materials are urged together is characterised in that at least one of the surfaces is treated with an agent to remove contaminates.

The invention is primarily concerned with treating the surface of one material (generally that one which does not flow significantly, or as much as the other, under the conditions of operation) with an agent so as to modify the properties of the surface and improve the bonding via the plasticised layer to the other component.

In some examples where the agent is an active agent, the agent is preferably activated or energised by the frictional movement itself. The active agent may comprise a powder, paste, liquid, or gaseous atmosphere and is used to etch or dissolve a surface layer of the material to which it is applied to reduce or eliminate the natural oxide or other surface contaminate.

An example of a suitable paste is a flux compound Murex Aluminium Welding Saffire Flux such as is used in oxygas welding of steels. This flux may be pasted on to the metal or alloy to which a component is to be joined as in friction welding or a surface applied as in friction

surfacing. At the elevated temperature of the friction welding process the flux is activated and chemically attacks the surface but as the friction welding or surfacing operation progresses it is dispersed so as not to remain as a barrier between the components to be joined. The beneficial action of this flux is illustrated in an extreme case of depositing an aluminium member onto a similar aluminium plate by friction surfacing, where the interface region is no longer apparent where the flux paste has been applied, prior to friction surfacing to the substrate material.

In some cases, the surface treatment by an active agent may be carried out prior to the frictional joining process, the surface being protected by suitable means from significant further contamination or oxidation until the joining process is completed. For example, the material to be surfaced may be etched in a suitable chemical re-agent and then friction welded or surfaced in the presence of the etchant or alternatively under a protective fluid layer (such as oil or water) or gaseous protection such as an inert gas or non reactive gas such as argon or nitrogen respectively. Sodium Fluoride may be used for stainless steel and nickel based alloys. The objective of the flux or etchant is to reduce the contaminated or oxide layers on the material such that the friction welding or friction surfacing process is more effective and higher bond strengths are achieved, even though one component is virtually not contributing directly to the plasticised intermediate layer which is formed.

Preferably, the active agent is removed at least on completion of the joining process.

The plasticised material (which is largely developed by the consumable member) is at a sufficient temperature and pressure, together with relative movement, to disperse the active agent (if still present while frictioning) so as to effect a reliable joint.

Examples of application are the use of fluxes for the friction surfacing of aluminium and its alloys, and similar materials with a tenacious oxide film and in the joining of soft materials to hard materials as in the friction bonding of copper and its alloys, or other suitable soft materials, to a steel cylinder as in the case of shell banding.

The above examples relate to active, chemical type agents for treating the surface of the substrate. However, according to another aspect of the invention physical (non-active) type agents or agents not necessarily relying on chemical action can be utilised. For example one well known problem is in friction welding or friction surfacing to cast iron type materials, due to smearing or spreading of the carbon content across the interface - thereby reducing the friction and associated heating produced at the interface, and causing the intermediate layer to be generated which prevents or reduces the effective bonding.

In such cases a scouring agent may be added to the consumable in a sufficient quantity to assist in the break up of any such free carbon layer, but not so much as to interfere significantly with the joint to be established. For example in attempting to bond a stainless steel consumable member to a spheroidal graphite iron substrate in a friction surfacing operation normally weak or virtually no adhesion is obtained. However by adding as little as 5% or less of ceramic such as alumina (for example as used in grit blasting with random sized particles of 200 micron or less), a reasonably strong bond is achieved.

This technique may also be used to improve the bonding in for example friction surfacing of coated substrates. Thus commonly in friction surfacing galvanised steel difficulty is experienced in generating sufficient friction at the interface due to the low frictional properties of the zinc layer which is smeared across the surface by the frictioning action. Here again suitable particulates may

be used, such as alumina or silica, for reducing or dispersing the coating layer of low frictional properties.

The scouring agent may be distributed through out the cross section of the consumable member as for example in an MMC type material. However, to reduce any unwanted scouring material in the region of the interface it is preferable for the scouring agent to be concentrated towards a periphery of a consumable.

The materials to be deposited in friction surfacing include metals and their alloys, and compound materials formed of metals and non-metals such as metal matrix composites (MMC).

Active agents both chemical and physical according to the invention may conveniently be incorporated in the consumable member by means of inserts and the like in holes in the consumable members. Such holes may be filled with powders or pastes or flux cored wires and so forth to provide active chemicals for reducing surface oxides or other contaminants and to provide active physical agents for cleaning or scouring surfaces, either separately or in combination.

