

HOT WORK TOOL STEEL

TECHNICAL FIELD

- 5 The invention relates to a hot work tool steel.

BACKGROUND OF THE INVENTION

10 Vanadium alloyed matrix tool steels have been on the market for decades and attained a considerable interest, because of the fact that they combine a high wear resistance with an excellent dimensional stability and because they have a good toughness. These steels have a wide range of applications such as for die casting and forging. The steels are generally produced by conventional metallurgy and sometimes followed by Electro Slag Remelting (ESR).

15

The E-mobility has led to an increased demand for large structural casting in the automotive industry. Several car manufacturers have started to, or plan to, build Bodies In White (BIW) using giant aluminium casting using High Pressure Direct Casting (HPDC) equipment. This technique is labelled Mega- or Giga-casting and the presses operates with up to 12000 tons of force, wherein the entire holder block and insert may be replaced by a solid steel block.

25 The large dimensions of the blocks as well as the complex geometry of the moulds present the same particular problems. The large size may lead to segregation during casting and may result in banding and structural inhomogeneity in the forged block. In the past, there has been several attempts to reduce this type of defects, in particular by trying to reduce the segregation by modification of the chemical composition of the steel, as described in WO03/083154 A1, EP1490526 A1, EP0882808 A1 and US 2011/01108169 A1.

30 However, a reduction of the amount of segregation elements will influence other properties of the steel and lead to a decreased quenchability and a low amount of equilibrium carbides at austenitizing temperatures a result, which often leads to an undesired grain growth and imparted mechanical properties. This effect is pronounced at the surface due to longer

holding times at the austenitizing temperature (T_A). For this reason, a lower T_A is often recommended for large tools, dies and moulds.

In addition, in large HPDC-moulds it is difficult or even impossible to obtain a sufficient fast cooling in the core of the mould. This may lead to precipitation of grain boundary carbides, a coarse microstructure including bainite and thereby a low toughness, which may lead to a catastrophic failure named gross cracking. In order to mitigate these problems WO2010/074017 A1 discloses a quenching method involving a rapid cooling from 1020 -1070 °C to an isothermal holding temperature of 530 °C followed by a slow cooling to 150 °C.

The most frequently used materials for the moulds of this HPDC is the standard H11 (1.2343) and H13 (1.23344) hot work tool steels as well as different modifications thereof.

H11 and H13 type of steels are matrix steels alloyed with vanadium. They have been on the market for decades and attained a considerable interest, because they combine a high wear resistance with an excellent dimensional stability and because they have a good toughness.

Uddeholm DIEVAR® of the present applicant is a high-performance hot work chromium-molybdenum-vanadium matrix tool as described in WO 99/50468 A1. Other examples of matrix steels are given in EP4095281A1, EP3050986 A1, WO 03/106728 A, EP1469094 A1.

Although the vanadium alloyed matrix tool steels produced by ESR have better properties than conventionally produced tool steels with respect to heat checking, gross cracking, hot wear and plastic deformation, there is a need for further improvements in order to reduce the risk for hot work tool failure, in particular heat checking and gross cracking in high pressure die casting.

Accordingly, it would be beneficial to further improve the steel composition in order to obtain a higher temper resistance, in particular in combination with an improved toughness in order to increase the resistance against gross cracking.

DISCLOSURE OF THE INVENTION

The general object of the present invention is to provide a hot work tool steel having an improved temper resistance leading to an increased life time of the tool.

5

A further object is to improve the resistance against gross cracking of the moulds using high pressure die casting. Hence, it would be of great interest to improve the toughness, the high temperature strength and the thermal fatigue resistance of the steel, in order to reduce the risk for heat checking and gross cracking and furthermore to improve the temper softening resistance. Accordingly, it is desirable that the steel combines a high hardenability such that a fully martensitic structure can be formed also in large steel moulds with a slow cooling rate with a high toughness in order to reduce the risk for catastrophic failure.

10

15 In particular, it is desirable that the objects mentioned above also are achieved in HPDC-moulds for pressure die casting of large parts such as for tools used in mega-casting and giga-casting. For this reason it is desirable to provide a big block of a hot work tool steel and a large mould suitable for mega- and giga-casting, wherein the block preferably has a thickness of at least 200 mm, a length of at least 1000 mm and a width of at least 400 mm and/or the sum of the thickness, length and width of the block and the mould is at least 2000 mm, 2500 mm, 3000 mm or 3500 mm.

20

The foregoing objects, as well as additional advantages, are achieved to a significant measure by providing a hot work tool steel having a composition specifically adapted to HPDC in general as well as for HPDC of large structural parts.

25

The invention is defined in the claims.

DETAILED DESCRIPTION

30

The importance of the separate elements and their interaction with each other as well as the limitations of the chemical ingredients of the claimed alloy are briefly explained in the following.

