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(54) Title: WELDING FLUX AND WELDING METHOD

(57) Abstract: A flux is provided which comprises CaF_2, MgF_2 and Li_3AlF_6, and which contains additionally at least one fluoride selected from the group consisting of SrF_2 and BaF_2. The flux or a flux composition which comprises the flux and certain additives, e.g. a liquid carrier and/or a binder, is especially suitable to be used in a method for welding parts of aluminum or aluminum alloy, especially using a fuel/oxygen flame to provide heat. A preferred fuel is acetylene.

WELDING FLUX AND WELDING METHOD

This application claims priority to European application No. 14160610.3, the whole content of this application being incorporated herein by reference for all purposes.

The invention concerns a flux which is useful for welding of parts of aluminum or of aluminum alloys and a method of welding.

Parts of aluminum or parts of aluminum alloys, e.g. aluminum alloys containing magnesium, are used, for example, for the construction of machinery like vehicles. To joint such parts, the parts are assembled. A flux may be applied and the parts to be joint are, preferably, locally heated to melt a part of the aluminum or the alloy to obtain a stable joint. The heat can be applied, for example, by irradiation with a laser light, by applying electric energy, e.g. in the form of a light arc, or by using an oxygen acetylene flame to provide heat. The latter method can be supported by a wire providing solder metal, often being aluminum.

A flux is known which is suitable for oxyacetylene welding of aluminum which flux comprises CaF_2, MgF_2, BaF_2 and LiF. LiF is considered as hazardous.

Object of the present invention is to provide a flux having a content of LiF which is lower than in known fluxes, and preferably, to provide a flux which is essentially free of LiF suitable for welding of aluminum or aluminum alloys to aluminum or aluminum alloys. Another object of the present invention is to provide a method for welding of aluminum or aluminum alloys to aluminum or aluminum alloys, especially for application using an oxygen acetylene flame. These and other objects are provided by the flux and the method as outlined herebelow.

A first aspect of the present invention relates to a flux which is suitable for welding of aluminum or aluminum alloys to aluminum or aluminum alloys.

The flux of the present invention comprises CaF_2, MgF_2 and Li_3AlF_6, and it further comprises at least one fluoride selected from the group consisting of SrF_2 and BaF_2 and optionally LiF, with the proviso that, if LiF is comprised, the weight ratio between LiF and Li_3AlF_6 is in a range of from 1:1 to 1:99. If LiF is comprised, the weight ratio between LiF and Li_3AlF_6 is preferably in a range of from 1:3 to 1:99, and most preferably, in a range of from 1:9 to 1:99.

While the flux may contain both SrF_2 and BaF_2 it is preferred that it contains only BaF_2.

The flux is especially suitable for autogenous welding of aluminum parts or aluminum alloy parts to aluminum parts or aluminum alloy parts using a mixture of oxygen or air and a flammable gas, especially an oxygen acetylene (also denoted as oxy acetylene) flame, to provide heat, and using a wire to provide solder metal, especially using an aluminum wire. But the flux may also be used for laser welding or arc welding of said parts.

The term “comprising” and “containing” include the meaning of “consisting of”.

Preferably, the flux is essentially free of LiF. The term “essentially free” preferably denotes a content of LiF which is equal to or lower than 0.5 % by weight, and more preferably, is equal to or lower than 0.2 % by weight. Especially preferably, the content of LiF is equal to or lower than 0.1 % by weight, including 0 % by weight. Any percentages relating to the content of CaF_2, MgF_2, Li_3AlF_6, LiF and SrF_2 relate to the total weight of the dry flux.

In one embodiment, the flux comprises CaF_2, MgF_2, Li_3AlF_6, and SrF_2. The flux, in this embodiment, contains no BaF_2. SrF_2 provides a red light during brazing which, from some users, may not be appreciated.

In another embodiment, the flux comprises CaF_2, MgF_2, Li_3AlF_6, and BaF_2.

Preferably, the content of CaF_2 in the flux is in a range of from 5 to 20 % by weight.

Preferably, the content of MgF_2 is in a range of from 15 to 30 % by weight.

Generally, the flux comprises an effective amount of Li_3AlF_6. Often, the content of Li_3AlF_6 is equal to or greater than 2 % by weight, preferably, equal to or greater than 5 % by weight. More preferably, it is equal to or greater than 10 % by weight. Even more preferably, the content of Li_3AlF_6 is equal to or greater than 20 % by weight. Especially preferably, the content of Li_3AlF_6 is equal to or greater than 30 % by weight. Often, the content of Li_3AlF_6 is equal to or lower than 65 % by weight. Preferably, the content of Li_3AlF_6 is equal to or lower than 60 % by weight. In a preferred aspect, the content of Li_3AlF_6 is in a range of from 30 to 60 % by weight. If LiF is contained, then the sum of LiF and Li_3AlF_6 is preferably in a range of from 30 to 60 % by weight.

