(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 985 820 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
29.10.2008 Bulletin 2008/44

(21) Application number: **07714523.3**

(22) Date of filing: **19.02.2007**

(51) Int Cl.:
F01N 7/10 *(2006.01)* ***B22C 9/24*** *(2006.01)*

(86) International application number:
PCT/JP2007/052997

(87) International publication number:
WO 2007/094500 (23.08.2007 Gazette 2007/34)

(84) Designated Contracting States:
DE FR IT

(30) Priority: **17.02.2006 JP 2006040499**

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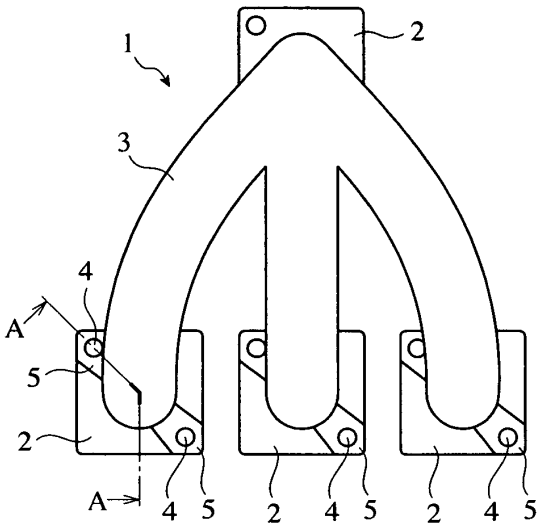
(54) HEAT-RESISTANT CAST STEEL EXHAUST MANIFOLD

(57) An exhaust manifold made of heat-resistant cast steel comprising pluralities of flanges each having a hole connected to each exhaust port of a cylinder head of an engine with bolts, pluralities of ports connected to the flanges, and a convergence portion in which the ports are converging, the thickness of the flanges being 80-150% of that of the ports.

Fig. 1(a)



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an exhaust manifold made of heat-resistant cast steel, which can be produced with a small number of steps at a high yield, and has small weight and excellent thermal deformation resistance.

BACKGROUND OF THE INVENTION

[0002] The exhaust manifold for gathering an exhaust gas from an engine and sending it to an exhaust pipe comprises pluralities of flanges each having a hole connected to each exhaust port of a cylinder head of an engine with bolts, a port connected to each flange, and a convergence portion in which pluralities of ports are converging. To prevent the thermal deformation of flanges by a high-temperature exhaust gas, the flanges are generally thicker than the ports in the exhaust manifold (Fig. 2) as described in JP 10-26018 A. For instance, the flanges have an average thickness of about 12 mm, and the ports have an average thickness of about 5 mm. In casting such exhaust manifold, voids are likely generated in the finally solidified flanges.

[0003] As automobile engines are recently required to have increasingly higher performance and fuel efficiency, an exhaust gas temperature has been elevating. To secure high-temperature strength and oxidation resistance at 900°C or higher, the exhaust manifold is made of heat-resistant cast steel. However, voids are likely to generate because the cast steel suffers large solidification shrinkage during casting. To cope with this problem, each flange is provided with a riser 6 as shown in Fig. 3, so that a melt is supplied to the flange during solidification. However, risers are not used as part of the products, resulting in a lower yield per the melt used. Further, risers should be removed after casting, a larger number of steps is needed.

OBJECT OF THE INVENTION

[0004] Accordingly, an object of the present invention is to provide an exhaust manifold made of heat-resistant cast steel, which can be produced with a small number of steps at a high yield, and has small weight and excellent thermal deformation resistance.

DISCLOSURE OF THE INVENTION

[0005] The exhaust manifold of the present invention made of heat-resistant cast steel comprises pluralities of flanges each having a hole connected to each exhaust port of a cylinder head of an engine with bolts, pluralities of ports connected to the flanges, and a convergence portion in which the ports are converging, the thickness of the flanges being 80-150% of that of the ports.

[0006] Hole-surrounding portions are preferably 110-300% as thick as the flanges.

[0007] The exhaust manifold preferably has a ridge extending along each port from the convergence portion. The thickness of the ridges is 70-140% of that of the ports.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1(a) is a schematic plan view showing the exhaust manifold of the present invention made of heat-resistant cast steel.

[0009] Fig. 1(b) is a cross-sectional view taken along the line A-A in Fig. 1(a).

