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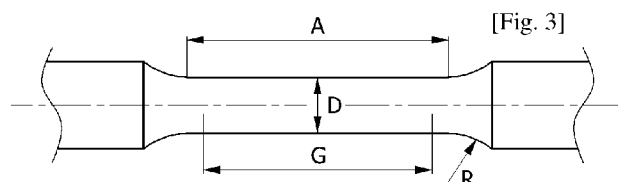
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(54) Title: AUSTENITIC HEAT-RESISTANT CAST STEEL AND TURBINE HOUSING FOR TURBOCHARGER USING THE SAME



(57) Abstract: Provided is an austenitic heat-resistant cast steel, which includes 0.4 to 0.5 wt% carbon (C), 1.0 to 2.0 wt% silicon (Si), 1.0 to 2.0 wt% manganese (Mn), 9.0 to 12.0 wt% nickel (Ni), 21 to 24 wt% chromium (Cr), 1.0 to 2.5 wt% niobium (Nb), 0.5 to 3.5 wt% tungsten (W), remainder iron (Fe), and other inevitable impurities. A turbine housing for a turbocharger including the minimum amount of Ni, which is expensive, and having required enhanced durability at high temperature may be manufactured.

Description

Title of Invention: AUSTENITIC HEAT-RESISTANT CAST STEEL AND TURBINE HOUSING FOR TURBOCHARGER USING THE SAME

Technical Field

- [1] The present invention relates to an austenitic heat-resistant cast steel having excellent physical properties at high temperature and a turbine housing for a turbocharger manufactured using the same.

Background Art

- [2] A turbocharger compresses and provides a larger amount of air to an inside of an engine cylinder to improve an output of an engine, and has a structure in which a turbine wheel in the turbine housing is rotated by exhaust gas from the engine, and a compressor wheel in a compressor housing compressing an atmospheric air by rotation power generated by rotation of the turbine wheel to provide the air to the engine.
- [3] Since the turbine housing surrounding the turbine wheel is in constant contact with exhaust from the engine having a temperature of 800 to 900 °C, and experiences a considerably high thermal impact according to the output of the engine, the turbine housing requires high durability.
- [4] While a material now used in the turbine housing of a car is SCH22 heat-resistant stainless steel, the SCH22 heat-resistant stainless steel includes 19 to 22 wt% Ni, which is expensive, and therefore it has a limit to a product cost in commercial application.
- [5] The descriptions above in the related art are merely provided to understand the background of the present invention, and it would not be understood that it corresponds to a related art previously known to those of ordinary skill in the art.

Disclosure of Invention

Technical Problem

- [6] The present invention provides austenitic heat-resistant cast steel and a housing for a turbocharger manufactured using the same that is capable of reducing expensive Ni and has enhanced required durability at room temperature can be manufactured.

Solution to Problem

- [7] The present invention is directed to providing an austenitic heat-resistant cast steel including a minimum amount of Ni, which is expensive, and enhancing durability at high temperature and a housing for a turbocharger manufactured using the same.
- [8] In one aspect, the present invention provides an austenitic heat-resistant cast steel,

which includes 0.4 to 0.5 wt% carbon (C), 1.0 to 2.0 wt% silicon (Si), 1.0 to 2.0 wt% manganese (Mn), 9.0 to 12.0 wt% nickel (Ni), 21 to 24 wt% chromium (Cr), 1.0 to 2.5 wt% niobium (Nb), 0.5 to 3.5 wt% tungsten (W), remainder iron (Fe), and other inevitable impurities.

