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(54) **Title**: A METHOD FOR THE MANUFACTURING OF METALLIC MATRIX COMPOSITES

(57) **Abstract**: The subject of the invention is a method for the manufacturing of metallic matrix composites through plastic working. Wherein the plastic working charge in the form of wires, tape or tapes or foil, which is the first component being covered with the second component or components with granulation less than 100 μm, after which they are connected by reciprocal surface contact, forming weaved bundles, and then the connected elements which form the charge material advantageously undergo initial rolling or drawing and in all cases the principal process, which is extrusion performed on a rolling mill with circumferential grooves, where between rollers a closing matrix is placed, rotating in reverse to its axis by an angle of ±20° advantageously ±12°, with a frequency up to 50 Hz, advantageously 15 Hz.

A method for the manufacturing of metallic matrix composites

The subject of the invention is a method for the manufacturing of metallic matrix composites through plastic working.

Metallurgical methods of manufacturing of metallic matrix composites consisting of adding to a liquid metal or alloy of small metallic elements with a higher melting temperature or of ceramic powder, mixing the bath and cooling it in order to obtain full crystallisation.

A method is also known where liquid metal or alloy is poured over one of the components in the form of a set of thin wires. After setting, a compact composite is obtained.

The aforementioned methods may be used both for individual manufacturing and in continuous processes.

Another method of composite manufacture is based on powder metallurgy and consists of mixing powdered components with specific chemical composition, size and shapes, mechanically compacting and then sintering them.

There is a need for the manufacturing of composites from components which do not mix to the required degree in known processes, in particular metallurgic processes.

The essence of the invention, which is a method for the manufacturing of metallic matrix composites through plastic working, advantageously in a continuous ~~pressing~~ extrusion process with oscillatory twisting, consists of the plastic working charge in the form of wires, tape or tapes or foil, which is the first component being covered with the second component or components with granulation less than 100 μm, after which they are connected by reciprocal surface contact, forming weaved bundles, and then the connected elements which form the charge material undergo initial rolling or drawing and the principal process, which is extrusion performed on a rolling mill with circumferential grooves, where between rollers a closing matrix is placed, rotating in reverse to its axis by an angle of ±20° advantageously ±12°, with a frequency up to 50 Hz, advantageously 15 Hz.

It is advantageous when the wires covered by the second component are placed in a bundle and twisted together with a twist of (0.8 - 0.2), advantageously 0.5 rotation per 100 mm of length.

It is also advantageous when the metal tape or foil covered by the second component is twisted in spiral coils, and multiple coils are placed in a bundle and twisted together.

Moreover it is advantageous when the charge undergoing the main process of extrusion is introduced into the grooves between the rolling mill's rolls with the shorter axis of its perpendicular cross-section parallel to the roll axis.

It is also advantageous when the first component is a metal tape or tapes.

It is moreover advantageous when the first component is a metal foil or foils.

Moreover it is advantageous when the first component is connected wires and foil, connected wires and metal tape, connected foil and metal tapes, and the second component is ground aluminium, advantageously in the form of powder.

It is additionally advantageous when the metal foil covered by the second component is twisted in spiral coils, and multiple coils are placed in a bundle and twisted together.

The use of the solution presented in the invention enables the following technical and utility effects:

- avoiding the metallurgical stage for the manufacturing of composites,
- the possibility of manufacturing composites from components which do not join together in a metallurgical process,
- the possibility of manufacturing composites using commonly available components, regardless of their chemical composition and form,
- obtaining composites by mechanical mixing and merging,
- a power saving process with no negative environmental impact

The method according to the invention requires the use of charge composed of one component in the form of wire, tape or foil, whereas the second or subsequent components may have the same form, or alternatively any ground form, whereas it is advantageous when at least one of the dimensions of one of the components does not exceed 100 μm. Charge preparation includes the placement of wire, tape or foil, and alternatively placing on their surface at least one component in ground form, or placing it in spaces between these elements, which then should be twisted or braided together.

Method according to the invention consists of plastic working of a charge prepared in such a manner, advantageously in the process of continuous extrusion with oscillatory twisting, whereas the deformed charge may be additionally covered, advantageously with a tape or foil.

The composite is obtained during the deformation of the charge, leading to its mechanical mixing and merging.

The advantage of the method presented in the invention is bypassing the metallurgical stage and the use of commonly available components in a solid state, both concerning their chemical composition and their form.

