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(54) HEAT TRANSFER ELEMENT FOR MANIFOLD

(57) Provided is a heat transfer element for manifold that enables the prevention of thermal fatigue of a manifold main body and has good high-temperature strength and oxidation resistance.

At least one part of the heat transfer element for manifold 11 is formed from ferritic stainless steel. The ferritic stainless steel contains at least one element, in terms of mass%, of: C: 0.03% or less; Si: 2.0% or less; Mn: 2.0% or less; Cr: 10 to 30%; Nb: 0.8% or less; and Ti: 0.8% or less, and N: 0.03% or less, and the remaining part thereof is formed from Fe and inevitable impurities. Further, an alloy content of the ferritic stainless steel is adjusted so that an A value in equation (1), where A value = Nb + Ti - 4(C + N), is 0.10 or more, and a B value in equation (2), where B value = Cr + 15Si, is 18 or more.

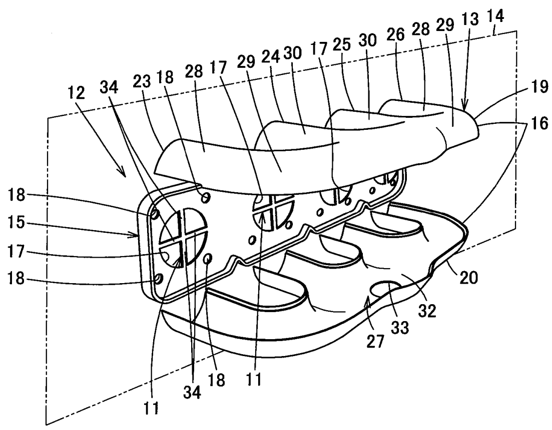

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a heat transfer element for manifold for transferring heat of exhaust gas to a manifold main body, in an exhaust manifold for guiding high-temperature exhaust gas from an engine to a manifold converter, an exhaust pipe, etc.

BACKGROUND ART

[0002] Conventionally, in an exhaust manifold, exhaust gas from an engine is flown into a manifold main body through a flange, and the flown-into exhaust gas is collected in a collection part after which it is flown out from an outlet of the collection part to a manifold converter, an exhaust pipe, etc.

[0003] In such an exhaust manifold, at an upstream side, that is, an engine side of the manifold main body, a contact surface of a flange is cooled as the engine is cooled by water, a heat transfer from the exhaust gas, prevents a material temperature from rising; however, due to the heat transfer from the exhaust gas, the material temperature increases as it goes down to a downstream side, that is, a collection part side of the manifold main body. As a result, at the downstream side of the manifold main body, heat extraction effect of the exhaust gas by the exhaust manifold deteriorates, and in the collection part or in the vicinity thereof, a thermal strain along with the temperature rise is generated, resulting in destruction of so-called "thermal fatigue." In particular, because the exhaust gas temperature of the engine tends to rise, in recent years, from the viewpoint of fuel efficiency and environmental measures, it has become important to prevent thermal fatigue of the manifold main body.

[0004] To solve this, ferritic stainless steel is known as a material of an exhaust manifold, in which heat resistance is improved (see Patent Literature 1, for example).

CITATION LIST

Patent Literature

[0005]

PTL 1: Japanese Patent Application No. 6-88168 (pages 3 to 6, and Fig. 1)

SUMMARY OF INVENTION

Technical Problem

[0006] However, it is expected that the temperature of the exhaust gas will further rise due to further improvements in engines in the future, for example, and therefore, it is important not only to improve the heat resistance from the viewpoint of a material, as described above, but also to prevent thermal fatigue of the manifold main body from the viewpoint of the structure of an exhaust manifold.

[0007] The present invention has been achieved in view of these points, and an object thereof is to provide a heat transfer element formanifold with which it is possible to prevent thermal fatigue of a manifold main body and which has good high-temperature strength and oxidation resistance.

Solution to Problem

[0008] A heat transfer element for manifold according to claim 1 is that which is located at least at the upstream side of a manifold main body through which exhaust gas flows from the engine in an exhaust manifold, and which transfers heat of the exhaust gas from the engine to the manifold main body, wherein at least one part thereof contains at least one element, in terms of mass%, of : C:0.03% or less; Si:2.0% or less; Mn: 2.0% or less; Cr: 10 to 30%; Nb: 0.8% or less, and Ti: 0.8% or less, and N: 0.03% or less, and the remaining part thereof is formed from Fe and inevitable impurities, and the heat transfer element for manifold is formed from ferritic stainless steel in which an alloy content is adjusted so that an A value in equation (1) is 0.10 or more, where A value = Nb + Ti - 4(C + N), and a B value in equation (2) is 18 or more, where B value = Cr + 15Si.

[0009] The heat transfer element for manifold according to claim 2, wherein in the heat transfer element for manifold according to claim 1, the ferritic stainless steel contains at least one element, in terms of mass%, of: Cu: 3.0% or less; Mo: 3.0% or less; and W: 3.0% or less.

Advantageous Effects of Invention

[0010] The present invention enables the prevention of thermal fatigue of a manifold main body by transferring heat of exhaust gas to the manifold main body to decrease a temperature of the exhaust gas and has good high-temperature strength and oxidation resistance.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

[Fig. 1] A perspective view showing the configuration of an exhaust manifold in which a heat transfer element for manifold according to one embodiment of the present invention.
[Fig. 2] A perspective view showing a modified example of the above heat transfer element for manifold.
[Fig. 3] A perspective view showing the modified example of the above heat transfer element for manifold.
[Fig. 4] A perspective view showing another modified example of the above heat transfer element for manifold.
[Fig. 5] A perspective view showing another modified example of the above heat transfer element for manifold.
[Fig. 6] A perspective view showing another modified example of the above heat transfer element for manifold.
[Fig. 7] A table showing structures of an exhaust manifold and a heat transfer element for manifold used in a heat test.

