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Minato et al.

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[45] **Sept. 2, 1975**

[54] **IMPELLER FOR GAS-HANDLING APPARATUS**

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[73] Assignee: **Hitachi, Ltd.,** Japan

[22] Filed: **June 24, 1974**

[21] Appl. No.: **482,563**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 351,551, April 16, 1973, abandoned.

[30] **Foreign Application Priority Data**

Apr. 24, 1972 Japan 47-40350

[52] **U.S. Cl.** **416/186;** 416/241; 416/187

[51] **Int. Cl.** **F04d 29/28**

[58] **Field of Search** 416/186, 187, 241

[56] **References Cited**

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Attorney, Agent, or Firm—Craig & Antonelli

[57] **ABSTRACT**

An impeller for, such as, gas compressors and blowers, fans, etc. comprising an impeller made of a martensite alloy steel consisting essentially of 0.06–0.15 % of carbon, 11–13.5 % of chromium, 1.5 to 3 % of nickel, 0.7 to 2 % of molybdenum, 0.03 to 0.6 % of niobium, up to 1 % of silicon, 0.2 to 2 % of manganese, up to 0.2 % of nitrogen and the balance of iron and incidental impurities has highly improved strength, toughness and corrosion resistance.

4 Claims, 8 Drawing Figures

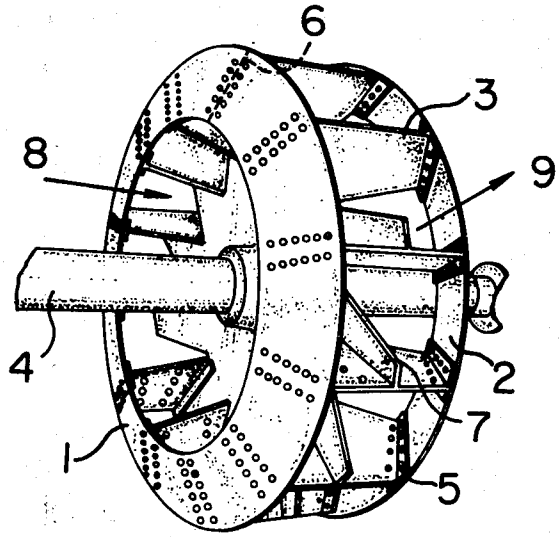


FIG. 1

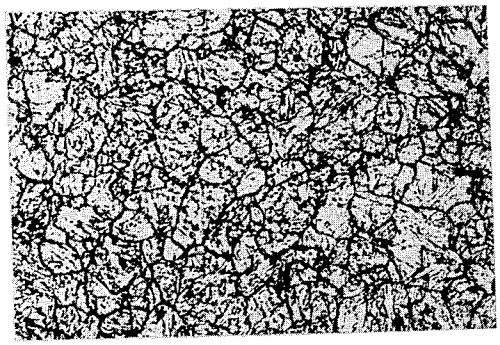


FIG. 2a

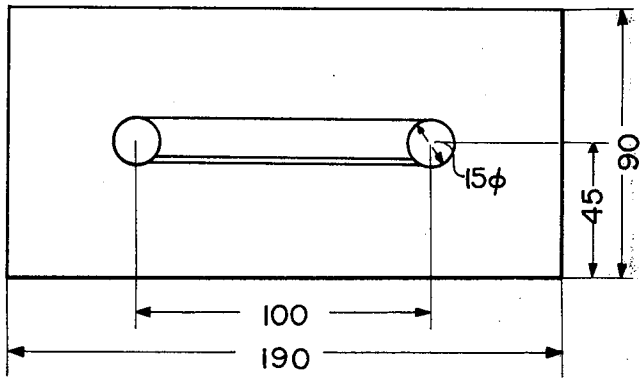


FIG. 2b

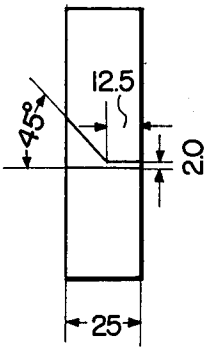


FIG. 3

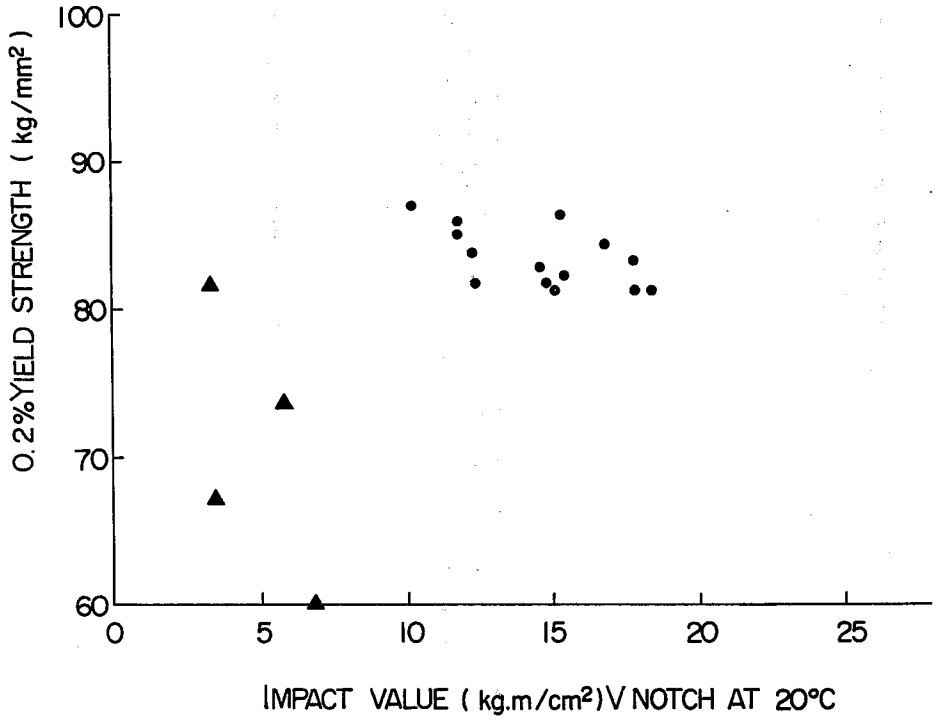

100
90
80
70
60
0
5
10
15
20
25
0.2% YIELD STRENGTH (kg/mm²)
IMPACT VALUE (kg.m/cm²) V NOTCH AT 20°C