- [9] In one embodiment of the present invention, the austenitic heat-resistant cast steel may further include 0.04 wt% or less phosphor (P) (not including 0) and 0.15 wt% or less sulfur (S) (not including 0).
- [10] In one embodiment of the present invention, the austenitic heat-resistant cast steel may include 0.42 to 0.48 wt% C, 1.25 to 1.75 wt% Si and 1.2 to 2.5 wt% Nb.
- [11] In one embodiment of the present invention, the austenitic heat-resistant cast steel may include 1.2 to 2.2 wt% Nb.
- [12] In one embodiment of the present invention, the austenitic heat-resistant cast steel may include 0.8 to 2.2 wt% W.
- [13] In one embodiment of the present invention, the austenitic heat-resistant cast steel may include more than 2.2 to 3.5 wt% W.
- [14] In another aspect, the present invention provides a housing for a turbocharger manufactured using the austenitic heat-resistant cast steel, which includes 0.42 to 0.48 wt% C, 1.25 to 1.75 wt% Si, 1.0 to 2.0 wt% Mn, 9.0 to 12.0 wt% Ni, 21 to 24 wt% Cr, 1.2 to 2.2 wt% Nb, 0.5 to 3.5 wt% W, remainder Fe, and other inevitable impurities.
- [15] In one embodiment of the present invention, the housing for a turbocharger manufactured using the austenitic heat-resistant cast steel may include 0.8 to 2.2 wt% W.
- [16] In one embodiment of the present invention, the housing for the turbocharger manufactured using the austenitic heat-resistant cast steel may include more than 2.2 to 3.5 wt% W.

Advantageous Effects of Invention

- [17] According to an austenitic heat-resistant cast steel and a housing for a turbocharger manufactured using the same of the present invention as described above, the housing of a turbocharger including the minimum amount of expensive Ni and having enhanced required durability at room temperature can be manufactured.

Brief Description of Drawings

- [18] The above and other objects, features, and advantages of the present invention will become more apparent to those of ordinary skill in the art by describing in detail exemplary embodiments thereof with reference to the adhered drawings, in which:
- [19] FIG. 1 is a graph showing a result for a room temperature tensile test according to an exemplary embodiment of the present invention;
- [20] FIG. 2 is a graph showing a result for a high temperature tensile test according to an exemplary embodiment of the present invention;

- [21] FIG. 3 shows cross-sectional views of samples for the tensile tests illustrated in FIGS. 1 and 2; and
- [22] FIG. 4 is a Schaeffler diagram according to an exemplary embodiment of the present invention.

Best Mode for Carrying out the Invention

- [23] In one aspect, the present invention provides an austenitic heat-resistant cast steel, which includes 0.4 to 0.5 wt% carbon (C), 1.0 to 2.0 wt% silicon (Si), 1.0 to 2.0 wt% manganese (Mn), 9.0 to 12.0 wt% nickel (Ni), 21 to 24 wt% chromium (Cr), 1.0 to 2.5 wt% niobium (Nb), 0.5 to 3.5 wt% tungsten (W), remainder iron (Fe), and other inevitable impurities.
- [24] In one embodiment of the present invention, the austenitic heat-resistant cast steel may further include 0.04 wt% or less phosphor (P) (not including 0) and 0.15 wt% or less sulfur (S) (not including 0).

Mode for the Invention

- [25] Hereinafter, an austenitic heat-resistant cast steel and a housing for a turbocharger manufactured using the same will be described with reference to the accompanying diagrams according to exemplary embodiments of the present invention.
- [26] The heat-resistant cast steel of the present invention includes 0.4 to 0.5 wt% C, 1.0 to 2.0 wt% Si, 1.0 to 2.0 wt% Mn, 9.0 to 12.0 wt% Ni, 21 to 24 wt% Cr, 1.0 to 2.5 wt% Nb, and 0.5 to 3.5 wt% W in addition to Fe. The austenitic heat-resistant cast steel of the present invention has excellent tensile strength and elongation at high temperature, and thus is very suitable for a turbine housing for a turbocharger operated in a high temperature environment (maximum 950 to 1050 °C) of 800 to 900 °C.
- [27] C is known as a potent austenite-stabilizing atom and solution-strengthened to a matrix structure, and serves as an important role for an intensity at high temperature. In addition, C is bound to a carbide former such as Cr or Nb, thereby forming a carbide, and therefore, castability of a liquid is enhanced and a high temperature strength is enhanced. To obtain an effect of the C, 0.4% to 0.5 wt% C is added.
- [28] Si has an effect of enhancing high temperature oxidation resistance, and serves as a deoxidizer in a melt of an alloy. Si serves to help to prevent oxidation by Cr, and enhances oxidation resistance. Silica particles formed by Si are precipitated under a film formed on a surface of the alloy by Cr to help in forming of the passivation film, and inhibit unnecessary escape of Cr ions.
- [29] Particularly, such an effect of Si is further reinforced at high temperature. To obtain such an effect of Si, 1.0 wt% or more Si should be added. However, Si reduces high temperature creep resistance when excessively added, and serves as a ferrite-stabilizing atom to make an austenite matrix structure unstable. Accordingly, Si is added lower

than 2%. Therefore, an Si content is limited to 1.0 to 2.0%.

