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(54) Age-hardening steel for die-casting dies

(57) The object is to provide an age-hardening steel for die-casting dies which is superior in heat check resistance, displays long life of the die, and has an improved ratio of dimensional change in the age heat treatment.For this object, the composition of the age-hardening steel for die-casting die, in weight %, contains C : ≦ 0.03 %, Si : ≦ 0.10 %, Mn : ≦ 0.10 %, Ni : 9.0 ~ 11.0 %, Cr : 0.10 ~ 5.0 %, Mo : 5.0 ~ 8.0 %, Co : 5.0 ~ 8.0 %, Ti : 0.10 ~ 1.0 %, Al : 0.05 ~ 0.15 %, and 30 ≦ Co (%) x Mo (%) ≦ 50, and the remainder substantially Fe. As a preferred embodiment in case of need, the composition may contains Cr : 0.30 ~ 1.0 %, or N may be regulated to 0.0050 % or less, or furthermore TiN inclusion larger than 10 micron m may be 2% of the whole or less.

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an age-hardening steel for die-casting dies and particularly to an age-hardening steel for die -casting dies which is superior in heat check resistance and has a small ratio of dimensional change by ageing.

2. Description of the Prior Art

Until now, as the steel material for die-casting dies has been used the tool steel for hot working which mainly contains 5 % Cr and 1 ~ 1.5 % Mo.

In case of forming the die-casting dies from this tool steel for hot working, the quenching and tempering treatments are carried out to cause the tool steel to display the required hardness and strength.

However, when the quenching and tempering treatments are carried out, it results in the large heat-treatment distortion and deformation, so that it used to perform rough machining once before the quenching and tempering treatment and then to carry out the quenching and tempering and thereafter to apply the finishing machining. As a result, it was inevitable to increase the number of process steps so as to take a long time for manufacturing the dies.

Accordingly, the age -hardening steel such as typically 18 % Ni marageing steel has been examined to apply to the die-casting dies.

In case of manufacturing the die-casting dies from such an age-hardening steel, the deformation in the heat treatment is not produced on a large scale differing from the quenching and tempering treatment in the above-described tool steel for hot working. Consequently, it becomes possible to omit a part of the process steps so as to abridge the required time for manufacturing the dies as well as the number of manufacturing process steps.

However, in the case of the 18 % Ni marageing steel, which is a general age-hardening steel, when it is used to constitute a die-casting die, it does not have a sufficient resistance to the heat checks generated on the surface portion, that is, the generation of cracks resulting from the periodical operation of the thermal stress incidental to the rapid heating and cooling. As a result, this marageing steel includes a problem that the life of the casting die constituted by this steel is remarkably short comparing to that made of the conventional tool steel for hot working.

Also, in the case of this marageing steel, although the deformation in the heat treatment for constituting die-casting dies is smaller than that for constituting the die-casting die by the conventional tool steel for hot working, the isotropic shrinkage due to the heat treatment is inevitable.

And, when the shrinking deformation (the ratio of dimensional change) is large, the dimensional deviation of the constituted die-casting dies becomes large, so that it becomes difficult, in fact, to apply this marageing steel to such a die-casting die.

To describe in full, when the die-casting dies are manufactured from the age-hardening steel, the form and dimension of the dies before the ageing treatment are determined making allowances for the shrinkage due to the heat treatment. However, if the shrinking deformation due to the heat treatment is in excess of a certain level, it becomes difficult to finally assure the dimensional accuracy of the die-casting dies.

With respect to the improvement of the breaking strength of the marageing steel, various technological proposals have been offered until now.

For instance, in Japan unscreened patent publication Toku-kai-hei 6-158228, there is disclosed a composition to improve the delayed fracture resistance of a marageing steel, wherein Cr : 6.0 ~ 15 %, Ni : 4.0 ~ 12 %, Mo : 0.3 ~ 3.0 %, Ti : 1.0 ~ 3.0 %, Al : 0.01 ~ 2.00 %.