All percentages of the chemical composition of the steel are given in weight % (wt. %) throughout the description. The amounts of hard phases are given in volume % (vol. %). The upper and lower limits of the chemical elements may be freely combined within the limits set out in claim 1 and/or within the ranges defined in the specification.

5

Carbon (0.28 – 0.39 %)

is to be present in a minimum content of 0.28 %, preferably at least 0.29, 0.30, 0.31, 0.32, 0.33 or 0.34 %. The upper limit for carbon is 0.39 % and may be set to 0.38, 0.37, 0.36 or 0.35 %. In any case, the amount of carbon should be controlled such that the amount of

10 primary carbides of the type $M_{23}C_6$, M_7C_3 and M_6C in the steel is limited, preferably the steel is free from such primary carbides.

Silicon (0.05 – 0.35 %)

Silicon is used for deoxidation. Si is present in the steel in a dissolved form. Si is a strong

15 ferrite former and increases the carbon activity and therefore the risk for the formation of undesired carbides, which negatively affect the impact strength. A low content of Si may result in the presence of finer carbides, which is beneficial for the ductility and toughness of the steel. Si is therefore limited to 0.35%. The upper limit may be 0.30, 0.29 or 0.28 %. The lower limit may be 0.10, 0.15 or 0.20 %.

20

Manganese (0.1 – 0.8 %)

Manganese contributes to improving the hardenability of the steel and together with sulphur manganese contributes to improving the machinability by forming manganese sulphides. Manganese shall therefore be present in a minimum content of 0.1 %, preferably

25 at least 0.2 %. The steel shall contain maximum 0.8 %. The upper limit may be 0.7 %, 0.65 % or 0.6 %.

Chromium (5.4 – 6.0 %)

Chromium is to be present in a content of at least 5.4 % in order to provide a good

30 hardenability in larger cross sections during heat treatment. If the chromium content is too high, this may lead to the formation of high-temperature ferrite, which reduces the hot-workability. Moreover, chromium has a negative effect on the tempering resistance because it counteracts the formation of MX. The lower limit may be 5.42, 5.44, 5.46, 5.48 or 5.50, 5.51 or 5.53 %. The upper limit may be 6.0, 5.9, 5.8 or 5.7 %.

Nickel (≤ 0.4 %)

Nickel may be present in an amount of up to 0.4 %. It gives the steel a good hardenability and toughness. The presence of nickel may also result in an improved machinability, possibly by reducing the amount of carbon in the martensite. However, because of the expense, the nickel content of the steel is limited to 0.4 %. The upper limit may be 0.3, 0.25, 0.20 or 0.15 %.

Molybdenum (1.8 – 2.5 %)

Mo is known to have a very favourable effect on the hardenability. Molybdenum is essential for attaining a good secondary hardening response by the formation of dispersive nano-sized Mo_2C , which prevent dislocation rearrangement and thereby prevents recrystallization and improves the tempering softening resistance. The minimum content is 1.8 %, and it may be set to 1.9 or 2.0 %. Molybdenum is a strong carbide forming element and also a strong ferrite former. The maximum content of molybdenum is therefore 2.5 %. Preferably Mo is limited to 2.4, 2.3 or 2.2 %.

Vanadium (0.6 – 1.1 %)

Vanadium forms evenly distributed primary precipitated vanadium carbides (VC) and carbonitrides of the type $\text{V}(\text{N,C})$ in the matrix of the steel. This hard phase may also be denoted MX, wherein M is mainly V but minor amounts of Cr and Mo may be present and X is one or more of C and N. Vanadium shall therefore be present in an amount of 0.6 - 1.1 %. The upper limit may be set to 1.05, 1.0, 0.95, 0.9 or 0.85%. The lower limit may be 0.65, 0.7 or 0.75 %.

Aluminium (0.001 – 0.03 %)

Al may be used in combination with Si and Mn for deoxidation of the steel. In addition, it may be deliberately added during the re-melting in the ESR-unit. The lower limit may be set to 0.001, 0.002, 0.003 or 0.004 %. The upper limit is restricted to 0.03 % in order to avoid precipitation of undesired phases such as AlN and spinel-phases like $\text{Al}_2\text{O}_3 \cdot \text{MgO}$. The upper limit may be 0.02 or 0.015%.

Nitrogen (0.0010 – 0.01 %)

Nitrogen may optionally be added in order to obtain the desired type and amount of hard phases, in particular $\text{V}(\text{C,N})$. Nitrogen is restricted to 0.0010 – 0.01 %. The lower limit

may be 0.002 or 0.003 % The upper limit may be 0.009, 0.008 or 0.007 %. When the nitrogen content is properly balanced against the vanadium content, vanadium rich carbonitrides V(C,N) will form. These will be partly dissolved during the austenitizing step and then precipitated during the tempering step as particles of nanometer size. The thermal stability of vanadium carbonitrides is considered to be better than that of vanadium carbides, hence the tempering resistance of the tool steel may be improved.