DESCRIPTION OF EMBODIMENTS

[0012] The configuration of one embodiment of the present invention will be described in detail with reference to Fig. 1 to Fig. 6, below.
[0013] In Fig. 1, reference numeral 11 denotes a heat transfer element for manifold, and the heat transfer element for manifold 11 is arranged in a manifold main body 13 of an exhaust manifold 12.
[0014] The manifold main body 13 is provided with a flange 15 attached to an engine 14, and a tube-shaped tubular body 16 connected to the flange 15.
[0015] The flange 15 is formed in an approximately rectangular shape so that a plurality, four, for example, of circular inlets 17 are arranged and separated from one another and aligned along the lengthwise direction at an approximately central portion in the widthwise direction. These inlets 17 are communicated to an exhaust port (not shown) of the engine 14. Further, in the vicinity of both ends in the widthwise direction of the flange 15, eight circular bolt holes 18 are each formed and separated from one another along the lengthwise direction. The flange 15 is fixed into the bolt hole 18 while in direct contact with the engine 14 by screwing a bolt (not shown) thereinto.
[0016] The tubular body 16 is configured from an upper first press material 19 and a lower second press material 20, which are press-molded. The tubular body 16 is a so-called "monaka structure" to have a plurality, four, for example, of tube-shaped tubular parts 23, 24, 25, and 26, which correspond to the number of the inlets 17, and a collection part 27 integrally arranged in these tubular parts 23, 24, 25, and 26. Further, one ends of the tubular parts 23, 24, 25, and 26 are connected to the inlets 17, respectively, and other ends thereof are connected to the collection part 27 so as to form an aggregate.
[0017] The tubular parts 23 and 26 located outside, out of the tubular parts 23, 24, 25, and 26, have a straight tubular part 28 extending approximately linearly from the inlet 17 to the downstream side, and a curved tubular part 29 that is curved from the straight tubular part 28 to the approximately vertical direction and connected to the collection part 27.
[0018] Further, the tubular parts 24 and 25 located inside, out of the tubular parts 23, 24, 25, and 26, have a straight tubular part 30 extending approximately linearly from the inlet 17 to the collection part 27.
[0019] The collection part 27 has a collected tubular part 32 at which the other ends, that is the downstream side, of the tubular parts 23, 24, 25, and 26 are collected, and a circular outlet 33 formed on the bottom surface of the collected tubular part 32. To the outlet 33, a manifold converter and an exhaust pipe not shown are connected.
[0020] Inside the manifold main body 13, the inlets 17, the tubular parts 23, 24, 25, and 26, and the collection part 27 serve as a passage of exhaust gas from the engine 14. That is, the exhaust gas passage inside the manifold main body 13 is configured by the inlets 17 located in order from the upstream side to the downstream side, the tubular parts 23, 24, 25, and 26, the collected tubular part 32, and the outlet 33.
[0021] The heat transfer element for manifold 11 is arranged in the inlet 17 so as to be located at the upstream side of the manifold main body 13, and comes into contact with the exhaust gas from the engine 14 in the exhaust gas passage.
[0022] The heat transfer element for manifold 11 has four rod-shaped heat transfer parts 34 integrally connected to the rim of the inlet 17, and is formed in an approximately cross shape where these heat transfer parts 34 cross approximately vertically. Further, the heat transfer element for manifold 11 is formed concurrently with the inlets 17 by punching, at the time of pressing the flange 15.
[0023] The heat transfer element for manifold 11 is formed from ferritic stainless steel which contains at least one

element, in terms of mass%, of: C: 0.03% or less; Si: 2.0% or less; Mn: 2.0% or less; Cr: 10 to 30%; Nb: 0.8% or less, and Ti: 0.8% or less, and N:0.03% or less, in which the remaining part is formed from Fe and inevitable impurities, and in which an alloy content is adjusted so that an A value in equation (1) is 0.10 or more, where A value = Nb + Ti - 4 (C + N), and a B value in equation (2) is 18 or more, where B value = Cr + 15Si.

[0024] Herein, each alloy content configuring the ferritic stainless steel and an amount of the alloy content will be described. It should be noted that the amount of each alloy content is expressed by mass%, unless otherwise specified.

[0025] C (carbon) and N (nitrogen) are elements effective, generally, for improving the high-temperature strength such as a creep strength; however, when these elements are contained excessively to exceed 00.3%, the oxidation characteristic, the processability, the low-temperature tenacity, and the weldability deteriorate. Therefore, the contents of C and N are set to 0.03% or less, respectively.

[0026] Si (silicon) is an element effective for improving the high-temperature oxidation characteristic; however, when Si is excessively contained to exceed 2.0%, the hardness rises and the processability and the low-temperature tenacity deteriorate. Therefore, the content of Si is set to 2.0% or less.

[0027] Mn (manganese) is an element effective for improving the high-temperature oxidation characteristic, in particular, the scale peelability; however, when Mn is excessively contained to exceed 2.0%, the processability and the weldability deteriorate. Further, Mn is an austenite stabilizer, and thus, when a large amount thereof is added, a martensitic phase tends to be generated, resulting in a thermal fatigue characteristic and a deterioration in the processability. Therefore, the content of Mn is set to 2.0% or less.

[0028] Cr (chromium) is an element effective for stabilizing a ferrite phase and for improving the oxidation resistance, which is important for a high-temperature material. In order that these effects are sufficiently exhibited, it is preferable to contain 10% or more. On the other hand, when it is contained excessively to exceed 30%, embrittlement or deterioration in the processability results. Therefore, the content of Cr is set to 10% to 30%.