However, since the marageing steel in the publication No. 6-158228 does not include Co, it is not sufficiently hardened in the ageing treatment. Moreover, this marageing steel, of which the objects are exclusively structural members such as bolts, sheet metal and the like, is large in the ratio of dimensional change, so that it is difficult to use this steel for the die-casting dies.

On one hand, in Japan unscreened publication Toku-kai-hei 6-248389, there is disclosed a marageing steel for die-casting die having the following composition to increase the softening resistance so as to improve the heat check resistance, wherein Ni : 12 ~ 14 %, Mo : 4.5 ~ 6.0 %, Co : 7.5 ~ 9.5 %, Ti : 0.5 ~ 1.0 %, C : $\leqq$ 0.03 %, Si : $\leqq$ 0.1 %, Mn : $\leqq$ 0.1%, P : $\leqq$ 0.01 %, S : $\leqq$ 0.01 %, Cr : $\leqq$ 0.05 %, N : $\leqq$ 0.01 %, Al : 0.02 ~ 0.20 %, Fe : the remainder.

However, since this marageing steel is set in rather high content of Ni, it is not sufficient in the heat check resistance and also not sufficiently small in the ratio of dimensional change.

On the other hand, in Japan unscreened patent publication Toku-kai-sho 63-145753, there is disclosed a marageing steel having the following composition to improve the delayed fracture resistance, wherein C : $\leqq$ 0.03 %, Si : $\leqq$ 0.10 %, Mn : $\leqq$ 0.10 %, Cu : $\leqq$ 0.10 %, Ni : 7 ~ 20 %, Cr : $\leqq$ 0.10 %, Mo : 2 ~ 6 %, Co : 5 ~ 18 %, Al : $\leqq$ 0.50 %, Ti : 0.8 ~ 2.5 %, B : 0.0005 ~ 0.005 %, P : $\leqq$ 0.0025 %, S : $\leqq$ 0.0025 % , P + S : $\leqq$0.0030 %, Fe : the remainder. Also, in Japan unscreened patent publication Toku-kai-sho 62-228455, there is disclosed a marageing steel having the following composition to improve the fatigue property, wherein C : ≦ 0.03 %, Si : ≦ 0.10 %, Mn : ≦ 0.10 %, Cu : ≦ 0.1 %, Ni : 7 ~ 20 %, Cr : ≦ 0.1 %, Mo : 1 ~ 10 %, Co : ≦ 18 %, Al : ≦ 1 %, Ti : ≦ 2.5 %, P : ≦ 0.002 %, S : ≦ 0.0015 %, P + S : ≦ 0.0030%, Fe : the remainder.

However, those marageing steels also have a problem that the ratio of dimensional change is not sufficiently small in the heat treatment.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an age-hardening steel for die-casting dies which is superior in heat check resistance, displays long life of the die, and has an improved ratio of dimensional change in the age heat treatment in the case of the application to the die-casting dies.

The present invention to accomplish this object is characterized in that the composition of the age-hardening steel for die-casting die, in weight %, contains C : ≦ 0.03 %, Si : ≦ 0.10 %, Mn : ≦ 0.10 %, Ni : 9.0 ~ 11.0 %, Cr : 0.10 ~ 5.0 %, Mo : 5.0 ~ 8.0 %, Co : 5.0 ~ 8.0 %, Ti : 0.10 ~ 1.0 %, Al : 0.05 ~ 0.15 %, and 30 ≦ Co (%) x Mo (%) ≦ 50, and the remainder substantially Fe.

In the present invention, as a preferred embodiment, the composition may contain Cr : 0.30 ~ 1.0 %.

Either in case of containing Cr within the range of 0.10 ~ 5.0 % or in case of containing Cr in the narrower range of 0.30 ~ 1.0 %, as a preferred embodiment, N may be regulated to 0.0050 % or less.

In the present invention, regarding to the TiN inclusion in the steel material, it is preferable that the TiN inclusion larger than 10 micron m in the equivalent circular diameter may be 2 % of the whole or less.

According to the present invention as described above, it is possible to obtain an age-hardening steel for die-casting dies which is superior in the heat check resistance and to improve the durable life of the die-casting dies in a large way.

