METHOD OF MAKING A PATTERNED COMPOSITE METAL PLATE

Figure 1. Pattern of the composite metal plate of the example.

Abstract: The invention relates to a method of producing a patterned composite metal plate by the steps of a) providing at least two different metal and/or metal alloy powders b) filling a container, b) with the powders in different individual layers, wherein the individual power layers include at least two non parallel layers and/or non straight layers, or b2) making a three dimensional non-solid body of one of the powders, which comprises least two non parallel parts or layers and/or non straight parts or layers, inserting said body in the container and filling the cavities in and around the said body completely with the other powder, c) sealing and evacuating the container, d) subjecting the container to hot isostatic pressing in order to form a consolidated body comprising non parallel and/or non straight metal and/or metal alloy layers, c) optionally subjecting the consolidated body to hot deformation in order to form an intermediate body having a thickness of 50 to 200 mm, f) hot rolling the consolidated or the intermediate body in two perpendicular directions in order to form a plate, optionally one or more of the steps of g) cold rolling the hot rolled plate in order to form a cold rolled
(84) Designated States (unless otherwise indicated, for every kind of regional protection available):


Declarations under Rule 4.17:
— as to applicant’s entitlement to apply for and be granted a patent (Rule 4.17(I))
— of inventorship (Rule 4.17(iv))

Published:
— with international search report (Art. 21(3))
METHOD OF MAKING A PATTERNED COMPOSITE METAL PLATE

TECHNICAL FIELD

The invention relates to a method of making a patterned composite metal plate. In particular the invention relates to a method of producing a composite plate, which can be used for the manufacture of decorative metal objects.

BACKGROUND OF THE INVENTION

Decorative metal manufacturing techniques have been known for hundreds of years for making mixed metal laminates having distinct layered patterns. Forge welding was used in Syria to produce hard and flexible Damascus steel for the blades of swords and knives. In Japan a similar technique called Mokume Gane was used for the same purpose. The objects obtained in this way are referred to have a damascened pattern.

Nowadays, damascene patterned metal objects are produced in many different ways for a large number of material combinations. WO2015076771, WO201018820 and US4399611 disclose different lamination techniques for obtaining the desired decorative pattern.

US20100227193 and US3171195 disclose extrusion methods, wherein one metal may be provided in the form of a powder.

WO95 19861 discloses the making of stainless composite metal products having a damascene pattern, including the step of 1) providing a capsule comprising at least two stainless steel powders arranged in parallel elongated layers, 2) hot isostatic pressing the capsule for forming a blank, 3) forging and hot rolling the blank to an intermediate dimension, 4) distorting the elongated structure by mechanical working and thereafter 5) hot working the blank to the final dimension. To be specific, WO95 19861 discloses in Example 3 hot rolling to a bar diameter of 18 mm and thereafter twisting the bar 40 turns/m around its own axis and flat rolling for obtaining the damascene pattern in the final product.
All the above techniques result in damascene patterned objects having a relatively small size. The use has therefore been restricted to small sized objects such as knives, weapons, golf club heads, rings and other jewellery.

5 SUMMARY OF THE INVENTION
The general object of the present invention is to provide an improved method for making patterned composite metal plate from powders.

Another object is to provide a method for making large size plates, which can be used to produce large size objects having a decorative pattern, in particular of the damascene type.

These objects are achieved by the means of the invention as defined in the independent claims.

15 Further advantageous embodiments of the invention have been specified in the dependent claims.

The present invention overcomes the drawbacks of the limited size of the composite material obtainable with the method known from W095 19861, by filling the powder container such that the step of distorting the elongated structure by mechanical working such as twisting needs not be performed, because the container is filled in a way such that the pattern will form during the normal hot deformation.

25 BRIEF DESCRIPTION OF THE FIGURES
In the following, the invention will be described in more detail with reference to the preferred embodiments and the appended drawing.

Fig. 1 discloses the pattern of a plate produced by the present method.
DETAILED DESCRIPTION OF THE INVENTION

The claimed method of producing a patterned composite metal plate comprising the steps of:

a) providing at least two different metal and/or metal alloy powders,

b) filling a container,
   bl) with the powders in different individual layers, wherein the individual power layers include at least two non parallel layers and/or non straight layers, or
   b2) making a three dimensional non-solid body of one of the powders, which comprises least two non parallel parts of layers and/or non straight parts or layers, inserting said body in the container and filling cavities in and around the said body with the other powder,

c) sealing and evacuating the container,

d) subjecting the container to hot isostatic pressing in order to form a consolidated body comprising non parallel and/or non straight metal and/or metal alloy layers,

e) optionally subjecting the consolidated body to hot deformation in order to form an intermediate body having a thickness of 50 to 200 mm,

f) hot rolling the consolidated or the intermediate body in two perpendicular directions in order to form a plate,

optionally

g) cold rolling the hot rolled plate in order to form a cold rolled plate

h) slitting the plate in two or more parts and
i) etching the plate in order to reveal or enhance the pattern.