[0029] Further, Si and Cr affect the oxidation resistance; when the contents of Si and Cr are adjusted so that a B value in equation (2), where B value = Cr + 15Si, is 18 or more, the oxidation resistance becomes good even under an exhaust gas environment. Therefore, in the contents of Si and Cr described above, the contents of Si and Cr are to be adjusted so that the B value in equation (2) is 18 or more.

[0030] Nb (niobium) and Ti (titanium) are elements effective for improving the high-temperature strength; however, these elements have a strong affinity with C or N, and thus, an excessive addition thereof tends to form a precipitate that attributes to deterioration in the processability or the low-temperature tenacity. Therefore, the content of Nb and that of Ti are set to 0.8% or less, respectively, and at least one of 0.8% or less of Nb and 0.8% or less of Ti is to be contained.

[0031] Moreover, for C, N, Nb, and Ti that affect the high-temperature strength, when the contents are adjusted so that an A value in equation (1), where A value = Nb + Ti - 4 (C + N) is 0.10 or more, the high-temperature strength becomes good even under a high-temperature environment of exhaust gas. Therefore, in the contents of C, N, Nb, and Ti described above, the contents of C, N, Nb, and Ti are adjusted so that the A value in equation (1) is 0.10 or more.

[0032] Mo (molybdenum) and W (tungsten) are elements effective for improving the high-temperature strength due to solute strengthening and hence preferable because it is possible to improve the high-temperature strength by containing these elements. However, when these elements are contained excessively to exceed 3.0%, carbide or a Laves phase is formed, which is a factor in the inhibition of the high-temperature strength or the low-temperature tenacity. Therefore, Mo and W are contained where necessary, and when contained, the content of Mo and that of W are set to 3.0% or less.

[0033] Cu (copper) increases the strength at about 600°C by taking advantage of a fine dispersion precipitation phenomenon of an ε-Cu phase, and improves the thermal fatigue characteristic, and further, at a high-temperature range exceeding 850°C, Cu improves the high-temperature strength by taking advantage of solute strengthening thereof, and thus, it is possible to improve the high-temperature strength by containing Cu, which is preferable. However, when it is contained excessively to exceed 3.0%, the processability, the low-temperature tenacity, and the weldability deteriorate. Therefore, Cu is contained where necessary, and when it is contained, the content of Cu is set to 3.0% or less.

[0034] Then, the heat transfer element for manifold 11 is formed from the ferritic stainless steel adjusted as described above, and thus, when the exhaust gas from the engine 14 passes through the inlet 17, the heat of the exhaust gas can be deprived, and at the same time, the deprived heat can be transferred to the manifold main body 13. Therefore, it is possible to decrease the temperature of the exhaust gas passing through the manifold main body 13 than that when discharged from the engine 14, and possible to prevent a rise of a material temperature due to the high-temperature exhaust gas, of the collection part 27 or near the collection part 27 or the like, and thus, it is possible to prevent the generation of a thermal strain or the like arising from the temperature rise thereby to prevent thermal fatigue of the manifold main body 13 from the view point of a structure of the exhaust manifold 12. It should be noted that since it is possible to decrease the temperature of the exhaust gas, it is possible to prevent a worsening of a catalyst of the manifold converter or the like connected to the outlet 33 of the collection part 27.

[0035] Further, the heat transfer element for manifold 11 is formed from the ferritic stainless steel adjusted as described above, and thus, it is possible not only to prevent thermal fatigue of the manifold main body 13 but also to have good high-temperature strength and oxidation resistance. Therefore, it is possible to prevent thermal fatigue and abnormal oxidation, generated as a result of being exposed to the exhaust gas, of the heat transfer element for manifold 11 itself.

[0036] It should be noted that in the above-described one embodiment, the heat transfer element for manifold 11 was arranged in the exhaust manifold 12 of a so-called monaka structure; however, the present invention is not limited to such a configuration, and for example, the present invention can be applied also to an exhaust manifold other than a monaka structure, such as an exhaust manifold of a so-called pipe structure in which a pipe is bent to form a tubular body.

[0037] For the heat transfer element for manifold 11, there is no need that the entire heat transfer element for manifold 11 is formed from the ferritic stainless steel adjusted as described above, and it may suffice that at least one part thereof is formed from the ferritic stainless steel adjusted as described above.

[0038] The heat transfer element for manifold 11 was configured such that it was formed concurrently with the inlet 17 by punching when pressing the flange 15, and was integrally connected to the rim of the inlet 17; however, the present invention is not limited to such a configuration, and a configuration may be adopted where the heat transfer element for manifold 11 is formed separately from the flange 15 and is attached and joined to the inlet 17.

[0039] Further, the heat transfer element for manifold 11 is not limited to the configuration where it is arranged at the inlet 17; it may suffice that the heat transfer element for manifold 11 is located at least at the upstream side of the manifold main body 13, and is located inside the tubular body 16, for example.

[0040] Moreover, in addition to a configuration where the entire heat transfer element for manifold 11 is located at the upstream side of the manifold main body 13, a configuration is acceptable where one part of the heat transfer element for manifold 11 is located at the downstream side of the manifold main body 13 or located outside the manifold main body 13, for example, as long as the heat transfer element for manifold 11 is located at least at the upstream side of the manifold main body 13.

[0041] The heat transfer element for manifold 11 was formed in an approximately cross shape; however, the present invention is not limited to this configuration, and the shape can be appropriately designed such as shapes in modified examples shown in from Fig. 2 to Fig. 6.