Moreover, the age-hardening steel according to the present invention has a small ratio of dimensional change in the heat treatment, so that it is possible to reduce the machining man power in the manufacturing of the die-casting dies and to improve the dimensional accuracy of the die-casting dies as well.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a diagram illustrating the heat check resistance and the Charpy impact value respectively relating to the solubility product of Co(%) and Mo(%) based on the example of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

When researching the technical measures to improve the heat check resistance and the ratio of dimensional change in the heat treatment for the age-hardening steel for die -casting dies, the present inventor has obtain a knowledge that the reduction of the Ni quantity and the addition of the proper Cr quantity are effective to the reduction of the ratio of dimensional change in the ageing treatment.

To put it concretely, the reduction of the Ni quantity results in the rising of the austenitic transformation point (As point) and contributes to the improvement of the heat check resistance. When the temperature of the As point is low, according to the heating operation of the molten metal during the use of the die-casting dies, the surface stratum of the die is liable to austenitize from the martensitic structure, and it promotes the generation of the cracks. On the contrary, when the As point is caused to be high, this problem can be prevented, so that it is possible to improve the heat check resistance.

However, the reduction of the Ni quantity simultaneously results in the decline of the toughness.

Accordingly, in the present invention, it was intended to assure the toughness by controlling the quantity of Co (%) x Mo (%) which greatly influences the deposition in the age-hardening treatment.

With respect to Cr, the ratio of dimensional change in the heat treatment is caused to be small according to the addition of the appropriate Cr quantity. On the other hand, the addition of Cr causes to lower the As point, so that it is feared that the heat check resistance may be made inferior.

Accordingly, in the present invention, it is intended that the adding quantity of Cr is controlled under the certain level.

In the present invention, the preferred content of Cr is in 0.30 ~ 1.0 % and the quantity of N is preferable to be as little as possible.

In the Ti -containing system, the increase of N results in the deposition of the TiN, and thereby the low cycle fatigue property of the die-casting dies is made inferior, wherein the low cycle fatigue is the phenomenon that the casting die is broken under the big die-tightening force, for example.

Since the increase of the N quantity also makes the toughness inferior, it is desirable that the N quantity is as little as possible. However, the extreme minimization of N results in the rising of the manufacturing cost, so that it is preferable that the upper limit of the N quantity is set in 0.0050 % even when the quantity of N is made as little as possible.

With respect to the above-described TiN inclusion in the steel material, when the TiN particles larger than 10 micron m in the equivalent circular diameter are contained more than 2% of the whole, they become the starting points of fracture to make the low cycle fatigue property inferior, so that it results in the occurrence of great fracture in the die-casting die.

Consequently, regarding to the TiN inclusion in the steel material, it is preferable that the TiN particles larger than 10 micron m in the equivalent circular diameter may be 2% of the whole or less.

Hereinafter, the cause of limiting the respective chemical components in the present invention will be described in detail.

C : ≦ 0.03 %

Since C causes to deposit the carbide such as TiC, Mo2C on the grain boundaries so as to lower the toughness remarkably, the upper limit is made to be 0.03 %, and it is desirable to be 0.01 % or less to assure the greater toughness.

Si : ≦ 0.10 %

Since Si causes the toughness inferior, it is necessary that Si is made 0.10 % or less.

Mn : ≦ 0.10 %

Mn is controlled to 0.10 % or less because it produces the MnS inclusion combining with S so as to make the toughness inferior.

Ni : 9.0 ~ 11.0 %

Ni is an essential element to form a matrix superior in the toughness in a solid solution of Fe. However, the quantity of depositing material increases along with the increase of the adding quantity, so that it causes to extend the ratio of age shrinkage (ratio of dimensional change). Also, along with the increase of the adding quantity of Ni, the austenitic transformation point As lowers to make the heat check resistance inferior. Since the surface of the casting die is exposed to the molten aluminum in high temperature of 600 ~ 650 °C , for example, it is required that the As point is over the arriving surface temperature. For that purpose, it is necessary that Ni may be 11.0 % or less. However, if the adding quantity of Ni is less than 9.0 %, the necessary toughness can not be assured. For that reason, the content of Ni is set in 9.0 ~ 11.0 % in the present invention.