Sulphur ($\leq 0.004\%$)

S is an impurity in the steel and negatively affects the mechanical properties of the steel.

The content of S may be limited to 0.003, 0.001, 0.0008, 0.0007 or even 0.0005 %.

Phosphorous ($\leq 0.05\%$)

P is an impurity element, which has negative effects on the mechanical properties of the steel. P may therefore be limited to 0.05, 0.04, 0.03, 0.02, 0.01 or 0.008 %.

Copper ($\leq 0.5\%$)

Cu is considered as an impurity element. It is not possible to extract copper from the steel. This drastically makes the scrap handling more difficult. For this reason, the maximum content of Cu is set to 0.5 %. The upper limit may be set to 0.4, 0.3, 0.2, 0.15, 0.12, 0.10 or 0.08 %.

Cobalt ($\leq 0.5\%$)

Co may be optionally present in amounts of up to 0.5 %, because Co causes the solidus temperature to increase and therefore provides an opportunity to raise the hardening temperature, which may be 15 - 30 °C higher than without Co. During austenitization it is therefore possible to dissolve larger fraction of carbides and thereby enhance the hardenability. Co also increases the M_s -temperature. However, a large amount of Co may result in a decreased toughness and wear resistance. However, for practical reasons, such as scrap handling, deliberate additions of Co need not to be performed. The maximum content may be set to 0.45, 0.40, 0.35, 0.30, 0.25, 0.20, 0.15 or 0.10 %.

Tungsten ($\leq 1\%$)

In principle, molybdenum may be replaced by twice as much with tungsten. However, tungsten is expensive and it also complicates the handling of scrap metal. The maximum

amount is therefore limited to 1 %, preferably 0.5 %, more preferably 0.3 % and most preferably no deliberate addition is made. W is then accepted in an amount of up to 0.1 %.

Niobium (≤ 0.03 %)

- 5 Niobium is similar to vanadium in that it forms carbonitrides of the type $M(N,C)$. However, Nb results in a more angular shape of the $M(N,C)$. The maximum amount is therefore 0.03 %. The upper limit may be 0.02 %, 0.01 %, 0.005 % or 0.003 %. Preferably, niobium is not deliberately added.

10 **Ti, Zr and Ta**

These elements are carbide formers and may be present in the alloy as impurities. The upper impurity limit of these elements may preferably be set to 0.1 %, 0.05 %, 0.01 % or 0.005 %.

15 **Hydrogen**

Hydrogen is an undesirable impurity element in the steel. It is therefore desirable to decrease the hydrogen content in the liquid steel as much as possible by vacuum degassing. Preferably, the impurity content is limited to 0.0004 % (4ppm), 0.003, 0.00025 or 0.0002 %.

20

Mo/V

The ratio Mo/V should preferably lie in the range of 2.3 – 3.5, more preferably 2.5 -2.7. The upper limit may be restricted to 3.2, 3.1, 3.0 or 2.9 in order to limit the amount Mo_2C and promote VC and in order to get the desired precipitation sequence and precipitation

- 25 potential of the secondary carbides

Steel production

- The tool steel having the claimed chemical composition can be produced by conventional metallurgy, including melting in an Electric Arc Furnace (EAF) and further refining in a ladle. Optionally, the steel may be subjected to vacuum treatment before casting into ingots. The ingots are subjected to Pressurized Electro Slag Remelting (PESR) in order to further improve the cleanliness and the microstructural homogeneity. The remelted ingots may thereafter be subjected to conventional forging or upset forging followed by machining to the desired block size.
- 30

Hardening and tempering

Normally the steel is subjected to hardening and tempering before being used. Austenitizing may be performed at an austenitizing temperature (T_A) in the range of 1020 - 1070 °C, preferably 1040 - 1060 °C. A typical T_A is 1050 °C with a holding time of 30 minutes followed by quenching. The tempering temperature is chosen according to the hardness requirement and is performed at least twice at 600 - 650 °C for 2 hours (2x2h) followed by cooling in air.

Microstructure after hardening and tempering

The microstructure is fully martensitic also after a fairly slow cooling, which results in a steel can have a high toughness also in thick sections subjected to slow cooling. A cooling time of 1000s in the temperature interval of 800 °C– 500 °C ($t_{8/5}$) results in a fully martensitic structure with no formation of bainite.

In the present application this means that the amount of tempered martensite should be at least 97 vol. %, preferably between 98% and 100 vol %. It may contain small amounts of hard phase particles such as carbides, and/or nitrides, and/or carbonitrides. It may also contain small amount of retained austenite. The contents of hard phase particles and retained austenite should be equal to or less than vol. 3 %, preferably less than 2 vol. %, more preferably less than 1 vol. %. The hard phase particles and the tempered martensite may be determined by using a SEM (Scanning Electron Microscope) at a magnification of 1500 times. The retained austenite can be determined by an X-ray diffractometer using ASTM E975-13.

