



(51) International Patent Classification:

<i>C21D 6/00</i> (2006.01)	<i>C22C 38/24</i> (2006.01)
<i>C21D 7/13</i> (2006.01)	<i>C22C 38/28</i> (2006.01)
<i>C21D 9/00</i> (2006.01)	<i>C22C 38/18</i> (2006.01)
<i>C21D 9/46</i> (2006.01)	<i>C22C 38/12</i> (2006.01)
<i>C21D 1/18</i> (2006.01)	<i>C22C 38/14</i> (2006.01)
<i>C21D 1/673</i> (2006.01)	<i>C22C 38/38</i> (2006.01)
<i>C22C 38/02</i> (2006.01)	<i>C22C 38/00</i> (2006.01)
<i>C22C 38/04</i> (2006.01)	<i>B21D 22/02</i> (2006.01)
<i>C22C 38/06</i> (2006.01)	

(21) International Application Number:

PCT/EP2017/053807

(22) International Filing Date:

20 February 2017 (20.02.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

EP16156976.9 23 February 2016 (23.02.2016) EP

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: HOT FORMED PART AND METHOD FOR PRODUCING IT

(57) Abstract: The invention relates to a hot formed part or portion of a hot formed part made of steel. According to the invention, the steel has the following composition in weight%: C: 0.03 - 0.09, Mn: 0.50 - 1.90, Si: 0 - 0.5, Al: 0.01 - 0.07, N: 0.0010 - 0.010, P: ≤0.03, S: ≤0.03, Ti: 0.01 - 0.09, V: 0.02 - 0.15, Cr: ≤0.2, Mo: ≤0.1, Nb: ≤0.1, Cu: ≤0.1, Ca: ≤0.05, B: ≤0.001, the remainder being iron and unavoidable impurities, wherein the hot formed part or hot formed portion has a tensile strength of at least 450 MPa. The invention also relates to a method for producing such a hot formed part, a blank for producing such a part and the use of such a part.



WO 2017/144419 A1

HOT FORMED PART AND METHOD FOR PRODUCING IT

The invention relates to a hot formed part or portion of a hot formed part. The invention also relates to a method for producing such a hot formed part, a blank for
5 producing such a part and the use of such a part.

Hot formed parts are nowadays used frequently in the production of a body-in-white of cars. EP0971044 A1 for instance describes the aluminium based coating on the hot forming steeltype 22MnB5, and the hot formed parts produced thereof usually have a strength of at least 1500 MPa. Such parts have good anti-intrusion properties, but
10 these parts are fully or almost fully martensitic and have a low elongation.

Certain parts in the body-in-white not only need high strength, but also good energy absorption. To provide a good energy absorption, the part has to have a high elongation. Often, a part in a body-in-white needs to have good anti-intrusion properties and good energy absorption. Such parts are often provided as a tailor welded blank
15 (TWB), of which a portion is made of a steel that obtains a high strength after hot forming, and another portion is made of a steel that obtains a lower strength but a high elongation after hot forming. Such a TWB can for instance be used to hot form a B-pillar.

A steeltype having lower strength but high elongation after hot forming is for
20 instance known from WO2007/034063.

However, the steeltypes mentioned in WO2007/034063 must be heated to a temperature between Ac1 and Ac3 before pressing, as follows from the description of WO2007/034063 and from claim 1 of EP1929053 B1, which is based on WO2007/034063. This is disadvantageous, because the usual hot forming steeltypes
25 such as 22MnB5 must be heated to a temperature well above Ac3. This makes the hot forming procedure cumbersome. For such a TWB, the furnace in which the TWB is heated should have two parallel sections, one at a temperature between Ac1 and Ac3, and the other at a temperature above Ac3. Such a furnace is not easy to attain and not easy to operate.

30 It is an object of the invention to provide a hot formed part or a portion thereof having good energy absorption.

It is a further object of the invention to provide a steeltype for such a part or portion that can be hot formed in the same temperature range as a steeltype providing

high strength.

It is a further object of the invention to provide a steeltype having good elongation after hot forming that can be easily hot formed as portion of a TWB with a steeltype providing high strength.