Cr : 0.10 ~ 5.0 %

By adding Cr of 0.10 % or more, it is possible to cause the ratio of dimensional change by ageing to lower. However, in case of excessive addition of Cr over 5.0 %, the heating transformation point and the toughness are lowered, so that Cr is set in 0.10 ~ 5.0 %. The preferred range of Cr is in 0.3 ~ 1.0 %.

Mo : 5.0 ~ 8.0 %

To obtain the age hardness HRC 40 or more to be required to the die-casting dies, Mo over 5 % is necessary. However, if Mo is over 8.0 %, it results in the occurrence of the lowering of Ms point and the higher cost. Consequently, Mo is set in 5.0 ~ 8.0 %.

Co : 5.0 ~ 8.0 %

The increase of the Co quantity has an effect to promote the age hardening property because it results in the lowering of the solubility degree of Mo in the solid solution.

However, when Co is under 5 %, the effect is small, and even the As point lowers. When Co is over 8 %, it results in the inferior toughness and also the higher cost, so that Co is set in 5.0 ~ 8.0 %.

Ti : 0.10 ~ 1.0 %

Although Ti is a hardening element which forms Ni_3Ti and contributes the age-hardening, the excessive addition of Ti causes to deposit TiN and to make the toughness and the low cycle fatigue property inferior. Furthermore, the Ms point is caused to lower, so that the Ti segregation band becomes the retained austenitic band, and also the austenitic transformation point is caused to lower, so that the heat check resistance is made inferior. Consequently, the upper limit of Ti is set in 1.0 %.

Along with the reduction of the Ti quantity, the toughness is improved and the austenitic transformation point is raised. However, in case of Ti under 0.10 %, it results in the insufficient age-hardening property, so that the lower limit of Ti is set in 0.10 %.

Al : 0.05 ~ 0.15 %

Al is a component to be added as a deoxidizer and contributes even to the age-hardening together with Ti. However, when it is under 0.05 %, the age-hardening property is insufficient, and on the contrary, when it is over 0.15 %, the toughness is made inferior. Consequently, Al is set in 0.05 ~ 0.15 % in the present invention.

N : ≦ 0.0050 %

Along with the increase of the N quantity, TiN as an inclusion is deposited so as to make the low cycle fatigue property inferior. The damage of the casting dies is caused to occur by the thermal stress during heating and cooling. In the case of large casting dies, the question is in the low cycle fatigue which may lead to the big fracture.

Furthermore, because of making the toughness also inferior, it is desirable that the quantity of N may be reduced as far as possible. However, the extreme minimization of N results in rising of the manufacturing cost, so that the upper limit is set in 0.0050 %.

TiN inclusion larger than 10 micron m of equivalent circular diameter : 2 % of the whole or less.

In case that there are particles larger than 10 micron m of equivalent circular diameter in the TiN inclusions in the die material, the particles become the starting points of fracture in the portion under the die-tightening force, the teeming stress or the thermal stress. As a result, it causes the lowering of the low cycle fatigue property and even the big fracture of the casting die. Consequently, it is required that the particles of TiN inclusion larger than 10 micron m may be 2 % of the whole or less.

$$30 \leqq Co(\%) \times Mo(\%) \leqq 50$$

The solubility product of Co (%) x Mo (%) indicates the age-hardening property, and when this solubility product is reduced, also the aged hardness is lowered. As a result, it restrains the toughness from lowering due to the reduction of the Ni quantity and results in the assurance of the toughness. Consequently, the upper limit of this value is set in 50.

On the contrary, when Co (%) x Mo (%) is under 30, the softening resistance in the high temperature is not sufficient, and the heat check resistance rapidly becomes inferior. Consequently, the lower limit of this value is set in 30.

EXAMPLE

Hereinafter, an example of the present invention will be described in detail.