FIG. 4

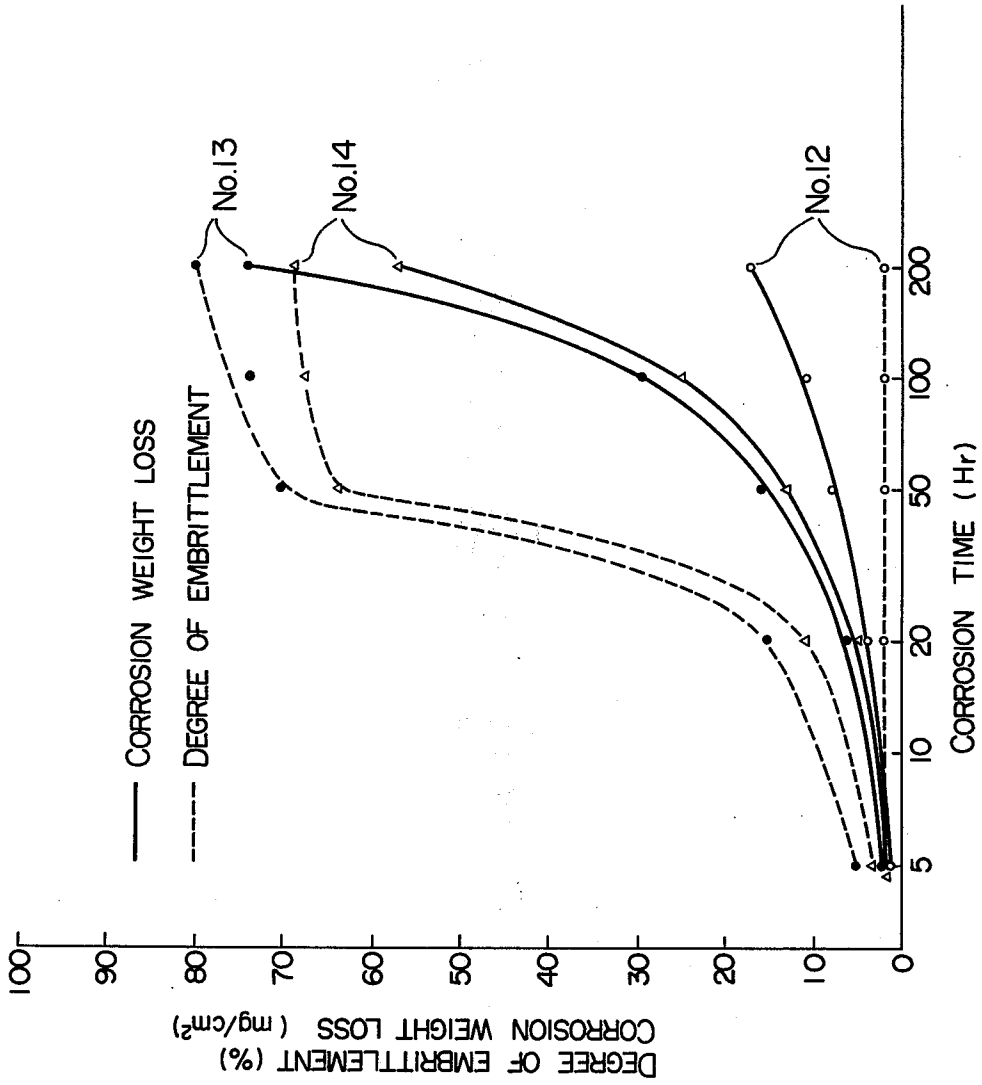

No.13
No.14
No.12
CORROSION WEIGHT LOSS
DEGREE OF EMBRITTLEMENT
DEGREE OF EMBRITTLEMENT (%)
CORROSION WEIGHT LOSS (mg/cm²)
CORROSION TIME (Hr)
0
10
20
30
40
50
60
70
80
90
100
5
10
20
50
100
200

FIG. 5

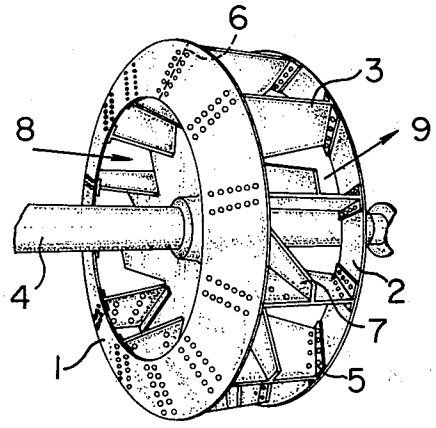


FIG. 6

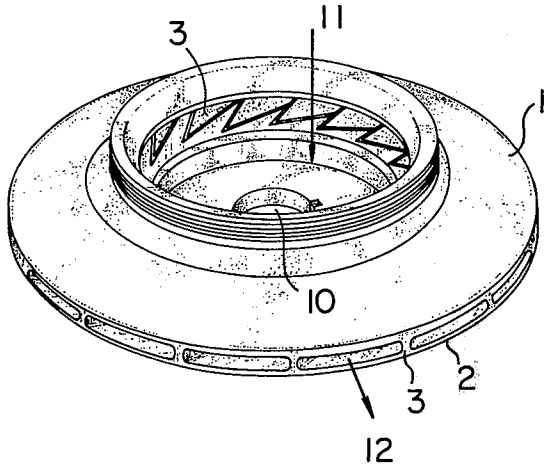
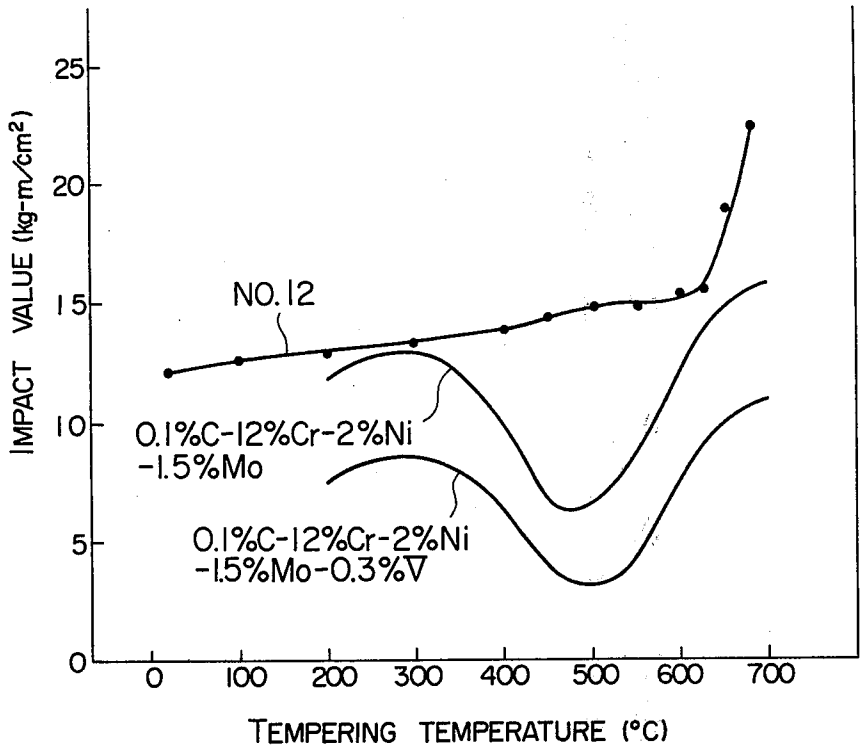


FIG. 7


IMPACT VALUE (kg-m/cm²)
25
20
15
10
5
0
NO. 12
0.1%C-12%Cr-2%Ni
-1.5%Mo
0.1%C-12%Cr-2%Ni
-1.5%Mo-0.3%V
0
100
200
300
400
500
600
700
TEMPERING TEMPERATURE (°C)

IMPELLER FOR GAS-HANDLING APPARATUS

CROSS-REFERENCE OF THE RELATED APPLICATION

This is a continuation-in-part application of the copending U.S. Ser. No. 351,551 filed on Apr. 16, 1973, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to an impeller for gas handling apparatus which comprises an impeller made of a martensite steel having high strength, high toughness and corrosion resistance.