5 It is also an object of the invention to provide a method for producing such hot formed parts.

According to the invention, one or more of these objects are reached by providing a hot formed part or portion of a hot formed part having the following composition in weight%:

10 C: 0.03 - 0.09,
Mn: 0.50 - 1.90,
Si: 0 - 0.5,
Al: 0.01 - 0.07,
N: 0.0010 - 0.010,
15 P: ≤ 0.03 ,
S: ≤ 0.03 ,
Ti: 0.01 - 0.09,
V: 0.02 - 0.15,
Cr: ≤ 0.2 ,
20 Mo: ≤ 0.1 ,
Nb: ≤ 0.1 ,
Cu: ≤ 0.1 ,
Ca: ≤ 0.05 ,
B: ≤ 0.001 ,

25 the remainder being iron and unavoidable impurities, wherein the hot formed part or hot formed portion has a tensile strength of at least 450 MPa.

The inventor has found that by using both Ti and V in limited amounts, a steeltype is created that can be heated in a furnace to a temperature above Ac3 before it is pressed and quenched in a hot forming press. The hot formed part produced with this
30 steeltype has a dual phase structure. The steeltype according to the invention can thus be advantageously used in combination with steeltypes having a high strength after hot forming, such as in a TWB, because the standard furnaces can be used.

The steeltype according to the invention has a tensile strength of at least 450 MPa after hot forming, and possesses a good ductility.

The steeltype according to the invention also has the advantage that it can be cold rolled very well into a steel strip because the cold mill loads are lower due to the use of vanadium. Thus, wider strip material can be rolled, and the control of flatness and shape is better. This can improve homogeneity after the hot forming process.

The composition of the steel according to the invention will be elucidated.

Carbon is required for hardenability. If lower than 0.03%, the hardness of the hot formed part will be too low, and no martensite will be formed to produce a dual phase structure. If carbon is higher than 0.09% the weldability of the hot formed part in the body in white can be a problem.

Manganese is required for hardenability and solid solution strengthening. If lower than 0.50%, the hardness of the hot formed part will be too low, and no martensite will be formed to produce a dual phase structure. If manganese is higher than 1.90% the weldability of the hot formed part in the body in white can be a problem, or more segregation can occur.

Silicon is an optional element and provides solid solution strengthening. Silicon is always present as impurity. If too much silicon is present, that is more than 0.5%, surface problems and coating difficulties can occur.

Aluminium is used as deoxidizer in steel and its minimum amount should be 0.01% to ensure the deoxidation during steelmaking. At a concentration higher than 0.07% aluminium, the occurrence of surface defects resulting from alumina clusters increases.

Nitrogen has an effect similar to that of carbon. This element will combine preferentially with Al and Ti to form AlN and TiN precipitates. These precipitates can be detrimental if a large amount of N is added ($>0.010\%$) because elongation of the hot formed steel is degraded and cracking of slabs occurs. Nitrogen will always be present in small amounts, more than 0.0010%.

Phosphorus and sulphur must be kept low, less than 0.03%, to avoid embrittlement problems or difficulties in welding of the hot formed part.

Titanium forms precipitates. These are a key aspect of the invention, because they restrict austenite growth during heating in the hot forming process. Thus, finer austenite

grains are formed, altering the transformation characteristics of the steel during cooling in the hot forming press. This adjusts the CCT diagram such that rapid and complete formation of ferrite occurs, allowing martensite to be formed without the need for an intercritical heating regime; small amounts of bainite and pearlite are also formed.

- 5 Titanium has a lower limit of 0.01%, because otherwise insufficient precipitates will be formed. If more than 0.09% titanium is present, coarse precipitates will be formed, which is detrimental for elongation.

Vanadium forms precipitates. These also are a key aspect of the invention, because they restrict austenite growth during heating in the hot forming process as well.

- 10 Thus, finer austenite grains are formed, altering the transformation characteristics of the steel during cooling in the hot forming press. This adjusts the CCT diagram such that rapid and complete formation of ferrite occurs, allowing martensite to be formed without the need for an intercritical heating regime. Vanadium has the added advantage that it does not increase cold mill rolling loads to the same extent as niobium does.

- 15 Vanadium has a lower limit of 0.02%, because otherwise insufficient precipitates will be formed. If more than 0.15% vanadium is present, coarse precipitates will be formed, which is detrimental for elongation.

- The combination of the use of titanium and vanadium has proven to provide the right amount of precipitates which effectively forms the small grain size of austenite, such that the right microstructure of the hot formed part comes into existence during the hot forming process.

- Chromium, molybdenum, niobium, copper and boron can be added in small amounts, and will in such small amounts not essentially affect the properties of the steel or the hot formed part. However, these elements are usually not added and are thus only present as impurity.

Calcium is added to the melt to change hard inclusions into soft inclusions.