The age-hardening steel of the chemical composition shown in Table 1 was treated in atmospheric induction melting and

TABLE 1

	Item No.	Chemical Component (Wt%)										
		C	Si	Mn	Ni	Cr	Mo	Co	Ti	Al	N	CoxMo
Example of Invention	1	0.007	0.05	0.02	9.3	0.15	7.7	6.1	0.42	0.07	0.005	47.0
	2	0.015	0.06	0.04	9.2	0.10	7.6	5.1	0.39	0.11	0.005	38.8
	3	0.009	0.07	0.05	9.5	0.13	7.4	6.6	0.25	0.12	0.005	48.8
	4	0.008	0.05	0.06	9.9	0.15	5.9	6.8	0.16	0.08	0.003	40.1
	5	0.012	0.06	0.05	10.2	0.11	7.1	6.9	0.38	0.09	0.005	49.0
	6	0.008	0.02	0.02	10.1	0.20	6.4	7.5	0.45	0.11	0.004	48.0
	7	0.011	0.02	0.03	10.4	0.15	6.1	6.0	0.53	0.10	0.003	36.6
	8	0.011	0.02	0.03	10.9	0.35	7.1	6.0	0.66	0.10	0.004	42.6
	9	0.008	0.03	0.02	9.8	0.64	5.1	7.8	0.56	0.10	0.005	39.8
	10	0.009	0.03	0.02	9.6	0.80	5.9	7.9	0.39	0.10	0.003	46.6
	11	0.015	0.03	0.02	10.5	0.90	6.5	6.5	0.47	0.11	0.005	42.3
	12	0.013	0.04	0.03	9.9	0.89	5.0	7.0	0.48	0.11	0.005	35.0
	13	0.007	0.03	0.05	9.8	0.87	5.1	6.0	0.49	0.10	0.003	30.6
	14	0.009	0.05	0.03	10.2	0.98	6.0	5.1	0.50	0.12	0.010	30.6
	15	0.009	0.03	0.03	10.4	0.88	7.0	5.2	0.51	0.11	0.010	36.4
	16	0.011	0.03	0.03	10.0	2.50	6.1	6.0	0.53	0.10	0.011	36.6
	17	0.010	0.02	0.03	10.1	4.80	6.0	6.0	0.50	0.11	0.010	36.0
Comparative Example	18	0.020	0.02	0.01	12.1	0.05	7.9	8.1	0.49	0.07	0.010	64.0
	19	0.016	0.01	0.01	18.1	0.03	5.1	10.0	0.50	0.11	0.010	51.0
	20	0.009	0.03	0.05	10.4	0.10	5.0	5.0	0.56	0.10	0.011	25.0
	21	0.009	0.04	0.03	10.9	0.13	5.1	4.0	0.39	0.10	0.008	20.4
	22	0.011	0.03	0.03	9.8	0.15	7.9	8.1	0.47	0.11	0.009	64.0
	23	0.010	0.05	0.03	9.6	0.11	8.1	9.2	0.48	0.11	0.010	74.5

in ingot-making (350 mm phi) , cooled by water after holding in 930 ~ 1130 °C, and moreover cooled by air after holding in 880 ~ 980 °C. From such a steel material were extracted a JIS No.3 Charpy impact test piece in the T direction (vertical to the rolling direction) of 1/2R (radius) portion, a heat check test piece of 15 mm phi (diameter) x 5 mm t (thickness), and a low cycle fatigue test piece. Then, the Charpy impact test, heat check test, and low cycle fatigue test were performed with those test pieces.

Also, from the central part of the material was extracted a block of 210 mm L (length) x 130 mm W (width) x 45 mm t (thickness), and the ratio of dimensional change was measured in the order of the dimensional measurement, ageing treatment and again dimensional measurement of the block.

Incidentally, the conditions of the ageing, heat check resistance test and Charpy impact test were respectively set in the following conditions.

The ageing : 520 °C x 5 hr, Air cooling (in the peak ageing condition)

The heat check resistance test : High-frequency heating 650 °C x 4 sec and Water cooling 3 sec, repeated in 1000 times of this heating and cooling cycle.