[0010] Fig. 2(a) is a schematic plan view showing a conventional exhaust manifold.

[0011] Fig. 2(b) is a cross-sectional view taken along the line B-B in Fig. 2(a).

[0012] Fig. 3 is a schematic view showing a riser provided for casting a conventional exhaust manifold.

[0013] Fig. 4(a) is a schematic plan view showing a preferred example of the exhaust manifolds of the present invention made of heat-resistant cast steel.

[0014] Fig. 4(b) is a schematic front view showing another preferred example of the exhaust manifolds of the present invention made of heat-resistant cast steel.

[0015] Fig. 4(c) is a schematic side view showing a further preferred example of the exhaust manifolds of the present invention made of heat-resistant cast steel.

[0016] Fig. 5 is a cross-sectional view showing a ridge.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] In the present invention, the thickness of flanges, ports and bolthole-surrounding portions is expressed by an average value. The bolthole-surrounding portion in the flange has a thickness t_3 as shown in Fig. 1(b). The ridge has a thickness t_4 in a cross section perpendicular to a longitudinal direction as shown in Fig. 5.

[0018] As shown in Fig. 1, because the flanges 2 are 80-150% as thick as the ports 3, the flanges 2, finally solidified portions, are less likely to have voids. Accordingly, each flange 2 need not be provided with a riser, making it possible to produce the exhaust manifold with a smaller number of steps at a higher yield. When the thickness of the flanges 2 is less than 80% of that of the ports 3, the flanges 2 are not easily filled with a melt, resulting in insufficient melt flow. When the flanges 2 are more than 150% as thick as the ports 3, the flanges 2 are likely to have voids. The flanges 2 are preferably 85-130% as thick as the ports 3. Although each flange 2 and the surrounding portion 5 of each bolthole 4 after casting and before machining are thicker by a predetermined machining margin 7, the thickness t_1 of the flange 2 and the thickness t_3 of the surrounding portion 5 of the bolthole 4 are expressed as thickness from the surface 21 of the flange 2 after machining in the present invention, as shown in Fig. 1(b).

[0019] Because the thickness of the surrounding portions 5 of the boltholes 4 is 110-300% of that of the flanges 2, the flanges 2 are not easily thermally deformed even if the exhaust manifold is exposed to a high-temperature exhaust gas. Thus, an exhaust gas is prevented from flowing out through gaps between the exhaust ports of a cylinder head and the flanges 2 of the exhaust manifold. When the surrounding portions 5 of the boltholes 4 are less than 110% as thick as the flanges 2, the flanges 2 are easily thermally deformed by a high-temperature exhaust gas. When it exceeds 300%, voids are likely generated in the flanges 2 during casting.

[0020] When an ridge 11 extends along each port 3 from the convergence portion 8 to each flange 2 as shown in Fig. 4(a), the ports 3 are not thermally deformed even if exposed to a high-temperature exhaust gas, thereby preventing an exhaust gas from leaking. The thickness t_4 of the ridge 11 is preferably 70-140% as thick as the port 3. When t_4 is less than 70% of the thickness of the ports 3, the thermal deformation of the ports 3 cannot be sufficiently prevented. When t_4 exceeds 140%, the exhaust manifold cannot be made light in weight. The thickness t_4 of the ridges 11 is preferably 80-120% as thick as the ports 3. Instead of extending along each port 3 from the convergence portion 8 to each flange 2 as shown in Fig. 4(a), the ridges 11 may extend from the convergence portion 8 to the branching portions of the ports 3 as shown in Figs. 4(b) and 4(c).

[0021] To have small weight and excellent thermal deformation resistance, the heat-resistant-cast-steel-made exhaust manifold of the present invention is preferably made of, for instance, heat-resistant, austenitic cast steel comprising by mass 0.2-1.0% of C, 0.05-0.6% of (C-Nb/8), 2% or less of Si, 2% or less of Mn, 8-20% of Ni, 15-30% of Cr, 0.5-6.0% of Nb, 1-6% of W, 0.01-0.3% of N, and 0.01-0.5% of S, the balance being Fe and inevitable impurities.

[0022] The present invention will be explained in more detail referring to Examples below without intention of restricting the scope of the present invention.