- [30] Mn serves as an austenite-stabilizing atom, and as a deoxidizer in a melt, which is similar to Si. However, since Mn reduces oxidation resistance and a creep strength, 2.0 wt% or more Mn is not included.
- [31] Ni serves as a potent austenite-stabilizing atom, and a large amount of Ni is added to an austenite-based stainless steel (STS).
- [32] When Ni is added to the stainless steel, tension and elongation are increased, and the alloy has excellent performance in corrosion resistance and high temperature stabilization. To obtain such an effect of Ni, 90 wt% or more Ni should be added. However, Ni is an expensive atom, and thus not more than 12.0 wt% Ni is added in consideration of an economical aspect.
- [33] Cr is the most critical atom for excellent oxidation resistance and corrosion resistance of the stainless steel, and forms a stable passivation film having a formula of Cr_2O_3 on a surface of the alloy to enhance corrosion resistance.
- [34] As a content of Cr is increased, the corrosion resistance is increased, and it contributes to enhancement of oxidation resistance and corrosion resistance at high temperature. To enhance excellent corrosion resistance, Cr may be added at 21.0 wt% or more. Cr is a ferrite-stabilizing atom to form a ferrite phase when excessively added, and forms a large amount of carbides, and thus the Cr content is limited to 24.0 wt% or less.
- [35] Nb is bound to C to form a carbide which is not degraded at high temperature, and therefore, enhances high temperature intensity and high temperature creep resistance. In addition, the oxidation resistance is enhanced by inhibiting formation of Cr-carbide by the bond of Cr and C.
- [36] Nb-carbide is formed in an eutectic type to enhance castability, and effective to manufacture a cast having a complicated form such as an automotive exhaust system. For such an effect, 1 wt% or more Nb is added.
- [37] However, when excessively added, Nb form a large amount of Nb carbides at a cell interface to make the alloy brittle, and to reduce intensity and ductility. Therefore, 1.0 to 2.5 wt% Nb is added.
- [38] W is an atom having a high temperature reinforcing effect, and added to the heat-resistant stainless steel in a large amount. W should be added at 0.5 wt% or more to enhance a high temperature intensity by being employed in a matrix tissue. However, W is an expensive atom, and bound to C to form a carbide in the form of M_2C or M_7C_3 when excessively added, and thus an input amount of W is limited to 3.5 wt%.
- [39] In such an austenite heat-resistant cast steel, 0.04 wt% or less P (not including 0) and 0.15 wt% or less S (not including 0) may be further included.
- [40] S forms a sulfide such as MnS in the alloy to enhance processibility of the alloy.

However, since such a sulfide reduces total physical properties of the alloy, a content of S may be limited to 0.15% or less, and since P generates segregation in the alloy to have a negative influence on the alloy, a content of P may be limited to 0.04 wt% or less.

- [41] C of the heat-resistant stainless steel composition described above prevents precipitation of a large amount of processable Cr carbides, and a content of C may be limited in a range of 0.42 to 0.48 wt% to improve processability.
- [42] Here, Si may be used in a range of 1.25 to 1.75 wt% to stabilize an austenite matrix tissue and increase high temperature creep resistance, and Nb may be used in a range of 1.2 to 2.2 wt% to improve oxidation resistance and brittleness.
- [43] Nb may be used in a range of 1.2 to 22 wt% to increase improvement of oxidation resistance and brittleness according to an embodiment.
- [44] In addition, in the austenitic heat-resistant cast steel, W is bound to C to form a carbide when excessively added, and thus may be used in a range of 0.8 to 2.2 or 2.2 to 3.5 wt%.
- [45] The austenitic heat-resistant cast steel described above can be used at the maximum available temperature of 800 to 900 °C and an exhaust gas temperature at 950 to 1050 °C. Accordingly, the austenitic heat-resistant cast steel according to the present invention may be suitably used for the housing of a turbocharger in direct contact with exhaust gas.
- [46] Table 1 show composition ratios (unit: wt%) of components of the austenitic heat-resistant cast steels in Examples 1 to 3 and Comparative Example according to the present invention.
- [47]
- [48] Table 1