Recently, with increase of large sized various plants in iron industry and chemical industry, volume of turbo type air compressors is also apt to become greater and increasing of number of revolution of impellers and making the impellers of compressors larger have been attempted. In order to attain high speed revolution of a large impeller, not only the progress of design and manufacturing technique, but also supply of materials which have high strength and high toughness, are weldable and mechanically workable with ease and can be economically made into articles on an industrial scale are required.

High strength and high toughness enough to stand high speed revolution are required for impellers for compressors and blowers. The reason why high strength materials of 0.2 % yield strength 80 kg/mm² grade are required for said impellers is that they must stand high centrifugal force (statial stress) and vibration stress generated by high speed revolution. Improvement in strength and toughness makes it possible to obtain small-sized and light weight impellers and moreover it results in remarkable improvements in economical problem, efficiency, durability and reliability of machineries.

Conventionally, as materials for impellers, carbon steel has been used in case of relatively low speed revolution and low alloy steel of high strength has been used in case of high speed revolution and high stress. Recently, however, due to increase of atomospheric pollution in industrial areas, impellers made from these steels result in extreme reduction in efficiency, durability and reliability of apparatus, by corrosion weight loss of the steels. Hitherto, ferrite, martensite, and austenite stainless steels have been used in a corrosive environment. However, impellers made of the ferrite and austenite stainless steels cannot be operated at a high speed which produces a high stress because they have low strengths. On the other hand, in case of using martensite stainless steel, low temperature cracking is easily caused at welding because of great self-hardening property. In order to remove the defect, a temperature for preheating and temperature between welding layers are required to be kept high, and thus there is a problem in weldability. With reference to a martensite stainless steel, considerably high strength can be attained by increasing the content of carbon or choosing a tempering temperature lower than 600C.

However, when it is intended to obtain high strength by increasing the content of carbon, toughness, corrosion resistance and weldability are deteriorated and when the tempering temperature is lowered, toughness and corrosion resistance are extremely decreased.

SUMMARY OF THE INVENTION

The main object of this invention is to provide impellers for air compressors, blowers, fans, gas compressors, etc. having a high strength and toughness and an improved corrosion resistance.

The impellers of the present invention are made of a martensite alloy steel comprising, based on weight, 0.06–0.15 % of carbon, 11–13.5 % of chromium, 1.5–3 % of nickel, 0.7–2 % of molybdenum, 0.03–0.6 % of niobium and the balance of iron except for the incidental impurities. According to the present invention, weldability, strength, toughness and corrosion resistance of the known martensite alloy steel are improved by adding molybdenum and niobium, and simultaneously adjusting the content of carbon.

With the conventional martensite stainless steel of this kind, low temperature cracks occur unless the preheating temperature at welding is allowed to raise to about 250C, while the alloy steel in this invention results in no cracks even if the preheating temperature is lowered to about 100C. Moreover, the conventional martensite stainless steel has no sufficient strength and toughness, while the alloy steel in this invention has both high strength and extremely excellent toughness as clarified in the Examples hereinafter given. Specifically, the alloy steel in this invention has such high strength and toughness as 0.2 % yield strength of more than 80 kg/mm² and impact value of more than 10 kg-m/mm². Furthermore, nickel, molybdenum and niobium all directly or indirectly contribute to improvement in corrosion resistance.

The reasons for restriction of the component elements as mentioned above are as follows:

Carbon is an essential element for enlarging the austenite area of an iron-chromium alloy which has an increased hardenability so that a quench hardenability is given to the alloy steel. With increase of the content of carbon, precipitation of ferrite is prevented and hardenability is improved to increase tensile strength, yield point and hardness while weldability and toughness are decreased and moreover, carbon is combined with chromium to form carbide to cause reduction of content of chromium in the base metal matrix thereby to extremely damage corrosion resistance. Therefore, taking the strength, toughness and corrosion resistance into account, content of carbon is restricted to the range of 0.06 % to 0.15 % which satisfies the three requirements. Especially, 0.07 to 0.11 % of carbon will bring about best results.