Preferably the hot formed part or portion of a hot formed part according to the invention has a composition with more limited ranges, as indicated hereinafter:

- 30 C: 0.04 - 0.08, preferably 0.05 - 0.07 and/or
Mn: 0.60 - 1.50, preferably 0.70 - 1.10 and/or
Si: 0 - 0.20, preferably 0 - 0.10 and/or
Al: 0.01 - 0.05 and/or

- 5 -

Ti: 0.02 - 0.07, preferably 0.03 - 0.06 and/or

V: 0.03 - 0.13, preferably 0.04 - 0.12 and/or

Cr: ≤ 0.10 , preferably ≤ 0.05 and/or

Mo: ≤ 0.03 , preferably ≤ 0.01 and/or

5 Nb: ≤ 0.03 , preferably ≤ 0.01 and/or

Cu: ≤ 0.05 .

These ranges are chosen such that the steel part will be less expensive to produce, for instance because less Ti and/or V is used, and on the other hand the ranges are such that the advantages of the composition in the hot formed part are more pronounced.

10 According to a preferred embodiment the hot formed part or portion of a hot formed part according to the invention has a tensile strength of at least 500 MPa, preferably a tensile strength of at least 550 MPa. Such strengths are often requested by the car manufacturers using these types of steel.

Preferably the hot formed part or hot formed portion has a tensile strength of at
15 most 700 MPa. The tensile strength of the steel part should not be too high, because a tensile strength that is too high will lessen the energy absorption of the hot formed part because the elongation will deteriorate.

According to a preferred embodiment the hot formed part or hot formed portion has a yield strength of at least 350 MPa. The yield strength also influences the total
20 energy absorption of the hot formed part, and thus should not be too low.

Preferably the hot formed part or hot formed portion has a total elongation A80 of at least 12%, more preferably a total elongation of at least 15%. The higher the elongation, the more energy the hot formed part can dissipate during a crash. The elongation should thus be as high as possible, and preferably 15% or higher.

25 According to a preferred embodiment the hot formed part or portion of a hot formed part according to the invention possesses a tensile strength and an elongation such that the tensile strength (in MPa) times the total elongation (in %) of the hot formed part or hot formed portion is at least 7500 (in MPa%), and preferably at least 9000 (in MPa%). Since both the tensile strength and the elongation influence the energy
30 absorption of the hot formed part, the multiplication of both values provides a very good indication of the energy absorption of the hot formed part.

Preferably, the steel of the hot formed part or portion of the hot formed part has a

dual phase microstructure of ferrite and martensite with at most 10% bainite and/or pearlite. This provides for a hot formed steel having the right strength above 450 MPa and a good elongation, such that the hot formed part or portion has a good energy absorption. More preferably the hot formed steel has a microstructure with at most 5%
5 bainite and/or pearlite, such that the properties of the steel are consistently reached.

According to a preferred embodiment the hot formed part is coated with a zinc based alloy or aluminium based alloy, preferably the zinc based alloy containing 0.2 - 4.0 Al and/or 0.2 - 4.0 Mg, and preferably the aluminium based alloy containing up to 13% Si. Such coatings are needed to protect the steel surface during the hot forming
10 process. An aluminium based coating is mostly used in the automotive industry.

According to a second aspect of the invention a method for producing a hot formed part is provided, comprising the following steps:

- providing a blank that is at least partly made of steel with the composition of the first aspect of the invention, the blank having a zinc based coating or an
15 aluminium based coating;
- optionally deforming the blank to a pre-formed part;
- heating the blank in a furnace to a temperature above $Ac3 + 2^{\circ}C$;
- keeping the blank or pre-formed part in the furnace during a total time period of at least 4 minutes and at most 11 minutes;
- 20 - removing the blank or pre-formed part from the furnace and transferring it into a hot forming press in a time period of at most 15 seconds;
- forming the blank or pre-formed part in the hot forming press and cooling it with a cooling rate of at least $30^{\circ}C/s$.

This hot forming process resembles the standard hot forming process for a part
25 having a high strength, but is different from the hot forming process according to the state of the art for tailor welded blanks (TWB) using the process and steel of EP1929053 B1. The hot forming process for this TWB needs a furnace having a portion for heating the steel providing a portion with good energy absorption to a temperature between $Ac1$ and $Ac3$, and another portion of the furnace for heating the steel providing
30 a portion with high strength to a temperature above $Ac3$. With the process according to the invention a standard furnace can be used, because the whole TWB can be heated to a temperature above $Ac3 + 2^{\circ}C$, as is used for hot forming 22MnB5 steel. This is a

considerable simplification for the process for hot forming TWB.