The method involves the use of at least two different metal and/or metal alloy powders. Accordingly, if the powders are carefully produced it is possible to manufacture a plate having a high cleanliness and a small size of any hard phases present. The Equivalent Circle Diameter (ECD) of at least 95 vol. % of any oxide particles may be \( \leq 10 \mu \eta \) and the ECD of at least 95 vol. % of any carbide and/or carbonitride particles may be \( \leq 5 \mu \eta \), wherein the ECD = \( 2\sqrt{A/\pi} \), where A is the surface of the particles in the studied section.

The claimed method can be applied to any metal or metal alloys that can be consolidated by Hot Isostatic Pressing (HIP). In particular the metal and/or metal alloy powders may comprise one or more of the following metals: Ag, Al, Au, Be, Bi, Cu, Ce, Cr, Fe, Mo, Nb, Ni, Pb, Pd, Pt, Sn, Ta, Ti, V, W and Zn. For many applications stainless steel powders are the best choice. The stainless steel powders comprise at least 11%Cr, preferably at least 13%Cr.

The method of filling the container is a key feature of the present invention, because the container is filled in a way such that the pattern will form during the normal hot deformation. Accordingly, the conventional step of size reduction and distortion of the elongated structure need not be performed.

One way of filling the container is to use two different metal and/or metal alloy powders and filling the container with the powders in separate individual layers, wherein the individual power layers include at least two non parallel layers and/or non straight layers. This can be done by placing a vertically movable powder-filling tool inside the stationary container, moving different individual filling sections of the powder-filling tool, which are connected to the respective powder source, independently of each other. Alternately, the feed of powder to one or more of the individual filling sections may be stopped for a certain time. These measures allow the individual power layers from the neighbouring section to flow also in the horizontal direction and form non parallel
layers and/or non straight layers. In this way the ground for the desired pattern is formed already in the container.

Another way of forming the ground for the desired pattern is to make a three dimensional non-solid body of one of the powders, thereby inserting the body in the container and filling the container completely with the other powder. The body can be manufactured by a technique known as 3D-printing or Additive Manufacturing. Again the body must comprise at least two non parallel parts or layers and/or non straight parts or layers. The only restriction to the geometry of the body is that it must allow the complete filling of the container with the other powder.

The hot rolling in two perpendicular directions results in a product, that can have a substantial width. The width can be influenced by the size of the HIPed container and the rolling parameters. However, for practical reasons the size of the hot rolled plate may be in the range of 0.6 m x 1.5 m to 1.0 m x 3 m. The thickness (t) of the hot rolled plate may be 1-15mm. The upper limit may be 12, 10, 8 or 6 mm and the lower limit may be 2, 3 or 4 mm. The width (w) of the plate is at least 50 mm, the smallest width may be set to 100 mm, 150 mm, 170 mm, 190 mm, 210 mm, 250 mm, 300 mm, 400 mm, 500 mm 600 mm or 700 mm. The length (l) of the plate is larger the width (w) of the plate. The length depends on the size of the container used for HIPing and can e.g. be adjusted to 1 m, 1.5 m, 2 m, 2.5 m, 3 m, 3.5 m or even more.

The hot rolled plate may be subjected to cold rolling in order to produce a cold rolled plate, which may have a thickness in the range of 0.1-3 mm, preferably 0.2 - 2 mm, more preferably 0.5-1.5mm. The width of the cold rolled plate may be adjusted by slitting the plate. The hot rolled plate may also be subjected to slitting and/or cutting in order to obtain the desired width and length.

The invention is defined in the claims.
EXAMPLE

A patterned composite metal plate was produced from the two austenitic stainless steel powders 316L and 304L. The powders were filled in two supply units, wherein each unit was connected to different individual parts of a vertically movable powder-filling tool: The filling tool was placed inside a container having a diameter of 250 mm, which remained stationary during the powder filling.

During the powder filling, different individual filling sections of the powder-filling tool were moved upwards independent of each other in a way such that ground for the desired pattern was formed inside the container, because the individual power layers could flow also in the horizontal direction during the filling and thereby form non parallel and non straight layers of the powders supplied. Thereafter the container was sealed and evacuated and processed according to standard HIP practice 1150 °C, 1000 bar, lh.