Preferably, the content of SrF_2 if no BaF_2 is present, or of BaF_2 if no SrF_2 is present, or, if both are present, the content of the sum of SrF_2 or BaF_2 is in a range of from 15 to 35 % by weight.

Preferably, BaF_2 is present, and the content of BaF_2 is equal to or lower than 28 % by weight.

A preferred flux comprises 5 to 20 % by weight of CaF_2, 15 to 30 % by weight of MgF_2, 30 to 60 % by weight of Li_3AlF_6 and 15 to 35 % by weight of BaF_2. A more preferred flux comprises 5 to 20 % by weight of CaF_2, 15 to 30 % by weight of MgF_2, 30 to 60 % by weight of Li_3AlF_6 and 15 to 28 % by weight of BaF_2. Preferably, the LiF content of these preferred fluxes is equal to or lower than 0.5 % by weight, more preferably, equal to or lower than 0.2 % by weight, and especially preferably, the flux is essentially free of LiF. In certain embodiments, the fluxes consist of said fluorides. In other embodiments, the fluxes consist of said fluorides and are essentially free of LiF.

Preferably, the flux is in the form of a powder. The particle size is variable.

Preferably, the particles have a diameter such that 99 % or more of the particles have a diameter of equal to or lower than 100 μm, preferably of equal to or lower than 50 μm.

The flux is useful as coating on metallic rods or sticks which serve as filler metal, and the resulting coated electrode is especially useful for shielded metal arc welding.

Preferably, the flux is used in processes in which metallic parts, especially parts made of aluminum or aluminum alloys, are joint under the application of heat. In the following, it is described how the flux is preferably applied to at least one of the parts, or to the parts, respectively, to be joint.

The flux may be applied as such onto parts to be joined, e.g. by pneumatic transport and electrostatic forces.

Alternatively, the flux may be applied in the form of a composition which comprises additives providing useful properties in methods of using the flux.

If it is intended to apply the flux in the form of a flux composition, the composition preferably comprises the flux and at least one liquid carrier and/ or at least one binder. The liquid carrier allows a wet application of the flux. The binder increases the viscosity of a wet flux composition and the adhesion of a dry flux composition to the parts.

In one embodiment, the flux composition of the present invention comprises the flux and any additive, if present, being dispersed in an organic carrier to form a flux slurry. The organic carrier is e.g. a monobasic alcohol, for example, ethanol or isopropanol, or a dibasic alcohol, for example, glycol. The disadvantage of organic carriers is the flammability unless the flux composition is dried after application on the parts.

Thus, preferably, the carrier is water or an aqueous composition and more preferably, water. The term "aqueous composition" denoted mixtures of water and organic liquids miscible with water, e.g., alcohols or ketones.

Preferably, the flux composition is aqueous slurry, a paste based on an aqueous carrier or a flux composition comprising a binder, especially for pre-fluxing.

The flux of the present invention is contained in the composition in an amount equal to or greater than 20 % by weight, preferably equal to or greater than 30 % by weight of the total flux composition. Preferably, the content of the flux of the present invention in the flux composition is equal to or lower than 70 % by weight of the total flux composition.

According to one embodiment, the flux composition is an aqueous composition in the form of a suspension comprising or consisting of a flux, water and a binder. This flux composition can be used for any wet application of the flux, and preferably, it is used for pre-fluxing. In this flux composition, the flux of the present invention is preferably contained in an amount equal to greater than 20 % by weight of the total weight of the flux composition. Preferably, the content of the flux is equal to or lower than 50 % by weight of the total flux composition. The binder is preferably contained in an amount of equal to or greater than 0.1 % by weight, more preferably, 1 % by weight of the total flux composition. Preferably, the content of binder is equal to or lower than 30 % by weight, preferably equal to or lower than 25 % by weight, of the total flux composition. The balance to 100 % by weight is an aqueous carrier consisting of water or containing water and a water-miscible organic liquid as defined above. Preferably, the aqueous carrier consists essentially of water also in this embodiment.

The flux composition may comprise the flux, water, a binder, a thickener and optionally additives which facilitate the brazing process or improve the brazed parts. The thickener may also provide the flux composition with thixotropic properties. A wax as described in EP-A 1808264, methyl butyl ether, gelatine, pectine, acrylates or polyurethane, as described in EP-A-1 287941, are preferred thickeners if a thickener is applied.

Preferably, the flux preparation does not contain a thickener.