Chromium has a passivation action and is an element essential for allowing the steel of this invention to exhibit a function as a stainless steel. When the content is less than 11 %, the effect is conspicuously decreased and when the content is more than 13.5 % and when contents of carbon and nickel which are austenite stabilizing elements are near the lower limit or contents of ferrite forming elements such as molybdenum, niobium, etc. are near the upper limit, ferrite is markedly precipitated to cause reduction of strength and toughness. Therefore, content of chromium is restricted to the range of 11 to 13.5 %, especially to the range of 11.5 to 12.5 %.

Nickel is an austenite forming element like carbon and prevents precipitation of ferrite and increases hardenability, but it has the following useful characteristics different from action of carbon: That is, it does not produce reaction product such as a carbide which

damages corrosion resistance and it is dissolved in the base metal matrix as a solid solution to increase strength, to improve low temperature toughness and to stabilize austenite structure without lowering weldability due to increase in solid solution hardening and increase in temper softening resistance. Therefore, it becomes possible to add ferrite forming elements such as molybdenum, niobium, etc. and at the same time it becomes possible to decrease the content of carbon which has bad effect on corrosion resistance, weldability and toughness. Since nickel lowers A_1 transformation point, addition of it in a large amount makes it impossible to carry out hot tempering and causes reduction of M_s point, formation of retained austenite and decrease of yield point. Therefore, 3 % is an upper limit for the desired strength. On the other hand, when content of nickel is less than 1.5 %, formation of ferrite and reduction of strength and toughness become conspicuous and the lower limit is 1.5 %. Preferable results would be obtained in the range of 1.8 to 2.2 %.

Molybdenum is an element having an effective action for improvement in corrosion resistance, strength and toughness. Addition of at least 0.7 % results in remarkable effects. On the other hand, since molbdenum is a ferrite forming element, addition of more than 2 % causes formation of ferrite in a large amount to rather reduce strength and toughness. Such being the case, the lower limit and the upper limit are 0.7 % and 2.0 %, respectively. The range of 0.8 to 1.2 % of molybdenum is preferable.

Niobium is a strong carbide forming element which forms a carbide in preference to chromium. Therefore, addition of niobium increases effective amount of chromium to be dissolved in the base metal matrix as a solid solution to cause improvement in corrosion resistance and reduction in brittleness due to carbon. At the same time, it increases yield strength and moreover renders crystal grains refined to improve the toughness. However, increase of amount of niobium added accelerates formation of ferrite and furthermore reduces toughness due to excess dissolution in the base metal matrix, precipitation of intermetallic compound, etc. The amount of niobium to be added is suitably 0.5 to 4 times that of carbon, namely, 0.03 to 0.6 %. Particularly, 0.1 to 0.3 % of niobium is preferable.

Besides niobium, there are aluminum, titanium, vanadium, etc. as a grain refining agent. However, aluminum and titanium have strong affinity with oxygen and addition of them in a large amount causes increase in the amount of non-metallic oxide inclusion mainly composed of deoxidation products. Titanium reacts with nitrogen to produce coarse TiN which extremely deteriorates purity of the steel. Vanadium also has the similar action as niobium, but has smaller effects than niobium in improvements in tensile and yield strengths and grain growth inhibiting action and has ferrite forming action stronger than niobium by 2 to 3 times. Therefore, vanadium is inferior to niobium in increase of yield strength and improvement in toughness due to grain refining. The alloy steel according to the present invention can contain such a deoxidizing agent as aluminium, titanium, calcium, magnesium or rare earth metals, but the amount of each element should be less than 0.2 % by weight. The rare earth metals include celium, lanthanum, praseodymium, neodymium, promethium, samarium, etc. In order to exhibit the strength, toughness and other various characteristics to their maximum, suitable adjustment is required so that Cr equivalent (calculation formula: [CR] + 2[Si] + 1.5[Mo] + 2[Nb] 2[Ni] [Mn] 15[N]) is within the range of 7 to 13 within the range of addition amount of each alloy elements as mentioned above.

In the production of the alloy steel, addition of deoxidizer may be omitted if it is subjected to vacuum treatments such as vacuum dissolution, vacuum degasification, etc. Thus, in this case, an alloy steel containing no deoxidizing elements is obtained. However, in order to accomplish a stronger deoxidization or in case of no vacuum treatments being carried out, addition of deoxidizing elements is required.

Silicon which serves as a deoxidizing element slightly improves corrosion resistance and incrases strength due to dissolution in the base metal matrix as a solid solution. However, when it is added in a large amount, amount of ferrite precipitated is increased to result in heterogeneous structure and to cause reduction in toughness. Therefore, the amount of silicon should not exceed 1 %.