[0042] A heat transfer element for manifold 41 shown in Fig. 2 and Fig. 3 is formed of two heat transfer plates 42 of an approximately rectangular shape. These heat transfer plates 42 are each provided with a straight cutaway 43 from an approximately center of one end to an approximately center of the heat transfer plate 42. Such two heat transfer plates 42 can be engaged in an approximately vertical state to each other by way of the cutaway 43. Further, the heat transfer element for manifold 41 includes four heat transfer parts 44 formed by the two engaged heat transfer plates 42. These four heat transfer parts 44 intersect approximately vertically.

[0043] Further, the heat transfer element for manifold 41 is arranged between the first press material 19 and the second press material 20 so as to be located within the straight tubular parts 28 and 30 of the tubular parts 23, 24, 25, and 26 of the manifold main body 13.

[0044] Moreover, the heat transfer element for manifold 41 is welded and attached to the first press material 19 and the second press material 20 so that the distal end of each heat transfer part 44 comes into contact with an inner circumference portion of the tubular parts 23, 24, 25, and 26 when the tubular body 16 is formed by welding the first press material 19 and the second press material 20.

[0045] In the heat transfer element for manifold 41 configured like this, the heat transfer part 44 is of a planar shape in the direction into which the exhaust gas flows within the straight tubular parts 28 and 30, and thus, it is possible to ensure a sufficient area that enables a contact with the exhaust gas, resulting in an effective deprival of the heat of the exhaust gas. Further, the distal end of each heat transfer part 44 comes into contact with the inner circumference portion of the tubular parts 23, 24, 25, and 26, and thus, it is possible to effectively transfer the heat deprived from the exhaust gas to the tubular parts 23, 24, 25, and 26. Therefore, it is possible to effectively decrease the temperature of the exhaust gas, and thus, it is possible to prevent thermal fatigue of the manifold main body 13.

[0046] Moreover, in the direction into which the exhaust gas flows, the heat transfer part 44 is of a planar shape, and thus, it is possible to sufficiently ensure an opening area of a passage of the exhaust gas, as a result of which it is less likely that the heat transfer element for manifold 41 blocks the flow of the exhaust gas.

[0047] A heat transfer element for manifold 46 shown in Fig. 4 includes four heat transfer parts 47 that are connected to the inlet 17 of the flange 15 and intersect approximately vertically. These heat transfer parts 47 each include a rod-shaped base 48 connected to the rim of the inlet 17 and a fan-shaped protrusion 49 protruding toward the downstream side from the base 48.

[0048] Such a heat transfer element for manifold 46 includes the protrusion 49 protruding toward the downstream side from the base 48, and thus, it is possible to sufficiently ensure an area enabling a contact with a passing exhaust gas, as a result of which it is possible to easily deprive the heat of the exhaust gas. Further, the base 48 is connected to the rim of the inlet 17, and thus, it is possible to easily transfer the heat of the exhaust gas deprived by the protrusion 49 to the manifold main body 13. Therefore, it is possible to effectively decrease the temperature of the exhaust gas, and thus, it is possible to prevent thermal fatigue of the manifold main body 13.

[0049] Further, in the heat transfer element for manifold 46, the rod-shaped base 48 is connected to the rim of the inlet 17, and the fan-shaped protrusion 49 protrudes toward the downstream side from the base 48. Thus, it is possible to sufficiently ensure an opening area of the inlet 17, and therefore, it is less likely that the flow of the exhaust gas is blocked.

[0050] A heat transfer element for manifold 51 shown in Fig. 5 includes one rod-shaped heat transfer part 52 arranged at the inlet 17, and is formed in a straight line. That is, the heat transfer part 52 is arranged to traverse the inlet 17.

[0051] Such a heat transfer element for manifold 51 is formed concurrently with the inlet 17 by punching when pressing the flange 15. Therefore, it is possible to easily form the heat transfer element for manifold 51 with a simple configuration.

[0052] A heat transfer element for manifold 54 shown in Fig. 6 includes eight intersecting rod-shaped heat transfer parts 55. These heat transfer parts 55 extend radially from a central part of the heat transfer element for manifold 54, and are connected to the rim of the inlet 17.

[0053] Such a heat transfer element for manifold 54 can be formed concurrently with the inlet 17 by punching when pressing the flange 15.

[0054] Further, in the heat transfer element for manifold 54, the plurality of heat transfer parts 55 intersect and extend radially from the central part, and thus, it is possible to ensure a larger area enabling contact with the exhaust gas, as compared to the configuration shown in Fig. 5, and thus, it is easier to deprive the heat of the exhaust gas, and also, it is possible to transfer the heat deprived from the exhaust gas in many directions by each of the heat transfer parts 55, and therefore, a heat transfer effect is good and it is possible to effectively decrease the temperature of the exhaust gas. Examples

[0055] Examples and comparative examples will be described, below.

[0056] First, ferritic stainless steels having an alloy content shown in Table 1 were used to form a heat transfer element for manifold.