[0023] Examples 1-14 and Comparative Examples 1-3

[0024] Exhaust manifolds shown in Fig. 1 were formed by heat-resistant, austenitic cast steel having a composition comprising by mass 0.45% of C, 1.2% of Si, 1.0% of Mn, 0.015% of P, 0.015% of S, 10% of Ni, 20% of Cr, 1.5% of Nb, and 3.0% of W (Examples 1-8 and Comparative Examples 1-3). The thickness t_1 of a flange 2, the thickness t_2 of a port 3, and the thickness t_3 of an surrounding portion 5 of a bolthole 4 are shown in Table 1. Exhaust manifolds shown in Fig. 4(a) were also formed by the same heat-resistant, austenitic cast steel as above (Examples 9-14). The thickness t_4 of ridges 11 is shown in Table 1 together with t_1 to t_3.

[0025] With respect to each exhaust manifold, a yield (number of steps), and the thermal deformation of the flanges during use were evaluated as follows: The results are shown in Table 1.

[0026] (1) Evaluation of yield (number of steps)

Good: Good casting free from voids was conducted without providing a riser to each flange 2.

Poor: Good casting could not be conducted without providing a riser to each flange 2. Because the risers were used, they had to be cut after casting.

[0027] (2) Each exhaust manifold was connected to exhaust ports of a cylinder head of a usual engine, to evaluate the thermal deformation of flanges when the engine was operated.

Excellent: Thermal deformation did not occur in both of the ports 3 and the flanges 2.

Good: Thermal deformation did not occur in the flanges 2, causing no leak of an exhaust gas.

Fair: Thermal deformation occurred slightly in the flanges 2, but there was no leak of an exhaust gas.

Poor: Thermal deformation occurred in the flanges 2, causing the leak of an exhaust gas.

[0028]

Table 1

No.	Thickness (mm)			Thickness Ratio (%)	
	Flange t_1	Port t_2	Surrounding Portion t_3	t_1/t_2	t_3/t_1
Example 1	2.5	3.0	5.0	83	200
Example 2	3.0	3.0	6.0	100	200
Example 3	3.0	3.0	3.0	100	100
Example 4	3.5	4.0	5.3	88	151
Example 5	4.0	4.0	8.0	100	200
Example 6	5.0	4.0	12.5	125	250
Example 7	5.0	5.0	7.5	100	150
Example 8	6.0	5.0	12.0	120	200
Example 9	2.5	3.0	5.0	83	200
Example 10	3.0	3.0	6.0	100	200
Example 11	3.0	3.0	3.0	100	100
Example 12	4.0	4.0	8.0	100	200
Example 13	5.0	5.0	7.5	100	150
Example 14	6.0	5.0	12.0	120	200
Comparative Example 1	10.0	4.0	10.0	250	100
Comparative Example 2	2.0	4.0	2.0	50	100
Comparative Example 3	3.0	5.0	6.0	60	120

[0029]

Table 1 (Continued)

No.	Thickness t_4 (mm) of Ridge	t_4/t_2 (%)	Yield (Number of Steps)	Thermal Deformation
Example 1	-	-	Good	Good
Example 2	-	-	Good	Good
Example 3	-	-	Good	Fair
Example 4	-	-	Good	Good
Example 5	-	-	Good	Good
Example 6	-	-	Good	Good
Example 7	-	-	Good	Good
Example 8	-	-	Good	Good
Example 9	2.0	80	Good	Excellent
Example 10	3.0	100	Good	Excellent
Example 11	3.6	120	Good	Good
Example 12	4.0	100	Good	Excellent
Example 13	5.0	100	Good	Excellent
Example 14	6.0	120	Good	Excellent
Comparative Example 1	-	-	Poor	Good
Comparative Example 2	-	-	Good	Poor
Comparative Example 3	-	-	Good	Poor

[0030] As is clear from Table 1, the exhaust manifolds of the present invention having flanges 80-150% as thick as ports were produced free from voids without providing risers, and suffered only small thermal deformation during use. Examples 1, 2 and 4-8, in which the bolthole-surrounding portions were 110-300% as thick as the flanges, suffered small thermal deformation. The exhaust manifolds of Examples 9-14 each having ridges extending along the ports from the convergence portion suffered smaller thermal deformation.

EFFECT OF THE INVENTION

[0031] The exhaust manifold of the present invention made of heat-resistant cast steel and having the above structure, which has small weight and excellent thermal deformation resistance, can be efficiently produced with a small number of steps.