[Table 1]

	C	Si	Mn	P	S	Ni	Cr	Nb	W
Examp e1	0.45	1.5	1.5	0.04	0.15	10	22	1.5	1
Examp e2	0.45	1.5	1.5	0.04	0.15	10	22	1.5	2
Examp e3	0.45	1.5	1.5	0.04	0.15	10	22	1.5	3
Compa rative Examp e	0.44	1.17	0.69	0.04	0.14	9.8	20.1	1.22	2.53

[49] In Examples 1, 2 and 3, austenite heat-resistant stainless steel disclosed in the present invention is used, and in Comparative Example, conventional heat-resistant cast steel is used.

[50] Test results for Examples 1, 2, and 3 and Comparative Example are shown in FIGS. 1 and 2, FIG. 1 is a graph showing a result for a room temperature tensile test according to an embodiment of the present invention, and FIG. 2 is a graph showing a result for a high temperature tensile test according to an embodiment of the present invention.

[51] As a tensile test piece for the tensile test, the specification of a bar-type test piece according to ASTM E8 as shown in FIG. 3, and the specification of the tensile test piece is the same as shown in Table 2, and a unit is an inch.

[52] Table 2

[Table 2]

Length of reduced section (A)	diameter (D)	gage length (G)	radius of filet (R)
1.25	0.250±0.005	1.0±0.005	3/16

[53] The tensile test was performed at room temperature (approximately 25 °C) and high temperature (900 °C) according to ASTM E8.

[54] The test results are shown in Table 3 and FIGS. 1 and 2.

[55] Table 3

[Table 3]

	Room temperature			900 °C		
	Yield strength (MPa)	Tensile strength (MPa)	Elongation (%)	Yield strength (MPa)	Tensile strength (MPa)	Elongation (%)
Example 1	393	635	7.9	156	185	30.3
Example 2	405	639	7.7	172	203	25.3
Example 3	388	647	7.5	170	205	31.4
Comparative Example	365	548	7.0	149	177	30.0

[56] It can be seen from the room temperature and high temperature tensile tests that the yield strength and tensile strength at room temperature are increased 6.3 to 10.96%, 12.88 to 18.07% of those in Comparative Example, and the room temperature elongation is also improved.

[57] It can also be seen that the yield strength and tensile strength at high temperature are increased 4.70 to 15.82%, 4.52 to 14.69% of those in Comparative Example.

[58] In addition, referring to FIG. 4 showing the Schaeffler diagram according to an embodiment of the present invention, it can be seen that the austenite stability is increased, and the yield strength and tensile strength at high temperature are increased.

[59] According to an austenitic heat-resistant cast steel and a housing for a turbocharger manufactured using the same of the present invention as described above, the housing of a turbocharger including the minimum amount of expensive Ni and having enhanced required durability at room temperature can be manufactured.

[60] Description for presented exemplary embodiments is provided to use or realize the present invention by those of ordinary skill in the art. Various modifications for such exemplary embodiments are apparent to those of ordinary skill in the art, and general principles defined herein may be applied to other exemplary embodiments without departing from the scope of the invention. Therefore, while the present invention has been shown and described with reference to certain exemplary embodiments thereof, it will be understood in the most wide range corresponding to the principles and new characteristics disclosed herein.