[Table 1]

	Types of steel	Alloy content [mass%] A value = Nb + Ti - 4(C + N) B value = Cr + 15Si											
		C	Si	Mn	Cr	Mo	Nb	Ti	Cu	N	Other	A value	B value
Examples	A	0.009	0.30	0.22	17.0	-	-	0.24	-	0.008	-	0.17	21.5
	B	0.010	0.22	0.18	17.5	0.50	0.39	-	-	0.009	-	0.31	20.8
	C	0.011	0.18	0.19	17.5	0.85	-	0.30	-	0.007	-	0.23	20.2
	D	0.008	0.55	0.20	18.0	-	0.45	-	0.50	0.006	-	0.39	26.3
	E	0.010	0.91	1.08	14.0	-	0.42	-	-	0.008	-	0.35	27.7
	F	0.007	0.92	0.25	10.0	-	0.32	0.17	-	0.010	-	0.42	23.8
	G	0.009	0.26	0.98	18.0	1.85	0.45	-	-	0.009	-	0.38	21.9
	H	0.010	0.31	0.99	18.0	2.00	0.64	-	-	0.008	-	0.57	22.7
	I	0.008	0.18	0.18	17.0	-	0.54	0.18	1.40	0.009	-	0.65	19.7
	J	0.011	0.16	0.22	17.0	2.00	0.45	-	1.50	0.008	W:1.25	0.37	19.4
Comparative examples	K	0.008	0.27	0.16	11.0	-	-	0.15	-	0.011	-	0.07	15.1
	L	0.009	0.11	0.19	16.5	-	0.11	-	-	0.010	-	0.03	18.2
	M	0.011	0.22	0.50	10.0	-	0.21	-	-	0.008	-	0.13	13.3

[0057] The type of steel A to the type of steel J are examples using ferritic stainless steel that satisfy the above-described requirements.

[0058] The type of steel K is a comparative example using ferritic stainless steel in which the A value represented in equation (1) is less than 0.10, where A value = Nb + Ti - 4(C + N), and the B value represented in equation (2) is less than 18, where B value = Cr + 15Si.

[0059] The type of steel L is a comparative example using ferritic stainless steel in which the A value represented in equation (1) is less than 0.10 and the B value represented in equation (2) is 18 or more.

[0060] The type of steel M is a comparative example using ferritic stainless steel in which the A value represented in equation (1) is 0.10 or more and the B value represented in equation (2) is less than 18.

[0061] Then, in these examples and comparative examples, a high-temperature tension test at 900°C was conducted to evaluate high-temperature strength, and in order to evaluate oxidation resistance, a continuous oxidation test at 900°C for 200h under a 10%-water vapor atmosphere was conducted. The results of the high-temperature tension test and the continuous oxidation test are provided in Table 2.

[0062] Further, it is noted that in the high-temperature tension test, 0.2% yield strength at 900°C was measured; 20 N/mm^2 or more is marked with a "double circle," 15 N/mm^2 or more and less than 20 N/mm^2 is marked with a "circle," 10 N/mm^2 or more and less than 15 N/mm^2 is marked with a "triangle," less than 10 N/mm^2 is marked with a "cross," and 10 N/mm^2 or more was evaluated as good high-temperature strength.

[0063] Further, in the continuous oxidation test, an increased amount of oxidation after a continuous oxidation test at 900°C under a 10%-water vapor atmosphere was measured; 1 mg/cm^2 or less is marked with a "double circle," more than 1 mg/cm^2 and 10 mg/cm^2 or less is marked with a "circle, " more than 10 mg/cm^2 and 20 mg/cm^2 or less is marked with a "triangle," more than 20 mg/cm^2 is marked with a "cross," and 20 mg/cm^2 or less was considered not having abnormal oxidation and evaluated as good oxidation resistance.

[Table 2]

	Types of steel	0.2% yield strength at 900°C (N/mm^2)		Increased amount of oxidation after 900°C continuous oxidation test under 10%-water vapor atmosphere	
Examples	A	10	Δ	2.0	○
	B	12	Δ	2.5	○
	C	12	Δ	2.0	○
	D	13	Δ	0.4	●
	E	13	Δ	9.0	○
	F	13	Δ	12.0	Δ
	G	20	●	1.0	●
	H	25	●	1.0	●
	I	26	●	14.0	Δ
	J	29	●	1.0	●
Comparative examples	K	9	×	148.0	×
	L	6	×	19.2	Δ
	M	10	Δ	168.0	×

[0064] As shown in Table 2, the examples of the type of steel A to the type of steel J in which the A value in equation (1) was 0.10 or more and the B value in equation (2) was 18 or more exhibited excellent high-temperature strength as a 0.2%-yield strength at 900°C was high, that is, 10 N/mm^2 or more, and in addition, exhibited excellent oxidation resistance as an increased amount of oxidation at 900°C for 200h was low, that is, 20 mg/cm^2 or less.

[0065] On the other hand, the comparative example of the type of steel K in which the A value in equation (1) was less than 0.10 and the B value in equation (2) was less than 18 exhibited poor high-temperature strength as the 0.2%-yield strength at 900°C was lower than 10 N/mm^2, and in addition, exhibited poor oxidation resistance as the increased amount of oxidation at 900°C for 200h was high, that is, more than 20 mg/cm^2.

[0066] The comparative example of the type of steel L in which the A value in equation (1) was less than 0.10 and the B value in equation (2) was 18 or more did not exhibit excellent high-temperature strength as the 0.2%-yield strength at 900°C was lower than 10 N/mm^2; however, exhibited excellent oxidation resistance as the increased amount of oxidation at 900°C for 200h was low, that is, 20 mg/cm^2 or less.

[0067] The comparative example of the type of steel M in which the A value in equation (1) was 0.10 or more and the B value in equation (2) was less than 18 exhibited excellent high-temperature strength as the 0.2%-yield strength at 900°C was high, that is, 10 N/mm^2 or more; however, did not exhibit excellent oxidation resistance as the increased amount of oxidation at 900°C for 200h was high, that is, more than 20 mg/cm^2.

[0068] Next, as shown in Fig. 7, by using an exhaust manifold of a so-called monaka structure, heat transfer elements for manifold formed from the ferritic stainless steels of the above-described examples and comparative examples were arranged, and a heat test for an exhaust manifold was conducted.