Claims

1. An exhaust manifold made of heat-resistant cast steel comprising pluralities of flanges each having a hole connected to each exhaust port of a cylinder head of an engine with bolts, pluralities of ports connected to said flanges, and a convergence portion in which said ports are converging, the thickness of said flanges being 80-150% of that of said

ports.

2. The exhaust manifold made of heat-resistant cast steel according to claim 1, wherein hole-surrounding portions are 110-300% as thick as said flanges.

3. The exhaust manifold made of heat-resistant cast steel according to claim 1 or 2, which has a ridge extending along each port from said convergence portion.

4. The exhaust manifold made of heat-resistant cast steel according to claim 3, wherein the thickness of said ridges is 70-140% of that of said ports.

Fig. 1(a)

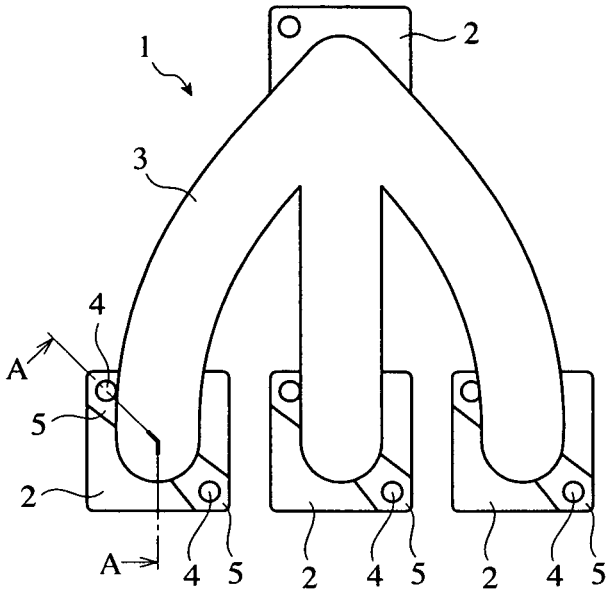


Fig. 1(b)

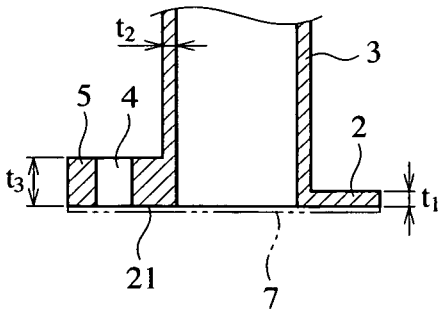


Fig. 2(a)

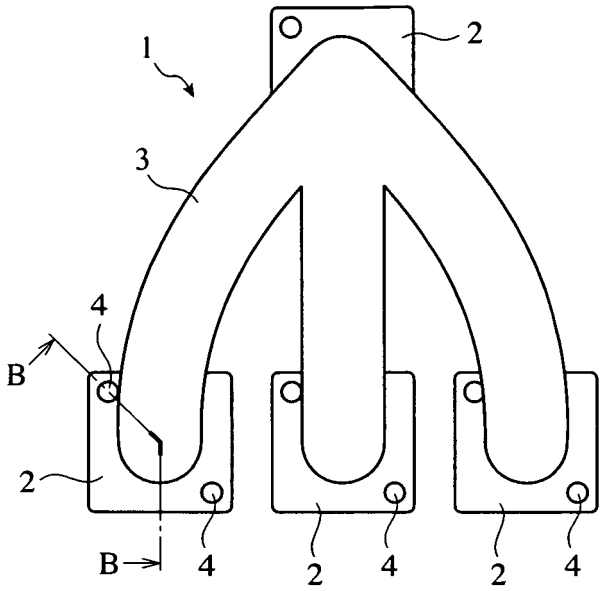


Fig. 2(b)

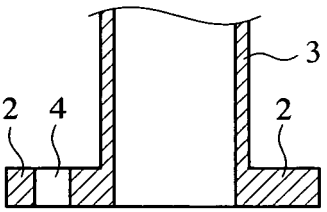


Fig. 3

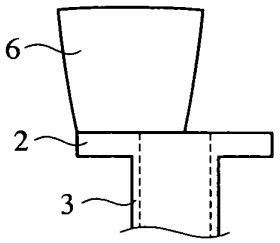


Fig. 4(a)