Some examples of a method according to the invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 illustrates the interface between E1B and S1B aluminium produced using one example of the invention;

Figure 2 illustrates the results of friction surfacing of stainless steel on to a spheroidal graphite iron substrate; and,

Figure 3 is a magnified version of Figure 2.

Figure 1 illustrates the result of providing an E1B aluminium surface on a S1B aluminium substrate, at x500 enlargement. In this process, a Murex Aluminum Welding Saffire Flux was provided as a paste on the aluminium substrate and a conventional friction surfacing process was then carried out. During this process, the flux was activated and chemically attacked the surface of the

substrate as described earlier. However, during the process, the flux is dispersed resulting, as seen in Figure 1, with an absence of any discontinuity or lack of bond in the vicinity of the interface.

Figure 2 illustrates the result of providing a stainless steel deposit on a spheroidal graphite (SG) iron substrate. In this case, a consumable member of stainless steel was provided containing less than 5% ceramic (alumina). As can be seen in Figure 2, the deposit is bonded to the SG iron base over most of the cross section of the deposit although the outer edges are not bonded as is well known in friction surfacing without recourse to techniques to increase the pressure at the edges.

Figure 3 shows the interface of Figure 2 at higher magnification where the stainless steel layer exhibits no continuous discontinuity between itself and the substrate. The free carbon layer is clearly broken up giving satisfactory bond strength between the stainless steel deposit and the SG iron substrate. It is also noted that the alumina particulate in the consumable member is also dispersed and does not form a barrier between the stainless steel and the SG iron.

A suitable form of particulate bearing member can be produced from bar stock with an insert containing the desired scouring agent, preferably set towards the periphery of the member. For example with a 25mm diameter bar, the insert may be a bore of 3mm or even 4mm diameter at some 8-9mm from the centre, giving a relative cross section of less than 2% and less that 3% respectively of that of the bar.

Other examples of applications of this technique include stud welding through a rust covered substrate and friction seam welding.

CLAIMS

1. A method of joining materials by causing relative, frictional movement between respective surfaces of the materials while the materials are urged together characterised in that at least one of the surfaces is treated with an agent to remove contaminates.

2. A method according to claim 1, wherein the agent is an active agent.

3. A method according to claim 2, wherein the agent is activated or energised by the frictional movement itself.

4. A method according to claim 2 or claim 3, wherein the active agent comprises a powder, paste, liquid, or gaseous atmosphere.

5. A method according to any of claims 2 to 4, wherein the active agent etches or dissolves a surface layer of the material to which it is applied to reduce or eliminate the natural oxide or other surface contaminate.

6. A method according to any of claims 2 to 5, wherein the surface treatment is carried out prior to the frictional joining process, the surface being protected from significant further contamination or oxidation until the joining process is completed.

7. A method according to claim 6, wherein following treatment by the active agent, the surface is protected in a suitable protective fluid or gaseous atmosphere.

8. A method according to any of claims 2 to 7, wherein the active agent is removed at least on completion of the joining process.

9. A method according to claim 1, wherein the agent comprises a scouring agent.

10. A method according to claim 9, wherein the scouring agent is incorporated into a consumable member for use in the friction surfacing process.

Fig.1.

Fig. 2.