Preferably, the blank or pre-formed part is heated in the furnace to a temperature above $A_{c3} + 5^{\circ}\text{C}$, or to a temperature between 900°C and 960°C , more preferably to a temperature between 910°C and 950°C . These temperatures can be used both for hot formable steel for a high strength part or portion, and for hot formable steel with the composition according to the invention.

According to a preferred process the time period for transferring the blank or pre-formed part from the furnace into the hot forming press is at most 13 seconds. However, it is possible to reduce this time period even further. The shorter this time period is, is usually the better. If the time period is too long, then the press temperature is lower and this results in a deterioration in properties.

Preferably, the blank or pre-formed part is kept in the furnace during a total time period of at least 4 minutes and at most 8 minutes. In this time period the austenisation should be fully completed.

According to a third aspect of the invention there is provided a steel blank or steel strip or steel sheet for producing a blank, for use in the method according to the second aspect of the invention, wherein the steel of the blank, strip or sheet has the composition as known from the first aspect of the invention.

According to a fourth aspect of the invention use is made of a part according to the first aspect of the invention or manufactured using the second aspect of the invention, for structural parts and/or anti-intrusion parts in a vehicle.

The invention will be elucidated with reference to the following examples.

A number of sheets has been produced as full production material, having a composition in accordance with the invention. Examples of these sheets are indicated with the numbers 1 and 2, the composition thereof is given in Table 1.

Table 1: composition in wt%, inventive examples

Ex.	C	Mn	P	S	Si	Al	Ti	V	Nb	Mo	N	Cr
1	0,057	0,891	0,013	0,003	0,030	0,037	0,045	0,063	0,001	0,005	0,0039	0,016
2	0,062	0,898	0,013	0,003	0,028	0,033	0,049	0,105	0,001	0,006	0,0049	0,024

Sheets of these two examples have been processed in accordance with the hot

forming process according to the invention. Table 2 shows a number of the experiments performed, in which different furnace (or oven) temperatures, furnace times, hot press temperatures, transfer times and gauges of the sheets have been used.

Table 2: processing and results

Ex.	Oven Temp (°C)	Oven Time (min)	Press Temp (°C)	Transfer time (s)	Gauge (mm)	Rp (MPa)	Rm (MPa)	A80	Rm x A80
1A	900	7	753	9,2	1,277	415	600	18,1	10860
1B	925	6	754	10,4	1,286	414	606	19,8	11999
1C	925	6	714	14,6	1,292	405	590	13,4	7906
1D	925	10	753	10,6	1,268	422	609	17	10353
1E	950	5	759	10,7	1,264	433	618	15,2	9394
2A	900	7	756	10,6	1,492	417	610	13,4	8174
2B	925	6	757	11,5	1,474	421	612	17,4	10649

5

For the composition of Example 1 in Table 1, the hot press conditions of Example 1B are most common; this especially relates to the furnace temperature of 925° C, the furnace time and the transfer time from furnace into hot forming press. A very good elongation A80 of 19,8% is reached, and also the tensile strength time elongation is very high.

10

The results of the composition of Example 2 in Table 1 are slightly less. Under almost the same conditions as Example 1B, example 2B has a good elongation A80 of 17,4%. The tensile strength times elongation is also high.

The above shows that the composition of the steel according to the invention provides a steeltype that, after the hot forming process, has a very good elongation and a good tensile strength, which indicates that the hot formed parts made thereof have a very good energy absorption.

15

Table 3 shows a steeltype as a comparative example for the steel composition, indicate as Example 3.

20

Table 3: composition in wt%, comparative example

Ex.	C	Mn	P	S	Si	Al	Ti	V	Nb	Mo	N	Cr
3	0,083	1,018	0,014	0,001	0,319	0,026	0,003	0,005	0,030	0,004	0,0036	0,024

In Example 3 also boron is measured in an amount of 3 ppm, which is an impurity level.

- 5 The steel sheet with the composition of Example 3 in Table 3 has been hot formed with the same preferred processing conditions of Examples 1 and 2, namely a furnace temperature of 925° C, a furnace time of 6 minutes, a press temperature of 757 ° C, and a transfer time of 8,8 seconds. The gauge of the sheet was 1,349 mm. The result of the hot forming process was a hot formed part with a tensile strength of 818 MPa and
- 10 an elongation A80 of 7,6%. The multiplication of tensile strength and elongation thus is 6217. It follows that the comparative material with niobium instead of titanium and vanadium provides a steeltpe that leads to a hot formed product with a tensile strength that is too high and an elongation A80 that is too low.