Example

Copper wires with a diameter of 1.0 mm were covered on the surface with aluminium powder with a grain size of 100 μm through gas injection. They were placed in a bundle, which was twisted together by 0.5 of rotation for each 100 mm

of their length. A line with a diameter of 12 mm was obtained, which underwent initial rolling on flat rolls, down to a thickness of 9.5 mm. The material thus prepared formed the charge for continuous extruding with twisting. The process was conducted using a duo rolling mill with a roll diameter of 260 mm rotating with a speed of 0.2 s^{-1} with circumferentially cut groove on each of them, which provide the closed rollers with a circular clearance with a diameter of 10 mm. In this location a die was placed with a 4 mm diameter opening, filling the opening between the rollers, and was subjected to reversible rotations along its axis at an angle of ±12° with a frequency of 15 Hz. The final stage of the composite manufacturing process on a copper matrix consisted of entering the charge into the rolling mill in a manner that the shorter axis of its cross-section was placed in parallel to the axis of the rollers. The friction between the charge and the rotating rollers directed it towards a reversibly rotating die, which by transferring its movement inside the charge located in its vicinity has caused the occurrence of a cyclic deformation path change effect, and as a consequence the permanent connection of charge elements and reducing its flow stress, resulting in extruding the charge through the die opening. Thus a compact composite was manufactured in the shape of a 4 mm diameter wire.

Claims

1. A method for the manufacturing of metallic matrix composites through plastic working, advantageously in a continuous extrusion process with oscillatory twisting, **characterized in that** the plastic working charge in the form of wires, tape or tapes or foil, which is the first component being covered with the second component or components with granulation less than 100 μm, after which they are connected by reciprocal surface contact, forming weaved bundles, and then the connected elements which form the charge material advantageously undergo initial rolling or drawing and in all cases the principal process, which is extruding performed on a rolling mill with circumferential grooves, where between rollers a closing matrix is placed, rotating in reverse to its axis by an angle of ±20° advantageously ±12°, with a frequency up to 50 Hz, advantageously 15 Hz.

2. A method in accordance with claim 1 **characterized in that** the wires covered by the second component are placed in a bundle and twisted together with a twist of (0.8 - 0.2), advantageously 0.5 rotation per 100 mm of length.

3. A method in accordance with claim 1, **characterized in that** the metal tape or foil covered by the second component is twisted in spiral coils, and multiple coils are placed in a bundle and twisted together.

4. A method in accordance with claim 1, **characterized in that** the charge undergoing the main process of extrusion is introduced into the grooves between the rolling mill's rolls with the shorter axis of its perpendicular cross-section parallel to the roll axis.

5. A method in accordance with claim 1, **characterized in that** the first component is a metal tape or tapes.

6. A method in accordance with claim 1, **characterized in that** the first component is a metal foil or foils.

7. A method in accordance with claim 1, **characterized in that** the first component is joined wires and foil.

8. A method in accordance with claim 1, **characterized in that** the first component is joined wires and metal tapes.

9. A method in accordance with claim 1, **characterized in that** the first component is joined foil and metal tapes.

10. A method in accordance with claim 1 or 4, **characterized in that** the metal foil covered by the second component is twisted in spiral coils, and multiple coils are placed in a bundle and twisted together.

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A. CLASSIFICATION OF SUBJECT MATTER
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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)
B22F C22C B21C

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.
A	"CONTINUOUS EXTRUSION PROCESS FOR METALS ADAPTED FOR METAL-MATRIX COMPOSITES", DESIGN ENGINEERING, MORGAN-GRAMPIAN LTD. LONDON, GB, 1 February 1989 (1989-02-01), page 33, XP000025516, ISSN: 0308-8448 the whole document -& "Conform TM Cold Pressure Welders", , 1 January 2014 (2014-01-01), XP055190304, Retrieved from the Internet: URL:http://www.bwe.co.uk/wp-content/uploads/2014/03/BWE-brochure-after-proof.pdf [retrieved on 2015-05-20] the whole document	1-10

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009 160635 A (TAMA TLO LTD) 23 July 2009 (2009-07-23) abstract; figures	1-10
A	JP 2009 090359 A (UNIV OSAKA PREFECTURE) 30 April 2009 (2009-04-30) abstract; figures	1-10
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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