The flux composition may include other additives, for example, suspension stabilizers, surfactants, especially nonionic surfactants, e.g. Antarox® BL 225, a mixture of linear C8 to C10 ethoxylated and propoxylated alcohols.

Preferred binders are selected from the group consisting of organic polymers. Such polymers are physically drying (i.e., they form a solid coating after the liquid is removed), or they are chemically drying (they may form a solid coating e.g. under the influence of chemicals, e.g. oxygen or light which causes a cross linking of the molecules), or both. Preferred organic polymers are selected from the group consisting of polyolefines, e.g. butyl rubbers, polyurethanes, resins, phthalates, polyacrylates, polymethacrylates, vinyl resins, epoxy resins, nitrocellulose, polyvinyl acetates and polyvinyl alcohols. The binder can be water-soluble or water-insoluble. The binder preferably is dispersed in the carrier. Polyacrylates, polymethacrylates, polyvinyl alcohols and polyurethanes are preferred binders in the present flux composition.

The part or parts obtained by applying the flux or flux composition as described below may then be welded to joint them together. This is described in the following.

A further aspect of the present invention relates to a method for welding of parts of aluminum or aluminum alloys to parts of aluminum or aluminum alloys.

The method of the present invention for joining parts from aluminum or from aluminum alloys wherein at least one part of the parts to be joined contains the flux of the invention or the flux composition of the invention, the method comprising at least one step of assembling the parts to be joined, and at least one step of welding the parts to form a joined assembly of parts applying chemical energy, electric energy or laser energy.

The flux or flux composition may be present as a coating on all the surface of the part or on selected areas of the part, preferably close to the area where the parts are to be joined. The flux may be applied in a dry method, e.g. it can be applied electrostatically or by pouring the dry powder to the the respective area.

Alternatively, the flux composition may be applied, e.g. in a wet method, e.g. it may be sprayed onto the parts, painted on the parts, or be applied by immersing the parts into the composition which usually contains the fluorides in the form of a slurry. Often, after being applied in a wet method, the parts will be dried, especially if the liquid carrier is or contains an organic liquid.

If not yet assembled, the parts to be joined are assembled and then are welded.

The term "chemical energy" preferably denotes energy provided by burning a flammable gas (or fuel gas), e.g. hydrogen, petrol, methane, low pressure gas ("LPG") or natural gas, using oxygen or air.

Preferably, energy is introduced to the preassembled parts by means of an oxyygen acetylene flame. An oxygen acetylene torch kit usually comprises cylinders for oxygen and acetylene, a flash back arrestor or a non return valve (or both), flexible hoses for feeding oxygen and acetylene via pressure regulators to a mixer, and a welding torch. The gas mixture, which may also be denoted as oxyacetylene gas, leaving the torch is ignited and provides heat.

Often, an aluminum wire is provided, preferably through the torch, as solder metal to the parts to be joined.

The method is, for example, suitable to join car parts, gutters, tubes or sheets made from aluminum or aöuminum alloys.

The preferred method of joining the parts is the autogenous welding type.

The advantage of the flux, the flux composition and the welding process using the flux or flux composition is that less LiF or even no LiF is needed or contained in the flux anymore. The content in BaF_2 may be lower than used in prior art methods.

Should the disclosure of any patents, patent applications, and publications which are incorporated herein by reference conflict with the description of the present application to the extent that it may render a term unclear, the present description shall take precedence.

The following examples are intended to explain the invention in detail without limiting it.

Example 1 : Manufacture of the flux

Example 1.1 : Flux containing SrF_2

All fluoridic constituents were provided in the form of powder.

8.4 g SrF_2, 9.3 g MgF_2, 5.7 g CaF_2 and 17.5 g Li_3AlF_6 were introduced into a mortar and mixed to provide the flux.

Example 1.2 : Flux containing BaF_2

All fluoridic constituents were provided in the form of powder.

10.8 g BaF_2, 9.6 g MgF_2, 6.0 g CaF_2 and 17.8 g Li_3AlF_6 were introduced into a mortar and mixed to provide the flux.

Example 2 : Manufacture of a flux composition

Example 2.1 : A flux composition containing SrF_2

Sodium polyacrylate is dissolved in water to provide a concentration of 5 % by weight. 20 ml of this solution is mixed with 10 g of the flux of example 1.1 to provide a flux slurry.

Example 2.2 : A flux composition containing SrF_2

Sodium polyacrylate is dissolved in water to provide a concentration of 5 % by weight. 20 ml of this solution is mixed with 10 g of the flux of example 1.1 to provide a flux slurry.

Example 3 : Welding of Al parts

Example 3.1 : Welding with a flux containing SrF_2

Welding was performed using an oxy acetylene torch under feeding of an Al wire to provide solder to the joint.