When aluminum, titanium, calcium, magnesium and rare earth elements are used as deoxidizing agent, these should be added in an amount of not more than 0.2 %. When they exceed 0.2 %, carbide and non-metallic inclusions are increased to reduce toughness and thus obtained steel becomes different from that of this invention. The total amount of deoxidizing agents other than silicon and magnesium is preferably limited to less than 0.2 % by weight.

Furthermore, manganese which serves as deoxidizing agent has effects of stabilization of austenite and increasing of strength is an useful element and so can be positively added. In this case, when amount of manganese is less than 0.2 %, the effect attained is insufficient and when more than 2 %, the yield point is apt to decrease probably because a stable retained austenite is formed due to synergistric effect thereof with nickel. Therefore, the content of manganese is preferably 0.2–2 %.

Nitrogen enters into alloy during dissolution from atomosphere or from the melting materials. Nitrogen in a slight amount is effective for stabilization of austenite and improvement of strength. Therefore, it can be positively contained in an amount of up to 0.2 %. However, when it exceeds 0.2 %, reduction in toughness is caused and such addition should be avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a microphotograph (¼ 400) of structure of Sample No. 1 alloy steel of this invention which was quenched from 1000C and then tempered at 630C. As is clear from the microphotograph, the structure is homogeneous tempered sorbite structure having fine crystal grain.

FIGS. 2*a* and 2*b* show V-shaped beveling Lehigh type test piece used for examining restriction welding cracks in the following Example.

FIG. 3 shows relation between 0.2 % yield strength and impact value of the steels of this invention and the conventional steels.

FIG. 4 shows corrosion weight loss and corrosion embrittlement of the steels of this invention and the conventional steels.

FIG. 5 is a schematic view of one embodiment of an impeller of blower of this invention.

FIG. 6 is a schematic view of one embodiment of an impeller of a gas compressor of this invention.

In FIGS. 5 and 6, 1 is a side plate, 2 is a center plate and 3 is blades.

FIG. 7 shows relation between tempering temperature and impact values of the steel of this invention and the comparative steels.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

This invention will be explained in more detail by the following Examples.

Alloy steels having the compositions as shown in Table 1 were subjected to the tests for examination of mechanical properties and state of welding cracks.

Table 1

Sample No.	Chemical Composition (% by weight) C	Si	Mn	Cr	Ni	Mo	Nb	Al	Ti	N	Fe
1	0.12	0.32	1.60	12.3	1.80	0.98	0.18	0.008	0.005	0.02	Balance
2	0.13	0.85	0.31	12.1	1.64	0.92	0.55	0.005	0.004	0.01	"
3	0.10	0.32	0.64	12.1	1.56	0.79	0.26	0.011	0.006	0.01	"
4	0.10	0.38	0.31	12.1	1.68	0.93	0.15	0.006	0.005	0.08	"
5	0.11	0.32	0.84	11.9	2.69	0.88	0.11	0.006	0.004	0.10	"
6	0.07	0.36	1.21	12.4	2.36	1.48	0.20	0.007	0.005	0.02	"
7	0.11	0.31	1.02	12.6	2.15	1.21	0.26	0.010	0.006	0.03	"
8	0.08	0.30	0.70	11.8	2.62	1.12	0.31	0.006	0.01	0.02	"
9	0.11	0.56	0.86	12.5	1.61	0.93	0.10	0.010	0.004	0.02	"
10	0.12	0.52	0.84	12.1	2.91	1.25	0.21	0.005	0.13	0.01	"
11	0.09	0.16	1.05	12.5	2.34	0.83	0.08	0.005	0.17	0.01	"
12	0.10	0.34	0.65	11.9	1.87	0.99	0.16	0.004	0.09	0.01	"
13	0.12	0.36	0.52	11.85	0.24	—	—	—	—	—	
14	0.13	0.58	0.66	12.38	1.74	—	—	—	—	—	

Samples No. 1–12 are the alloy steels used in this invention. These were hardened at 1,000C and then tempered for 5 hours at the temperatures as shown in Table 2. Thereafter, these samples were subjected to the tests. Samples No. 13 and 14 are commercially available stainless steel. These were hardened at 970C and then tempered for 5 hours at the temperatures as shown in Table 2. Thereafter, these samples were subjected to the tests. Table 2 shows mechanical properties at various tempering temperatures. Samples No. 1–12 of this invention were extremely higher than samples No. 13 and 14 impact value. Moreover, samples No. 1–12 had a 0.2 % yield strength of higher than 80 kg/mm² and thus had a high strength and toughness.