[0069] For the exhaust manifold, a pressed article of SUS430J1L/2mmt was used for the tubular body. Further, for the flange, 3.0 mmt of each of the types of steel shown in Table 1 was used and punched in a cross shape to form the heat transfer element for manifold. As a reference example, the flange was punched in a circle shape, and a heat test was also conducted when the heat transfer element for manifold was not arranged.

[0070] In the heat test, an electric heater as a heating device was used, a gas temperature at the inlet side of the exhaust manifold was set to 1100°C, and an amount of flown air was adjusted to reach 1.5m^3/min at each tubular part. Further, when cooling the flange, a connection blockmade of SUS304 was cooled by water, and an amount of water was arranged so that a material temperature of the flange reaches 340°C.

[0071] In this condition, in the collection part of the exhaust manifold, the material temperature and the exhaust gas temperature were measured. Moreover, the examples of the types of steel E, H, and J, and the comparative example of the type of steel K were used, the heater was driven continuously for 100h under the heating test conditions, and the heat transfer element for manifold after continuous driving was investigated for the level of deformation and abnormal oxidation caused by the continuous heating. The results are provided in Table 3.

[0072] It should be noted that ΔT in the measurements of the material temperature and the exhaust gas temperature indicates a difference between the measured temperatures in the examples and the comparative examples and that in the reference example. That is, ΔT = measured temperature - measured temperature in the reference example. Further, in the investigation for deformation, the specimen that had the generation of buckling due to the deformation is indicated by a "cross" while the specimen that had no generation is indicated by a "circle." Moreover, in the investigation for the abnormal oxidation, the specimen that had a reduced thickness due to the abnormal oxidation is indicated by a "cross" while the specimen that had no generation is indicated by "circle."

[Table 3]

	Structure	Types of steel	Material temperature of exhaust manifold collection part		Exhaust gas temperature of exhaust manifold collection part		Shape of heat transfer part after 100h-continuous driving	
			Measured temperature	ΔT	Measured temperature	ΔT	Deformation	Abnormal oxidation
Examples	Punching with cross shape	A	622	-30	724	-54	–	–
		B	618	-34	720	-58	–	–
		C	624	-28	727	-51	–	–
		D	619	-33	721	-57	–	–
		E	622	-30	721	-57	○	○
		F	630	-22	732	-46	–	–
		G	628	-24	730	-48	–	–
		H	616	-36	720	-58	○	○
		I	614	-38	718	-60	–	–
Comparative examples		J	626	-26	727	-51	○	○
		K	620	-32	722	-56	×	×
		L	623	-29	725	-53	–	–
		M	627	-25	728	-50	–	–
Punching with circle shape (reference example)		None	652	0	778	0	–	–

[0073] As shown in Table 3, when comparing the results of the examples and the comparative examples, and that of the reference example, it was shown that the arrangement of the heat transfer element for manifold decreases the material temperature in the collection part of the exhaust manifold, and also decreases the exhaust gas temperature in the collection part of the exhaust manifold, with which it was proved that both the examples and the comparative examples had excellent heat-extraction characteristics.

[0074] Further, the types of steel E, H, and J, which are examples, had no generation of a crack or a reduced thickness due to the deformation and the abnormal oxidation, after 100h-continuous driving, with which it was proved that they had excellent high-temperature strength and oxidation resistance, and although not provided in Table 3, even after the 100h-continuous driving, these types had a decrease in exhaust gas temperature by about 50°C as compared to the reference example, with which it was proved that these types had excellent heat-extraction characteristics.

[0075] On the other hand, the type of steel K, which is the comparative example, had one part thereof missing due to the deformation and the abnormal oxidation, after the 100h-continuous driving, and after the 100h-continuous driving, the type had no decrease in exhaust gas temperature by about 50°C as compared to the reference example, with which it was shown that the heat extraction characteristics were deteriorated.

INDUSTRIAL APPLICABILITY

[0076] The present invention can be used for a heat transfer element for manifold for transferring heat of exhaust gas to a manifold main body, in an exhaust manifold for guiding high-temperature exhaust gas from an engine to a manifold converter, an exhaust pipe, etc.

REFERENCE SIGNS LIST

[0077]

11	heat transfer element for manifold
12	exhaust manifold
13	manifold main body
14	engine
41	heat transfer element for manifold
46	heat transfer element for manifold
51	heat transfer element for manifold
54	heat transfer element for manifold

Claims

1. A heat transfer element for manifold which is located at least at the upstream side of a manifold main body through which exhaust gas from an engine flows in an exhaust manifold, and which transfers heat of the exhaust gas from the engine to the manifold main body, wherein
at least one part thereof contains at least one element, in terms of mass%, of: C: 0.03% or less; Si: 2.0% or less; Mn: 2.0% or less; Cr: 10 to 30%; Nb: 0.8% or less, and Ti: 0.8% or less, and N: 0.03% or less, and the remaining part thereof is formed from Fe and inevitable impurities, and the heat transfer element for manifold is formed from ferritic stainless steel in which an alloy content is adjusted so that an A value expressed in equation (1) below is 0.10 or more and a B value expressed in equation (2) below is 18 or more.

$$\text{Equation (1): A value} = Nb + Ti - 4(C + N)$$

$$\text{Equation (2): B value} = Cr + 15Si$$

2. The heat transfer element for manifold according to claim 1, wherein the ferritic stainless steel contains at least one element, in terms of mass%, of: Cu:3.0% or less; Mo:3.0% or less; and W:3.0% or less.