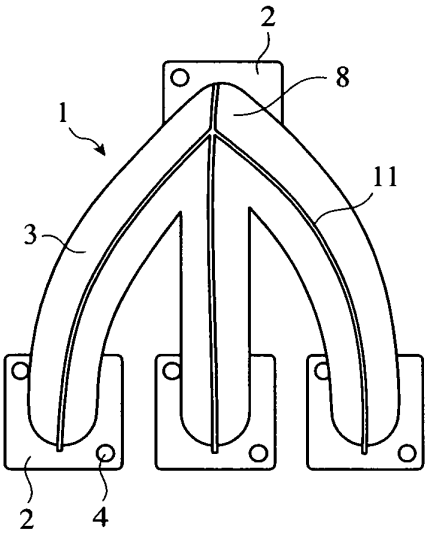


Fig. 4(b)

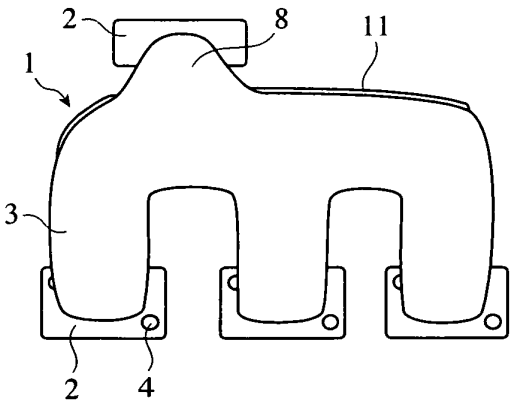


Fig. 4(c)

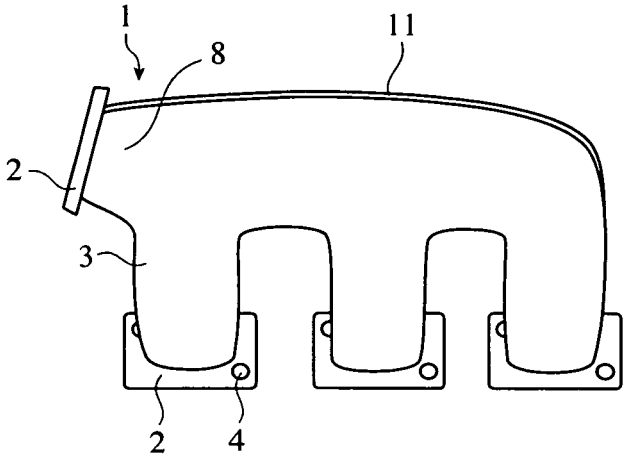
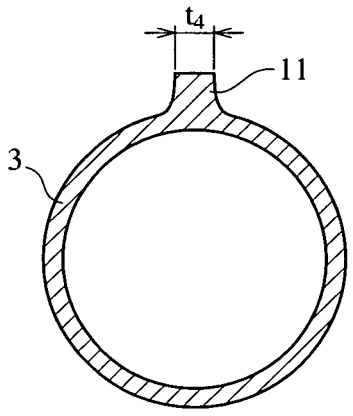


Fig. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/052997

A. CLASSIFICATION OF SUBJECT MATTER
F01N7/10(2006.01)i, *B22C9/24*(2006.01)i

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)
F01N7/10, B22C9/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2007
Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 63439/1991(Laid-open No. 58120/1994) (Honda Motor Co., Ltd.), 12 August, 1994 (12.08.94), Claim 1; Par. Nos. [0027] to [0028]; Figs. 1, 2, 4 (Family: none)	1-4
Y	JP 2002-309935 A (Hitachi Metals, Ltd.), 23 October, 2002 (23.10.02), Par. No. [0003] (Family: none)	1-4

☒ Further documents are listed in the continuation of Box C. ☐ 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
11 May, 2007 (11.05.07)	22 May, 2007 (22.05.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/052997

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-90287 A (Honda Motor Co., Ltd.), 07 April, 2005 (07.04.05), Par. Nos. [0004], [0008] (Family: none)	1-4
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 25231/1987(Laid-open No. 132825/1988) (Toyota Motor Corp.), 30 August, 1988 (30.08.88), Page 2, lines 6 to 19; Figs. 6, 7 (Family: none)	3-4

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 10026018 A **[0002]**