CLAIMS

1. Hot formed part or portion of a hot formed part having the following composition
5 in weight%:
C: 0.03 - 0.09,
Mn: 0.50 - 1.90,
Si: 0 - 0.5,
Al: 0.01 - 0.07,
10 N: 0.0010 - 0.010,
P: ≤ 0.03 ,
S: ≤ 0.03 ,
Ti: 0.01 - 0.09,
V: 0.02 - 0.15,
15 Cr: ≤ 0.2 ,
Mo: ≤ 0.1 ,
Nb: ≤ 0.1 ,
Cu: ≤ 0.1 ,
Ca: ≤ 0.05 ,
20 B: ≤ 0.001 ,
the remainder being iron and unavoidable impurities,
wherein the hot formed part or hot formed portion has a tensile strength of at least
450 MPa.
- 25 2. Hot formed part or portion of a hot formed part according to claim 1, wherein:
C: 0.04 - 0.08, preferably 0.05 - 0.07 and/or
Mn: 0.60 - 1.50, preferably 0.70 - 1.10 and/or
Si: 0 - 0.20, preferably 0 - 0.10 and/or
Al: 0.01 - 0.05 and/or
30 Ti: 0.02 - 0.07, preferably 0.03 - 0.06 and/or
V: 0.03 - 0.13, preferably 0.04 - 0.12 and/or
Cr: ≤ 0.10 , preferably ≤ 0.05 and/or

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Mo: ≤ 0.03 , preferably ≤ 0.01 and/or

Nb: ≤ 0.03 , preferably ≤ 0.01 and/or

Cu: ≤ 0.05 .

- 5 3. Hot formed part or portion of a hot formed part according to claim 1 or claim 2,
 wherein the hot formed part or hot formed portion has a tensile strength of at least
 500 MPa, preferably a tensile strength of at least 550 MPa.
4. Hot formed part or portion of a hot formed part according to claim 1, 2 or 3,
10 wherein the hot formed part or hot formed portion has a tensile strength of at most
 700 MPa.
5. Hot formed part or portion of a hot formed part according to any one of the
 preceding claims, wherein the hot formed part or hot formed portion has a yield
15 strength of at least 350 MPa.
6. Hot formed part or portion of a hot formed part according to any one of the
 preceding claims, wherein the hot formed part or hot formed portion has a total
 elongation A80 of at least 12%, preferably a total elongation of at least 15%.
- 20 7. Hot formed part or portion of a hot formed part according to any one of the
 preceding claims, wherein the tensile strength times the total elongation of the hot
 formed part or hot formed portion is at least 7500, and preferably at least 9000.
- 25 8. Hot formed part or portion of a hot formed part according to any of the
 proceeding claims, wherein the steel has a dual phase microstructure of ferrite and
 martensite with at most 10% bainite and/or pearlite, preferably at most 5% bainite
 and/or pearlite.
- 30 9. Hot formed part or portion of a hot formed part according to any of the
 proceeding claims, wherein the hot formed part is coated with a zinc based alloy
 or aluminium based alloy, preferably the zinc based alloy containing 0.2 - 4.0 Al

and/or 0.2 - 4.0 Mg, and preferably the aluminium based alloy containing up to 13% Si.

10. Method for producing a hot formed part as described in any one of the preceding
5 claims, comprising the following steps:
- providing a blank that is at least partly made of steel with the composition of any one of the preceding claims, the blank having a zinc based coating or an aluminium based coating;
 - optionally deforming the blank to a pre-formed part;
 - 10 - heating the blank in a furnace to a temperature above $Ac3 + 2^{\circ} C$;
 - keeping the blank or pre-formed part in the furnace during a total time period of at least 4 minutes and at most 11 minutes;
 - removing the blank or pre-formed part from the furnace and transferring it into a hot forming press in a time period of at most 15 seconds;
 - 15 - forming the blank or pre-formed part in the hot forming press and cooling it with a cooling rate of at least $30^{\circ} C/s$.
11. Method according to claim 10, wherein the blank or pre-formed part is heated in the furnace to a temperature above $Ac3 + 5^{\circ} C$, or to a temperature between $900^{\circ} C$ and $960^{\circ} C$, preferably to a temperature between $910^{\circ} C$ and $950^{\circ} C$.
20
12. Method according to claim 10 or claim 11, wherein the time period for transferring the blank or pre-formed part from the furnace into the hot forming press is at most 13 seconds.
25
13. Method according to claim 10, 11 or 12, wherein the blank or pre-formed part is kept in the furnace during a total time period of at least 4 minutes and at most 8 minutes.
14. Steel blank or steel strip or sheet for producing a blank, for use in the method
30 according to any one of claims 10 - 13, wherein the steel of the blank, strip or sheet has the composition of claim 1 or 2.