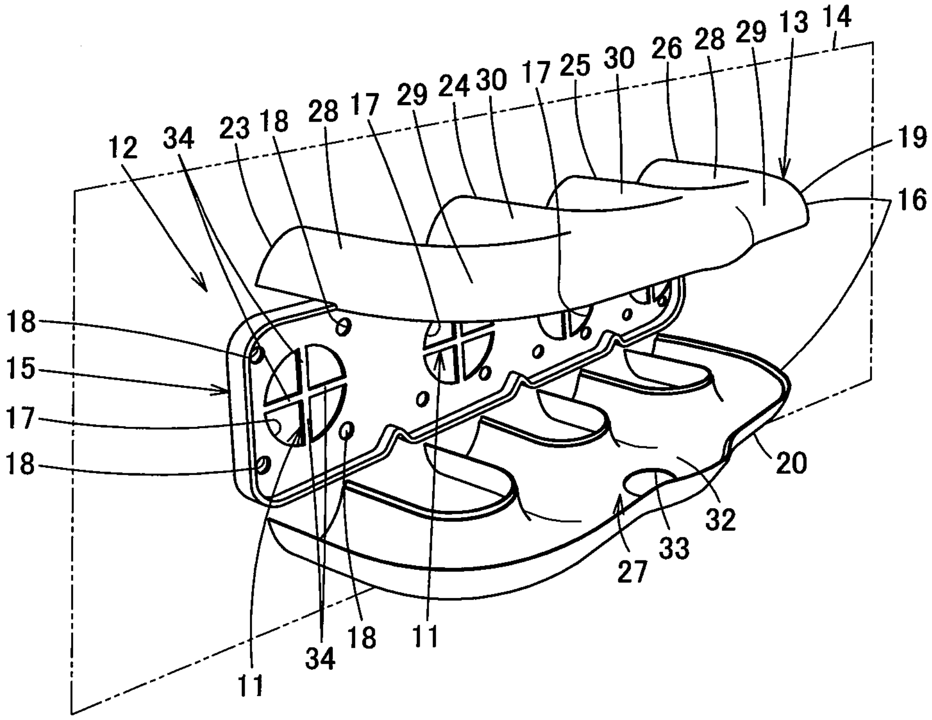
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FIG. 1

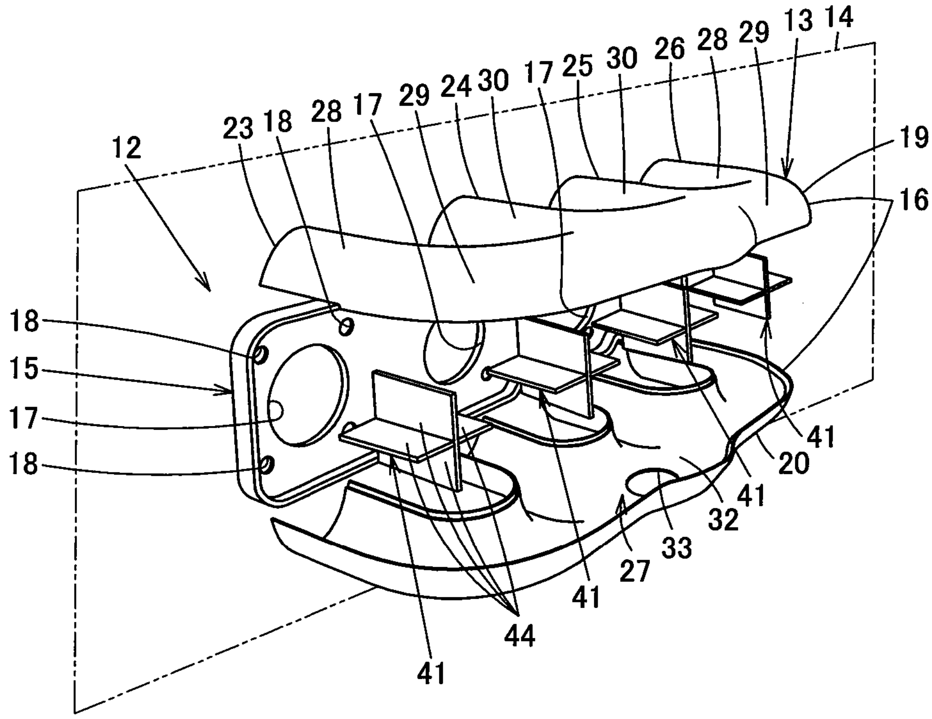
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FIG. 2

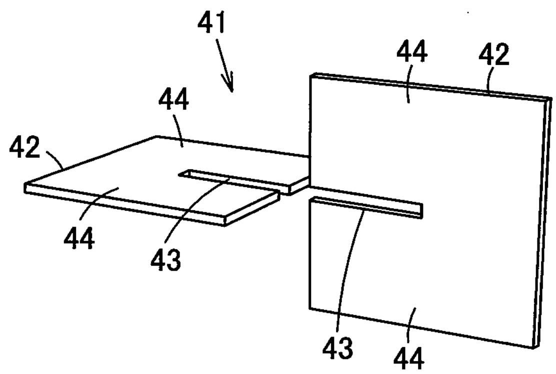
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FIG. 3

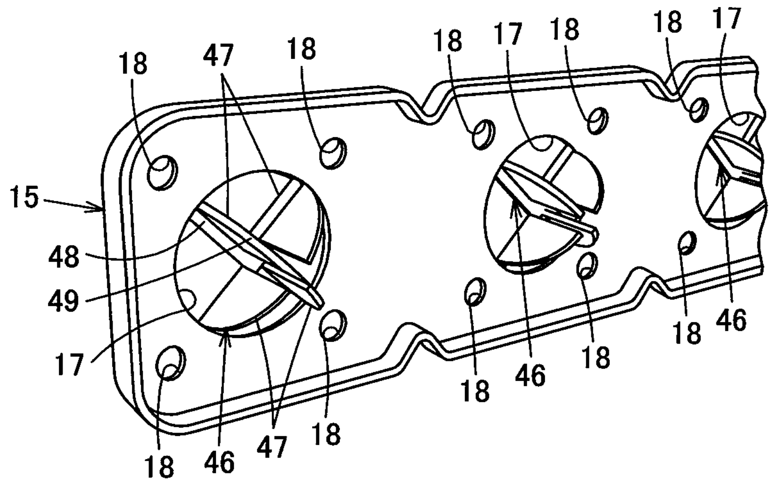
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FIG. 4