The consolidated body was forged to a block having a thickness of 100 mm, a width of 300 mm and a length of 1 m and then it was subjected to conventional hot rolling including a step of producing a slab having a thickness of 41 mm, a length of 960 mm and a width of 260 mm. Subjecting said slab to conventional hot rolling in two perpendicular directions in order to produce a plate having a thickness of about 2.74 mm, a length of 3 m and a width of 900 mm.

A sample was cut out of the plate and was subjected to polishing and etching in order to further enhance the pattern. The result is disclosed in Figure 1.
CLAIMS

1. A method of producing a patterned composite metal plate comprising the steps of:

5

a) providing at least two different metal and/or metal alloy powders,

b) filling a container,

bl) with the powders in different individual layers, wherein the individual

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power layers include at least two non parallel layers and/or non straight layers, or

b2) making a three dimensional non-solid body of one of the powders, which comprises least two non parallel parts or layers and/or non straight parts or layers, inserting said body in the container and filling the cavities

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in and around the said body completely with the other powder,

c) sealing and evacuating the container,

d) subjecting the container to hot isostatic pressing in order to form a consolidated body comprising non parallel and/or non straight metal and/or metal alloy layers,

e) optionally subjecting the consolidated body to hot deformation in order to form an intermediate body having a thickness of 50 to 200 mm,

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f) hot rolling the consolidated or the intermediate body in two perpendicular directions in order to form a plate,

optionally one or more of the steps of

g) cold rolling the hot rolled plate in order to form a cold rolled plate

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h) slitting the plate in two or more parts and
i) etching the plate in order to reveal or enhance the pattern.

2. A method according to claim 1, wherein the pattern is a damascene pattern.

3. A method according to claim 1 or 2, wherein thickness (t), width (w) and length (l) of the plate fulfil at least one of the requirements t=1-15 mm, w ≥ 50 mm and l ≥ w.

4. A method according to any of the preceding claims, wherein the metal and/or metal alloy powders comprise one or more of the following metals: Ag, Al, Au, Be, Bi, Cu, Ce, Cr, Fe, Mo, Nb, Ni, Pb, Pd, Pt, Sn, Ta, Ti, V, W and Zn.

5. A method according to any of the preceding claims, wherein the powders are stainless steel powders, each comprising at least 11% Cr, preferably at least 13% Cr.

6. A patterned composite metal plate obtained by the method of any of claims 1-5, wherein the plate comprises at least two different metals and/or metal alloys, wherein thickness (t), width (w) and length (l) of the plate fulfil the requirements t=0.1-15 mm, w ≥ 50 mm and l ≥ w.

7. A patterned composite metal plate according to claim 6, fulfilling at least one of the following requirements:

\[
\begin{align*}
  t & : 0.2-6 \text{ mm} \\
  w & : 30-100 \text{ cm} \\
  l & : 50-300 \text{ cm}
\end{align*}
\]

8. A patterned composite metal plate according to claim 6 or 7, wherein the pattern is a damascene pattern.
9. A patterned composite metal according to any of claims 6 to 8, wherein the at least two different metals and/or metal alloys comprise one or more of the following metals: Ag, Al, Au, Cu, Cr, Fe, Mo, Nb, Ni, Pb, Pd, Pt, Sn, Ta, Ti, V, W and Zn.

10. A patterned composite metal plate according to any of the claims 6-9, wherein the at least two different metals and/or metal alloys are stainless steels, each comprising at least 11% Cr, preferably at least 13% Cr, and optionally, wherein the Equivalent Circle Diameter (ECD) of at least 95 vol. % of any oxide particles is ≤ 10 µm and that the ECD of at least 95 vol. % of any carbide and/or carbonitride particles is ≤ 5 µm, wherein the ECD = 2√A/π, where A is the surface of the particles in the studied section.

11. A method according to any of claims 1 and 2, wherein the plate is slitted in two or more parts in order to form strips, optionally comprising one or more of the steps of: cutting the strips into blanks, using the blanks to form at least one knife and etching the knife.
Figure 1. Pattern of the composite metal plate of the example.
A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: B21 C, B22F, B44C

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search
16-1-2017

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**International Patent Classification (IPC)**

- B22F 7/06 (2006.01)
- B21C 37/02 (2006.01)
- B22F 5/00 (2006.01)
- B22F 7/02 (2006.01)
- B44C 3/02 (2006.01)
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