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15. Use of a part as claimed in claims 1 - 9 or manufactured using claim 10, 11, 12 or 13 for structural parts and/or anti-intrusion parts in a vehicle.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/053807

A. CLASSIFICATION OF SUBJECT MATTER

INV. C21D6/00	C21D7/13	C21D9/00	C21D9/46	C21D1/18
C21D1/673	C22C38/02	C22C38/04	C22C38/06	C22C38/24
C22C38/28	C22C38/18	C22C38/12	C22C38/14	C22C38/38

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)

C22C B21D C21D

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	EP 2 735 623 A1 (JFE STEEL CORP [JP]) 28 May 2014 (2014-05-28) paragraphs [0001], [0002], [0011], [0030], [0066], [0082] - [0093] tables 1-3 -----	1,3,5-7, 14,15
X	US 2003/129444 A1 (MATSUOKA SAIJI [JP] ET AL) 10 July 2003 (2003-07-10) paragraphs [0001] - [0004], [0125], [0126], [0144] tables 1(a), 3(a), 5(a), 7(a) ----- -/-	1,3,4, 6-8,14, 15



Further documents are listed in the continuation of Box C.



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)

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"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

8 May 2017

Date of mailing of the international search report

15/05/2017

Name and mailing address of the ISA/

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Martinavicius, A

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/053807

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2006 212663 A (NIPPON STEEL CORP) 17 August 2006 (2006-08-17) abstract paragraphs [0009] - [0013], [0033] - [0046], [0051] table 2 -----	1-15
X	US 2014/037980 A1 (KAWASAKI KAORU [JP]) 6 February 2014 (2014-02-06) paragraphs [0012] - [0047], [0055], [0114] - [0124], [0127] figures 1-4 -----	1-15
A	WO 2015/039763 A2 (TATA STEEL IJMUIDEN BV [NL]) 26 March 2015 (2015-03-26) page 1, line 31 - page 2, line 23 page 5, line 21 - page 6, line 22 page 7, line 15 - page 8, line 6; claims 1-15 table 2 -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/053807

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2735623	A1	28-05-2014	CA 2840724 A1 24-01-2013
		CN 103687976 A 26-03-2014	
		EP 2735623 A1 28-05-2014	
		JP 5754279 B2 29-07-2015	
		JP 2013023721 A 04-02-2013	
		KR 20140026608 A 05-03-2014	
		US 2014141280 A1 22-05-2014	
		WO 2013011660 A1 24-01-2013	
US 2003129444	A1	10-07-2003	AU 776043 B2 26-08-2004
			CA 2398126 A1 06-06-2002
			CN 1419607 A 21-05-2003
			EP 1338667 A1 27-08-2003
			TW 520398 B 11-02-2003
			US 2003129444 A1 10-07-2003
			WO 0244434 A1 06-06-2002
JP 2006212663	A	17-08-2006	JP 4575799 B2 04-11-2010
			JP 2006212663 A 17-08-2006
			JP 2006212663 K1 17-08-2006
US 2014037980	A1	06-02-2014	BR 112013028960 A2 01-03-2017
			CA 2832901 A1 22-11-2012
			CN 103534375 A 22-01-2014
			EP 2708613 A1 19-03-2014
			JP 5556961 B2 23-07-2014
			KR 20130140169 A 23-12-2013
			KR 20160023930 A 03-03-2016
			RU 2013149802 A 20-06-2015
			TW 201303042 A 16-01-2013
			US 2014037980 A1 06-02-2014
			WO 2012157581 A1 22-11-2012
WO 2015039763	A2	26-03-2015	CA 2924812 A1 26-03-2015
			CN 105658834 A 08-06-2016
			EP 2988887 A2 02-03-2016
			JP 2016537502 A 01-12-2016
			KR 20160057457 A 23-05-2016
			US 2016289809 A1 06-10-2016
			WO 2015039763 A2 26-03-2015