The Charpy impact test : 2 mm U-notched test piece, extracted in the T direction, tested in the room temperature.

Besides, the measurements of the ratio of dimensional change by ageing were performed respectively in the longitudinal (L) and transverse (T) directions of the block test piece of 210 mm L x 130 mm W x 45 mm t.

Moreover, the low cycle fatigue test was carried out by examining the number of the repeated times to result in the fracture when the one-side tension was repeatedly applied to the test piece along the single axis under the maximum stress of 123 kgf/ mm^2.

Those results are shown in Table 2.

As shown in the results of Table 2, the comparative example 18, in which the content of Ni is out of the range limited in the present invention, is low in As point and inferior in the heat check resistance; the comparative example 19, which contains Ni : 18 %, is extremely low in As point and also remarkably inferior in heat check resistance although it shows a good figure of the Charpy impact value.

In regard to the examples 20 and 21, in which the values of solubility product of Co and Mo, Co (%) x Mo (%), are lower than those of the range limited in the present

TABLE 2

	Item No.	D.C. Ratio(%) Ldir.	D.C. Ratio(%) Tdir.	As Pt. (℃)	A.H.Peak (HRC)	H.C.Resist(μm) Av.L.	H.C.Resist(μm) Max.L.	TiN Area Ratio(%)	Low Cyc.Ftg Life(Time)	Charpy Imp. Val. (J/cm²)
Example of Invention	1	-0.056	-0.083	666	49.9	6.24	43.1	1.54	3.50×10^4	20.6
	2	-0.062	-0.091	668	48.8	7.01	45.9	1.54	3.50×10^4	22.8
	3	-0.055	-0.082	664	50.2	5.86	43.3	1.54	3.50×10^4	20.1
	4	-0.064	-0.095	659	49.0	5.33	48.5	0.99	2.80×10^4	24.2
	5	-0.059	-0.087	656	50.2	6.13	46.1	1.54	3.50×10^4	20.7
	6	-0.059	-0.087	657	50.1	5.16	46.1	1.23	3.13×10^4	20.9
	7	-0.069	-0.095	653	48.5	6.70	52.4	0.92	2.71×10^4	27.5
	8	-0.066	-0.098	651	49.3	7.48	52.1	1.23	3.13×10^4	26.0
	9	-0.063	-0.093	660	49.0	4.10	48.1	1.54	3.50×10^4	24.1
	10	-0.056	-0.083	663	49.9	4.24	44.5	0.92	2.71×10^4	20.1
	11	-0.064	-0.094	652	49.3	6.50	50.3	1.54	3.50×10^4	25.0
	12	-0.066	-0.098	659	48.3	4.75	50.7	1.54	3.50×10^4	26.8
	13	-0.069	-0.097	660	47.7	5.61	52.2	0.92	2.71×10^4	28.7
	14	-0.070	-0.099	656	47.7	7.44	54.2	3.08	4.95×10^4	29.9
	15	-0.068	-0.099	653	48.5	7.50	52.5	3.14	5.00×10^4	27.6
	16	-0.062	-0.092	658	48.5	6.27	50.4	3.26	5.10×10^4	26.3
	17	-0.058	-0.086	657	48.4	6.32	51.2	3.08	4.95×10^4	26.9
Comparative Example	18	-0.057	-0.084	633	52.2	7.65	48.4	3.02	4.90×10^4	18.9
	19	-0.095	-0.141	560	50.5	11.02	95.3	3.08	4.95×10^4	43.7
	20	-0.078	-0.115	653	47.0	8.62	58.0	3.45	5.24×10^4	33.3
	21	-0.084	-0.124	647	46.3	9.52	63.2	2.40	4.37×10^4	37.2
	22	-0.045	-0.067	660	52.2	5.23	39.0	2.90	4.80×10^4	11.9
	23	-0.036	-0.054	663	53.6	4.46	34.9	2.96	4.85×10^4	6.1

invention, the heat check resistance is inferior. In regard to the examples 22 and 23, in which the values of the solubility product are higher than those of the range in the present invention, the figures of Charpy impact value are inferior. On the contrary, any data of the present invention are all in the good values.