Table 2

Sample No.	Tempering temperature (C)	0.2 % Yield strength (kg/mm²)	Tensile strength (kg/mm²)	ELongation (%)	Impact value (kg-m/cm²)
1	630	81.6	93.6	22.4	12.5
2	630	86.8	98.1	20.3	10.2
3	630	81.1	92.3	22.1	17.9
4	630	83.8	95.1	22.1	12.3
5	630	85.0	97.0	20.5	11.8
6	630	82.5	93.3	21.6	14.6
7	630	86.3	98.4	21.1	15.3
7	650	83.1	94.4	22.2	17.8
8	630	81.0	94.2	22.8	15.1
9	630	84.1	96.6	21.2	16.8
9	650	81.4	92.5	22.8	18.4
10	630	85.7	98.2	20.8	11.8
11	630	81.5	93.8	23.0	14.8
12	630	82.1	94.7	21.5	15.4
13	600	67.4	82.7	23.3	3.5
13	650	60.1	75.6	24.8	6.8
14	600	81.6	92.2	22.5	3.4
14	650	73.8	85.6	25.2	5.7

FIG. 3 in which the mark ● indicates the data of the alloy steels according to this invention and the mark ▲ indicates those of the comparative steels of Samples No. 13 and 14 shows relations between 0.2 % yield strength and impact value of the alloy steels according to this invention and the comparative steels of Samples No. 13 and 14 as shown in above Table. It is clear from this FIG. 3 that the impact value of Sample No. 13 and 14 steels is low, namely, 3–4 kg.m/cm² at high strength and 5–7 kg.m/cm² even at low strength while the alloy steel according to this invention has simultaneously high strength and high toughness. When impact values of the Samples No. 13 and 14 and those of the steels according to this invention are compared at an identical strength, it is clear that the steels according to this invention have high strength and high toughness simultaneously.

For examination of the state of welding crack, V-shaped beveling Lehigh type test pieces, as shown in FIGS. 2*a* and 2*b*, for restriction welding crack was welded using a mild steel welding rod for shield arc welding having a diameter of 4 mm and containing 0.08 % of carbon. The dimensions in FIGS. 2*a* and 2*b* are all milimeters. The welding conditions were as follows: preheating temperature—150C and 200C; welding current—145 to 155 A; arc voltage—23 to 24 V; welding speed—150 to 160 mm/min. After welding, the pieces were cooled to 100C and then kept at 600C for 3 hours. Thereafter, the pieces were allowed to stand for cooling to room temperature and then the cross section of the heat affected zone was examined.

Table 3 shows the results of the tests.

Table 3

Sample No.	Preheating temperature (C)	Presence of crack	Position of cracks
7	150	None	—
	200	None	
3	150	None	—
	200	None	
13	150	Present	At the heat affected zone
	200	Present	
14	150	Present	
	200	Present	

Samples No. 13 and 14 which were commercially available produced cracks even when the preheating temperature of 200C was employed while samples No. 7 and 3 of this invention showed no cracks when the preheating temperature of 150C as well as when the preheating temperature of 200C.

The following Table 4 shows the results when anode polarization curves of steel of Sample No. 12 according

to this invention and comparative steel of Sample No. 13 in 1 % sodium chloride solution were obtained and electric potentials at which pitting occurred were obtained. As is clear from the Table, the electric potential at which pitting of the steel according to this invention occurred was extremely higher than that of the Sample No. 13 steel. Thus, pitting resistance of the steel according to this invention is markedly higher than that of the Sample No. 13 steel.

Table 4

Sample No.	Electric potential at which pitting occurred (mV vs SCE)
12	40
13	300

The Sample No. 12 steel according to this invention and the comparative Samples No. 13 and 14 steels were subjected to corrosion weight loss test in a 0.5 % acetic acid aqueous solution saturated with hydrogen sulfide (about 2800 ppm). Furthermore, the steels were dipped in the corrosion solution for a predetermined period and then subjected to tension test and degree of embrittlement of the steels was calculated from elongations before and after the corrosion test in accordance with the following formula: Degree of embrittlement (%) = [(A Ao)/A] ¼ 100 wherein A is elongation before the corrosion test and Ao is elongation after the test. The results of the corrosion weight loss test and the corrosion embrittlement test are shown in FIG. 4 in which the corrosion time on horizontal axis is logarithmically indicated. As is clear from this FIG. 4, the steel according to this invention is much superior to the comparative Samples No. 13 and 14 steels in both the corrosion weight loss and corrosion embrittlement.

FIG. 7 shows relation between tempering temperature and impact value of Sample No. 12 steel of this invention which has hardened under the same condition as in Table 2 and tempered at a temperature of lower than 680C for 5 hours. Impact values of steels of 0.1 % C — 12 % Cr — 2 % Ni — 1.5 % Mo and 0.1 % C — 12 % Cr — 2 % Ni — 1.5 % Mo — 0.3 % V are also shown in FIG. 7 for comparison. As is clear from FIG. 7, the steel of this invention has remarkably higher impact values than the comparative steels and furthermore, the steel of this invention does not show reduction in impact value as recognized in the comparative steels when they are tempered at about 500C. Such characteristic of the steel of this invention provides the great merit that the steel can be tempered at about 500C and can be used at high strength state. V is a carbide forming element as Nb is and addition of V results in increase in strength, but as is clear from FIG. 7, impact value is extremely decreased and thus the effect of V on impact value is utterly different from that of Nb.