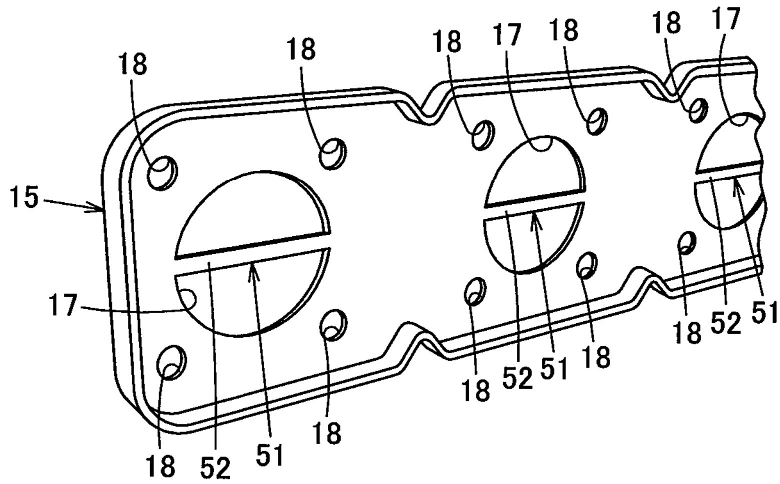
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FIG. 5

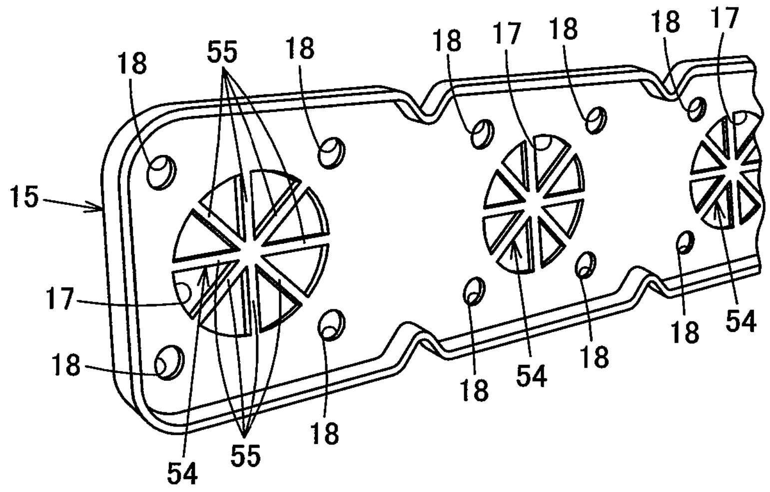


FIG. 6

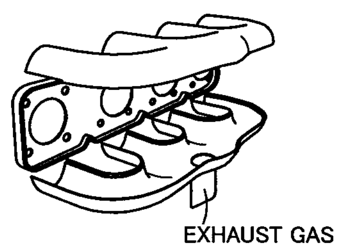
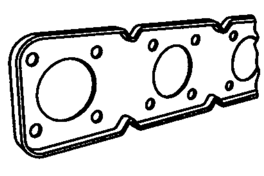
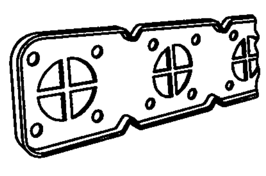
STRUCTURE OF EXHAUST MANIFOLD	FLANGE STRUCTURE	
	PUNCHING WITH CIRCLE SHAPE (REFERENCE EXAMPLE)	PUNCHING WITH CROSS SHAPE
		

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2011/068056

A. CLASSIFICATION OF SUBJECT MATTER
F01N13/16(2010.01)i, *C22C38/00*(2006.01)i, *C22C38/38*(2006.01)i, *F01N13/08*(2010.01)i, *F01N13/10*(2010.01)i, *F02F11/00*(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)
F01N13/08, F01N13/10, F01N13/16, C22C38/00, C22C38/38, F02F11/00

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	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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	JP 2007-16672 A (Kawasaki Heavy Industries, Ltd.), 25 January 2007 (25.01.2007), paragraphs [0036] to [0037]; fig. 4 to 6 (Family: none)	1-2
Y	JP 8-60306 A (Sumitomo Metal Industries, Ltd.), 05 March 1996 (05.03.1996), claims; paragraphs [0015], [0060] to [0062] (Family: none)	1-2
Y	JP 2004-76154 A (JFE Steel Corp.), 11 March 2004 (11.03.2004), claims; paragraphs [0001] to [0002], [0035] to [0037] & WO 2003/106722 A1 & US 2005/0211348 A1 & EP 1873271 A1 & CN 1662666 A	1-2

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 October, 2011 (26.10.11)	08 November, 2011 (08.11.11)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/068056

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 2007-278221 A (Toyota Motor Corp.), 25 October 2007 (25.10.2007), (Family: none)	1
A	JP 62-501022 A (Vincent Patents Ltd.), 23 April 1987 (23.04.1987), & WO 1986/003256 A1 & US 4815274 A	1

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REFERENCES CITED IN THE DESCRIPTION

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