[61]

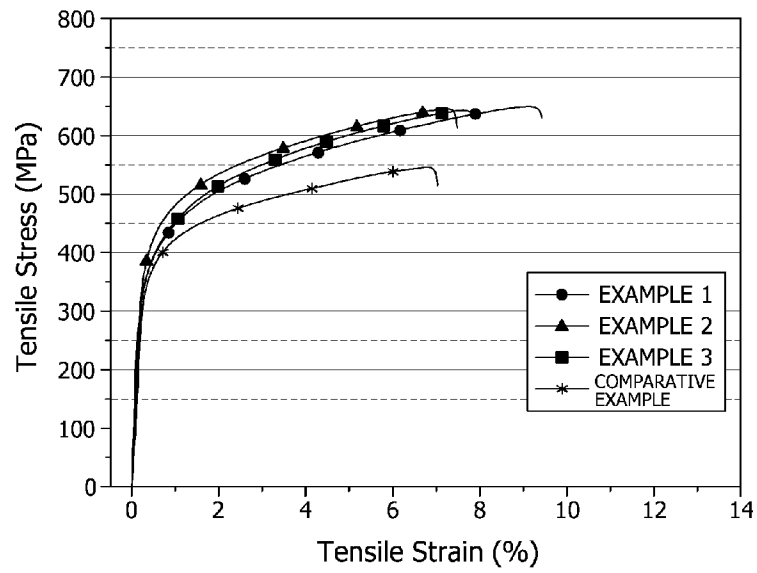
[62]

Claims

- [Claim 1] An austenitic heat-resistant cast steel, comprising:
0.4 to 0.5 wt% carbon (C), 1.0 to 2.0 wt% silicon (Si), 1.0 to 2.0 wt% manganese (Mn), 9.0 to 12.0 wt% nickel (Ni), 21 to 24 wt% chromium (Cr), 1.0 to 2.5 wt% niobium (Nb), 0.5 to 3.5 wt% tungsten (W), remainder iron (Fe), and other inevitable impurities.
- [Claim 2] The stainless steel according to claim 1, further comprising:
more than 0 to 0.04 wt% phosphor (P) and more than 0 to 0.15 wt% sulfur (S).
- [Claim 3] The stainless steel according to claim 1 or 2, which includes 0.42 to 0.48 wt% C, 1.25 to 1.75 wt% Si and 1.2 to 2.5 wt% Nb.
- [Claim 4] The stainless steel according to claim 3, which includes 1.2 to 2.2 wt% Nb.
- [Claim 5] The stainless steel according to claim 3, which includes 0.8 to 2.2 wt% W.
- [Claim 6] The stainless steel according to claim 3, which includes more than 2.2 to 3.5 wt% W.
- [Claim 7] A housing for a turbocharger, comprising:
0.42 to 0.48 wt% C, 1.25 to 1.75 wt% Si, 1.0 to 2.0 wt% Mn, 9.0 to 12.0 wt% Ni, 21 to 24 wt% Cr, 1.2 to 2.2 wt% Nb, 0.5 to 2.5 wt% W, remainder Fe, and other inevitable impurities.
- [Claim 8] The housing according to claim 7, which includes 0.8 to 2.2 wt% W.
- [Claim 9] The housing according to claim 7, which includes more than 2.2 to 3.5 wt% W.

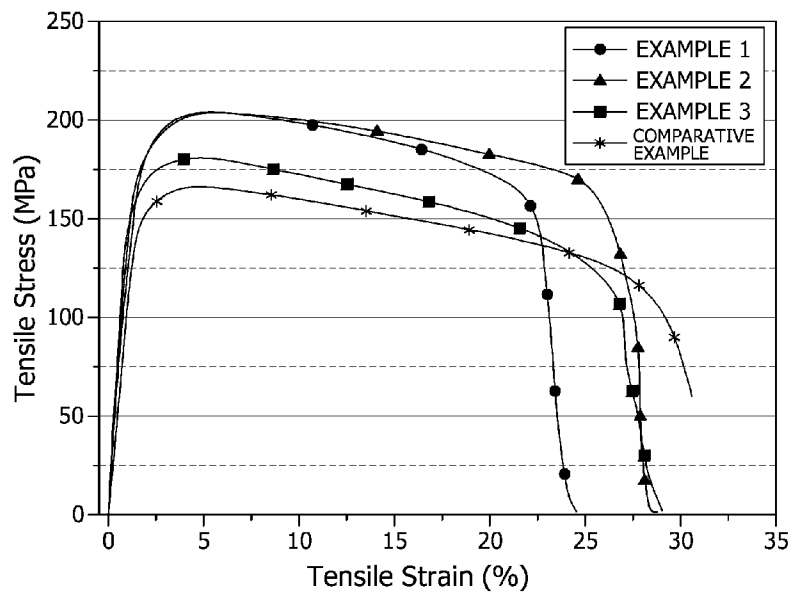
[Fig. 1]