The present invention may be applied to impellers of air compressors, blowers, gas compressors, fans, and the like.

In FIG. 5, the impeller for blower comprises center plate 2, side plate 1 and blades 3, and center plate 2 and blades 3 and blades 3 and side plate 1 are respectively rivet-jointed at 5. Auxiliary blades 7 are fixed to blades 3 by welding. Blades 3 and side plate 1 may be welded at butt portion 6. Thus assembled impeller is provided with shaft 4 which pierces the impeller. In FIG. 6, blades 3 of impeller for compressor are welded to center plate 2 and side plate 1 and a shaft (not shown) is fixed in shaft hole 10. However, blades 3 may be fixed to center plate 2 and side plate 1 by rivet-jointing. In case of blower, as shown in FIG. 5, air, air containing dusts or waste gases from various furnaces is sucked into impeller from the direction shown by arrow 8 and discharged from spaces between the blades 3 to the direction shown by arrow 9. Thus, in case of blower, area of inlet for sucking is relatively smaller than that of outlet for discharging. Therefore, when mechanical strength of blades 3 and 7, center plate 2 and side plate 1 is high, size of impeller per desired capacity can be made smaller or discharge amount can be made greater by increasing the number of revolution of impeller. The steel of this invention has a high mechanical strength and so the size of the impeller can be made smaller by 10–20 %. Furthermore, in case of compressor, air, or air containing carbon dioxide, nitrogen gas, oxygen gas, sulfurous acid gas, etc. (gases from plant for production of sulfuric acid) is sucked from sucking inlet in the direction shown by arrow 11, compressed in the impeller and discharged from the spaces between the blades to the direction shown by arrow 12. Thus, in case of impeller of compressor, the sectional area of sucking inlet is relatively greater than that of the discharging outlet.

Since the steel of this invention is excellent also in corrosion resistance, it is suitably used in devices which handle various corrosive gases as mentioned above.

As explained above, the impellers of this invention made of the alloy steel having components as specified in this invention are markedly superior to those of the conventional corrosion resistant martensite stainless steels in strength and toughness as well as corrosion resistance.

What is claimed is:

1. An impeller for gas handling apparatus comprising a pair of annular plates, a plurality of blades arranged in concentric relation with each other and fixed to each of the plates in the substantially axial direction, and a shaft disposed in the center of the arranged blades, said plates and blades being made of a martensite alloy steel consisting essentially of, based on weight, 0.06 to 0.15 % of carbon, 11 to 13.5 % of chromium, 1.5 to 3 % of nickel, 0.7 to 2 % of molybdenum, 0.03 to 0.6 % niobium, up to 1 % of silicon, 0.2 to 2 % of manganese, up to 0.2 % of nitrogen, up to 0.2 % in a total amount of at least one member selected from the group consisting of aluminum, titanium, calcium, magnesium and rare earth elements, and the balance substantially iron, amounts of chromium, silicon, molyblenum, niobium, nickel, manganese and nitrogen being adjusted so that chromium equivalent is within the range of 7 to 13.

2. An impeller for gas handling apparatus comprising a pair of annular plates, plurality of blades arranged in concentric relation with each other and fixed to each of the plates in substantially axial direction and a shaft disposed in the center of the arranged blades, said plates and blades being made of a martensite alloy steel consisting essentially of, based on weight, 0.07 to 0.11 % of carbon, 11.5 to 12.5 % of chromium, 1.8 to 2.2 % of nickel, 0.8 to 1.2 % of molybdenum, 0.1 to 0.3 % of niobium, up to 1 % of silicon, 0.2 to 2 % of manganese, up to 0.2 % of nitrogen, up to 0.2 % in a total amount of at least one member selected from the group consisting of aluminum, titanium, calcium, manganese and rare earth elements, and the balance substantially iron, amounts of chromium, silicon, molybdenum, niobium,

nickel, magnanese and nitrogen being adjusted so that chromium equivalent is within the range of 7 to 13.

3. An impeller according to claim **1,** wherein one of the plates has a gas inlet around the shaft, a section area of the gas inlet being smaller than a outlet formed between the blades whereby a gas introduced into the impeller is discharged from the outlet.

4. An impeller according to claim **2,** wherein one of the plates has a gas inlet around the shaft, a section area of the gas inlet being larger than a outlet formed between the blades, whereby a gas introduced into the impeller is compressed therein and discharged from the outlet.

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