Incidentally, the desired values as the standard to judge the respective qualities of the ratio of dimensional change by ageing (in the L direction), As point, the mean and maximum lengths in heat check resistance, and Charpy impact value are set as follows; the ratio of dimensional change (absolute value) : ≦ 0.070 %, As point : ≧ 650 °C, in the heat check resistance the mean length : ≦ 7.5 mic. m and the maximum length : ≦ 55 micron m, and Charpy impact value : ≧ 20 J/cm^2.

Next, the figures 1 (A) and 1 (B) show the heat check resistance and the Charpy impact value respectively relating to the solubility product of Co and Mo based on the results of Table 2. Referring to those figures, it will be seen that the good results are obtained either in the heat check resistance or in the Charpy impact value by controlling the solubility product of Co and Mo in the range of 30 ~ 50.

The example of the present invention described above in detail is only an illustration and the present invention may be carried into execution in any modes of various changes within the scope of the substance.

Claims

1. An age-hardening steel for die-casting die which is superior in heat check resistance and ratio of dimensional change by ageing; comprising, in weight %, C : ≦ 0.03 %, Si : ≦ 0.10 %, Mn : ≦ 0.10 %, Ni : 9.0 ~ 11.0 %, Cr : 0.10 ~ 5.0 %, Mo : 5.0 ~ 8.0 %, Co : 5.0 ~ 8.0 %, Ti : 0.10 ~ 1.0 %, Al : 0.05 ~ 0.15 %, and 30 ≦ Co (%) x Mo (%) ≦ 50, and the remainder substantially Fe.

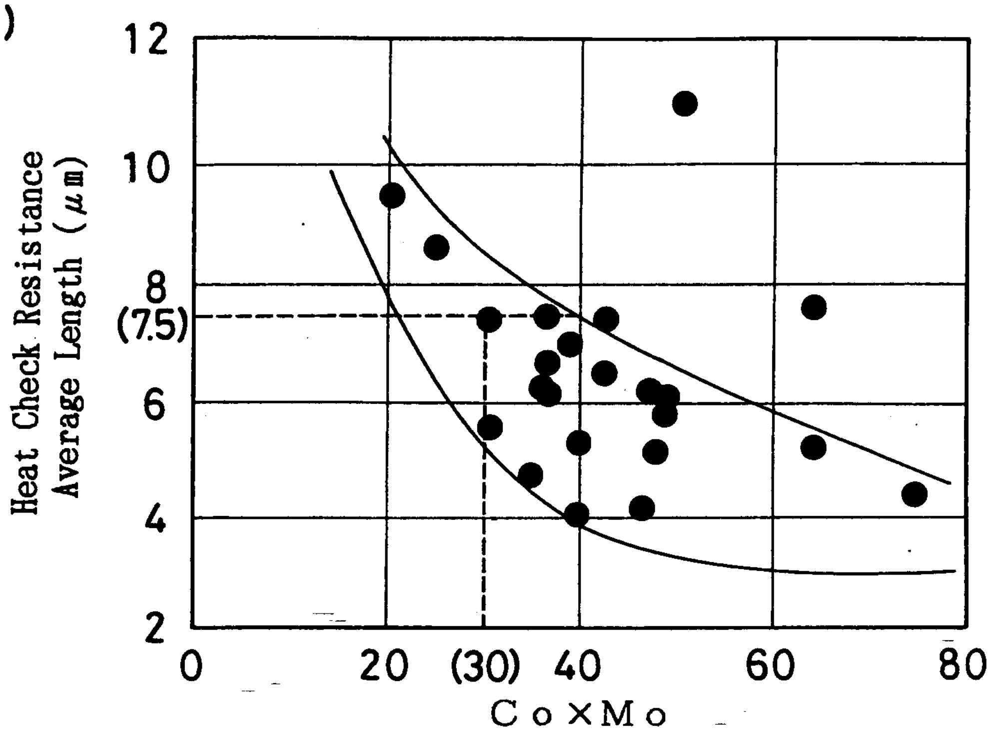
2. An age-hardening steel for die-casting die which is superior in heat check resistance and ratio of dimensional change by ageing as set forth in claim 1 characterized in that the composition is regulated in Cr : 0.30 ~ 1.0 %.