ROOM TEMPERATURE

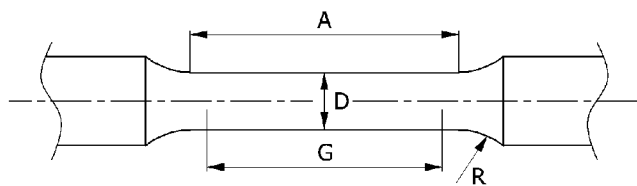


[Fig. 2]

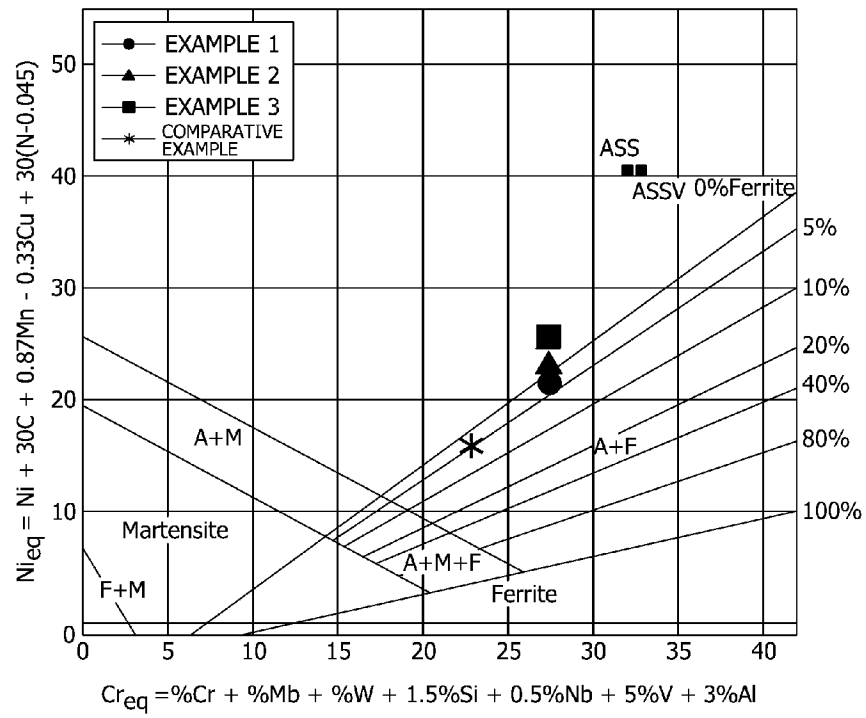
900°c



[Fig. 3]



[Fig. 4]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2015/000718**A. CLASSIFICATION OF SUBJECT MATTER****C22C 38/58(2006.01)i, C22C 38/44(2006.01)i, C22C 38/48(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
C22C 38/58; C21D 8/02; B22D 11/00; C22C 38/00; C22C 38/60; C22C 38/48; C22C 38/44Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: cast steel, austenitic heat-resistance, carbon, silicon, manganese, nickel, chromium, niobium, tungsten, and iron**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 54-096418 A (TOYOTA MOTOR CORP.) 30 July 1979 See abstract; and page 2, upper left column, line 11 - page 3, upper right column, line 14.	1-9
A	JP 07-278759 A (HITACHI METALS LTD.) 24 October 1995 See abstract; paragraphs [0015]-[0030]; and claim 1.	1-9
A	US 5501835 A (WATANABE, RIKIZOU et al.) 26 March 1996 See abstract; column 3, line 2 - column 5, line 55; and claim 1.	1-9
A	KR 10-2010-0113520 A (HITACHI METALS LTD.) 21 October 2010 See abstract; paragraphs [0038]-[0060]; and claim 1.	1-9
A	JP 09-287022 A (DAIDO STEEL CO., LTD.) 04 November 1997 See abstract; paragraphs [0030]-[0041]; and claims 4, 5.	1-9

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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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