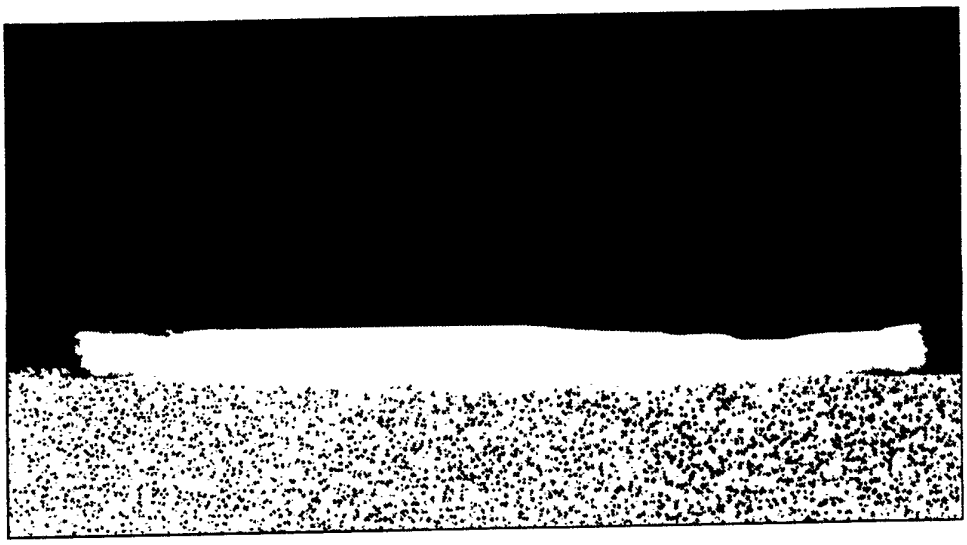
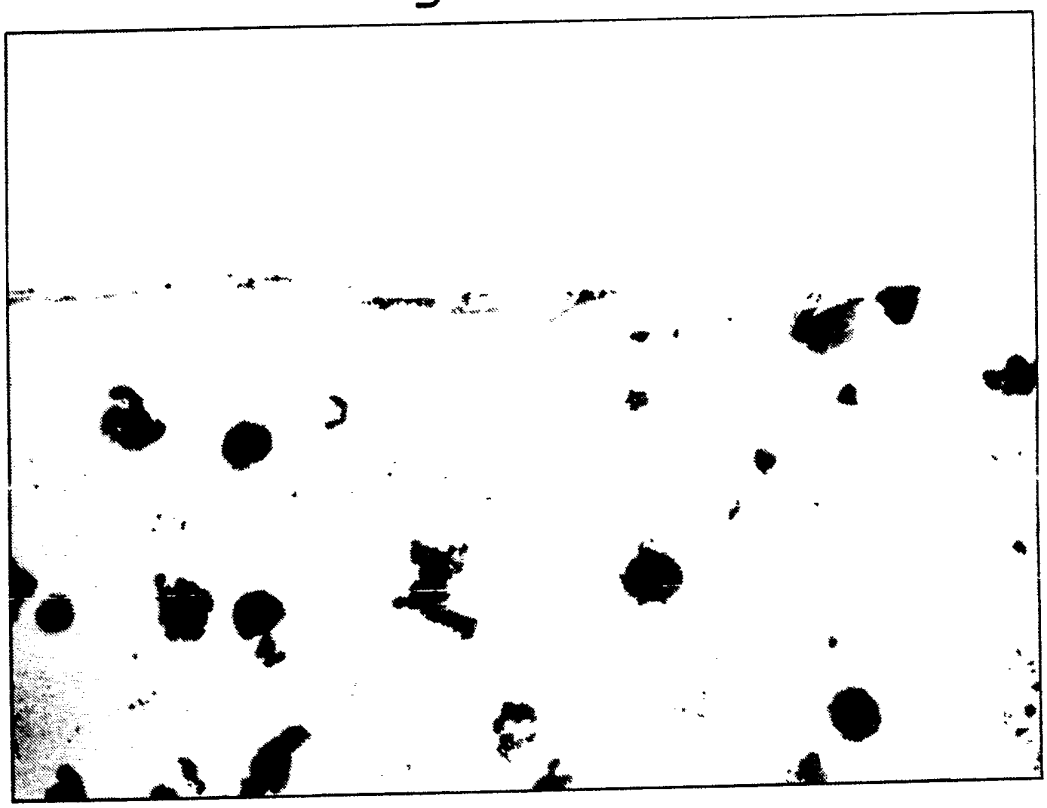


Fig. 3.



INTERNATIONAL SEARCH REPORT

PCT/GB 91/01396

International Application No

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 B23K20/12

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	B23K

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	DE,A,2 003 479 (CATERPILLAR TRACTOR CO.) 6 August 1970 see page 8, paragraph 2 see page 10, paragraph 2	1,2,4-6
X	DE,A,3 906 582 (KERNFORSCHUNGSANLAGE JÜLICH GMBH) 12 April 1990 see the whole document	1,2,4-7
X	DE,A,2 012 139 (CATERPILLAR TRACTOR CO.) 5 November 1970 see page 6, last paragraph - page 7, paragraph 1	1,2,4-6
X	DE,A,3 838 572 (VEB KOMBINAT POLYGRAPH WERNER LAMBERZ) 24 May 1989 see the whole document	1,2,4-7

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
12 DECEMBER 1991	17. 12. 91

International Searching Authority	Signature of Authorized Officer
EUROPEAN PATENT OFFICE	ARAN D.D.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	FR,A,2 469 241 (GOETZE AG) 22 May 1981 see the whole document	1-4

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9101396 SA 50500

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 12/12/91
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		FR-A- 2031176	13-11-70
		GB-A- 1292731	11-10-72
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		GB-A- 1281607	12-07-72
DE-A-3838572	24-05-89	None	
FR-A-2469241	22-05-81	None	