3. An age-hardening steel for die-casting die which is superior in heat check resistance and ratio of dimensional change by ageing as set forth in claim 1 or 2 characterized in that the composition is regulated in N : ≦ 0.0050 %.

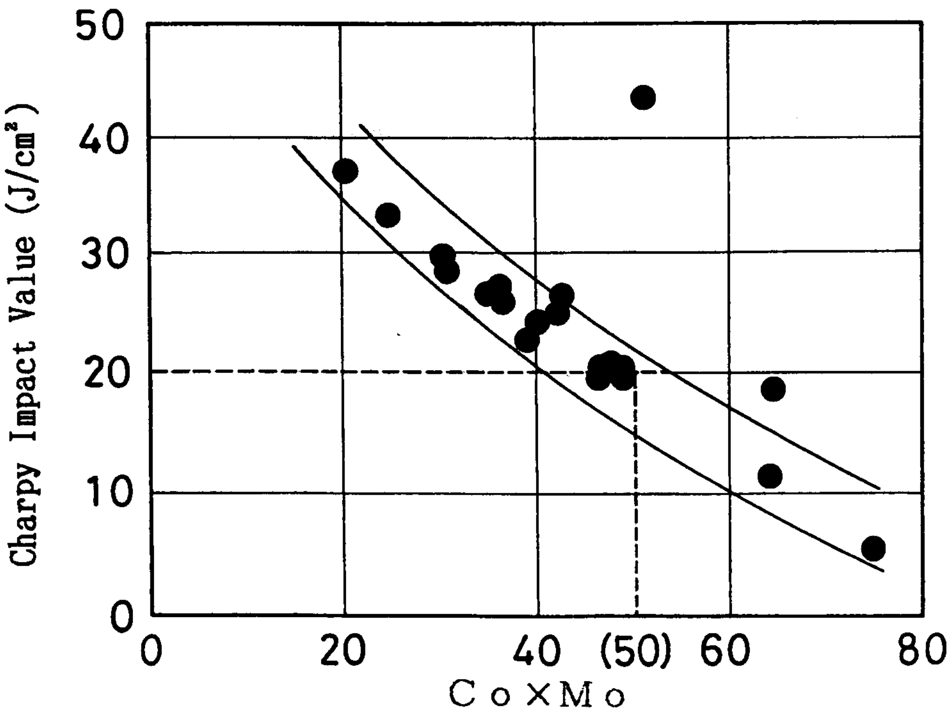
4. An age-hardening steel for die-casting die which is superior in heat check resistance, ratio of dimensional change by ageing, and low cycle fatigue as set forth in claim 1, 2 or 3 characterized in that TiN inclusion larger than 10 micron m of equivalent circular diameter is 2% of the whole or less.

FIG. 1

(A)


12
10
8
(7.5)
6
4
2
Heat Check Resistance
Average Length (μm)
0
20
(30)
40
60
80
Co×Mo

(B)


50
40
30
20
10
0
Charpy Impact Value (J/cm²)
0
20
40
(50)
60
80
Co×Mo

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 11 2457

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 105 864 (VOEST ALPINE AG) 18 April 1984 * claims *	1	C22C38/52 C22C38/44
A	GB-A-1 243 382 (NIPPON STEEL CORP) 18 August 1971 * table 5 *	1	
A	DATABASE WPI Section Ch, Week 8605 Derwent Publications Ltd., London, GB; Class A32, AN 86-033469 XP002018945 & JP-A-60 255 959 (JAPAN STEEL WORKS) , 17 December 1985 * abstract *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 011, no. 013 (C-397), 14 January 1987 & JP-A-61 190050 (HITACHI METALS LTD), 23 August 1986, * abstract *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			C22C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	20 November 1996	Ashley, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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