Two aluminum sheets were assembled, and the flux of example 1.1 was spread as a dry powder to the area near the intended joint. An oxy acetylene gas mixture was ignited to provide heat to the respective areas of the Al sheets. The sheets were welded. From some welders, the red flash emitted from the hot metal and the flux (caused by vaporized strontium compounds) was perceived as unpleasant.

Example 3.2 : Welding with a flux containing BaF_2

Welding was performed using an oxy acetylene torch under feeding of an Al wire to provide solder to the joint.

Two aluminum sheets were assembled, and the flux of example 1.2 was spread as a dry powder to the area near the intended joint. An oxy acetylene gas mixture was ignited to provide heat to the respective areas of the Al sheets. The sheets were welded.

Example 4 : Welding of Al parts using a flux composition

Example 4.1 : Welding with a flux composition containing SrF_2

Welding is performed using an oxy acetylene torch under feeding of an Al wire to provide solder to the joint.

Two aluminum sheets are assembled, and the flux composition of example 2.1 is sprayed to the area near the intended joint. The parts are then dried. An oxy acetylene gas mixture is ignited to provide heat to the respective areas of the Al sheets. The sheets are welded. The red flash emitted from the hot metal and the flux (caused by vaporized strontium compounds) will be perceived as unpleasant from some welders.

Example 3.2 : Welding with a flux composition containing BaF_2

Welding is performed using an oxy acetylene torch under feeding of an Al wire to provide solder to the joint.

Two aluminum sheets are assembled, and the flux of example 1.2 is spread as a dry powder to the area near the intended joint. An oxy acetylene gas mixture is ignited to provide heat to the respective areas of the Al sheets. The sheets are welded.

CLAIMS

1. A flux comprising CaF_2, MgF_2 and Li_3AlF_6, further comprising at least one fluoride selected from the group consisting of SrF_2 and BaF_2 and optionally LiF, with the proviso that, if LiF is comprised, the weight ratio between LiF and Li_3AlF_6 is in a range of from 1:1 to 1:99.

2. The flux of claim 1 comprising CaF_2, MgF_2, Li_3AlF_6, and SrF_2.

3. The flux of claim 1 comprising CaF_2, MgF_2, Li_3AlF_6, and BaF_2.

4. The flux of anyone of claims 1 to 3 which is essentially free of LiF.

5. The flux of anyone of claims 1 to 4 wherein the content of CaF_2 is in a range of from 5 to 20 % by weight.

6. The flux of anyone of claims 1 to 5 wherein the content of MgF_2 is in a range of from 15 to 30 % by weight.

7. The flux of anyone of claims 1 to 6 wherein the content of Li_3AlF_6 is equal to or greater than 2 % by weight, and preferably is in a range of from 30 to 60 % by weight.

8. The flux of anyone of claims 1 to 7 wherein the content of SrF_2 or BaF_2 or, if both are present, the content of the sum of SrF_2 or BaF_2 is in a range of from 15 to 35 % by weight.

9. The flux of claim 8 wherein BaF_2 is present, and wherein the content of BaF_2 is equal to or lower than 28 % by weight.

10. The flux of anyone of claims 1 to 9 which is in the form of a powder.

11. A flux composition comprising the flux of anyone of claims 1 to 10 and at least one liquid carrier and/ or at least one binder.

12. A method for joining parts from aluminum or from aluminum alloys wherein at least one part of the parts to be joined comprises the flux of claims 1 to 10 or the flux composition of claim 1, comprising at least one step of assembling the parts to be joined, and at least one step of welding the parts to

form a joined assembly of parts applying chemical energy, electric energy or laser energy.

13. The method of claim 12 wherein the chemical energy is introduced by means of an oxygen acetylene flame.

14. The method of claims 12 or 13 wherein an aluminum wire is provided as solder metal to the parts to be joined.

15. The method of anyone of claims 12 to 14 which is an autogenous welding method.

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. B23K35/36 B23K1/20 B23K35/362
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B23K F28F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP S60 196287 A (NIPPON STEEL CORP) 4 October 1985 (1985-10-04) abstract -----	1-6,8-15 7
X	GB 1 393 506 A (INST ELEKTROSWARKI PATONA) 7 May 1975 (1975-05-07) page 1, lines 12-19 page 1, lines 63-83 -----	1-4,8, 12-15
A	JP 2007 216276 A (KOBE STEEL LTD) 30 August 2007 (2007-08-30) abstract figures 1,2 table 1 ----- -/--	1-15

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
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International application No
PCT/EP2015/055425

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 586 194 A (MAGNESIUM ELEKTRON LTD; FRANCIS ARTHUR FOX; EDWARD FREDERICK EMLEY) 11 March 1947 (1947-03-11) the whole document -----	1-15
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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