EXAMPLE 1

In this example, a steel according to the invention is compared to the premium hot work steel DIEVAR®.

The steels had the following composition (in wt. %):

	Inventive steel	DIEVAR®
C	0.35	0.37
Si	0.25	0.2

	Mn	0.5	0.5
	Cr	5.6	5.0
	Mo	2.1	2.3
	V	0.80	0.53
5	Mo/V	2.6	4.2

balance iron and impurities.

The inventive steel was heated to an austenitizing temperature (T_A) 1050 °C with a
10 holding time of 30 minutes followed by quenching. The inventive steel was thereafter
subjected to tempering twice for two hours at a temperature of 620 °C (2x2h). Because of
the balanced composition of the steel, it will have a martensitic matrix even in large
sections, i.e. when the cooling time in the temperature interval of 800 °C– 500 °C ($t_{8/5}$) is
up to or even longer than 1000 seconds. The inventive steel is therefore less sensitive to
15 hardness decrease at high temperatures such that higher tempering temperatures can be
used for removing retained austenite without impairing the hardness.

The comparative steel was subjected to the recommended heat treatment, i.e. it was
heated to an austenitizing temperature (T_A) 1010 °C with a holding time of 30 minutes
20 followed by quenching followed by tempering twice for two hours at a temperature of 615
°C (2x2h).

Both the inventive steel and the comparative steel were subjected to a cooling time of 1248
seconds and the phase transformations were examined in a dilatometer. The curves
25 obtained in the dilatometer clearly revealed that the inventive steel solely underwent a
transformation to martensite whereas the comparative steel disclosed transformation to
bainite as well as to martensite.

The tempering resistance of the two steels was examined by measuring the hardness of the
30 samples after heating to 600 °C and holding times of 70 h and 100 h. The inventive steel
had a hardness of 33 HRC after 70 h and a hardness of 30 HRC after 100 h. The
corresponding values for the comparative steel were 31 HRC and 29 HRC, respectively.

It can thus be concluded, that the inventive steel has a better resistance against softening at high temperatures.

EXAMPLE 2

5 In this example, the cleanliness of the ESR-remelted hot work tool steel according to the present invention was investigated. The steel was produced in an industrial scale in a 65 ton EAF followed by conventional secondary metallurgy involving vacuum degassing and cast into ingots, which were remelted in a PESR-unit.

10 The steel thus obtained had the following composition (in wt. %):

	C	0.35
	Si	0.25
	Mn	0.5
15	Cr	5.6
	Mo	2.1
	V	0.80
	Al	0.005
	N	0.004
20	S	0.0001
	P	0.006
	O	0.0004
	H	0.00005
	balance iron and impurities.	

25

The cleanliness of steel was examined with respect to micro-slag according to ASTM E45-97, Method A. The result is shown below

	A	A	B	B	C	C	D	D
30	T	H	T	H	T	H	T	H
	0	0	1.0	0.5	0	0	1.0	0.5

The cleanliness was also measured by an automatic feature detecting software, INCA feature of Oxford Instruments, using a FEI Quanta 600F SEM, which allows the number,

size, shape and chemical analysis of the inclusions to be determined. The investigated area was 6000 mm². The size of the inclusions is given as Equivalent Circle Diameter (ECD), wherein the $ECD = \sqrt{4A/\pi}$, where A is the surface of the particles in the studied section. The examination revealed the following results.:

5

The ECD of 80 % of the number of all oxide particles was $\leq 10 \mu\text{m}$ and all inclusions had an ECD of $\leq 50 \mu\text{m}$.

EXAMPLE 3

10

In this example, the homogeneity of a steel block according to the present invention was investigated.

Scrap was melted in an EAF, subjected to VD and cast into ingots, which were remelted in a PESR-unit. The remelted ingots were thereafter subjected to upset forging followed by machining to the desired block size.

15

The steel block had the following composition (in wt. %):

20	C	0.35
	Si	0.25
	Mn	0.5
	Cr	5.6
	Mo	2.1
	V	0.80
25	balance iron and impurities.	

A steel block had the following size: thickness 305 mm, width 712 mm and a length of 3500 mm.

30

The block was soft annealed by heating to 860 °C and holding for 4 h, cooling to 750 °C at a cooling rate of 10 °C/h followed by cooling to 700 °C at a cooling rate of 7 °C/h and thereafter free cooling in air, which resulted in a Brinell hardness of 169 HBW_{10/3000}. The Brinell hardness HBW_{10/3000} is measured with a 10 mm diameter tungsten carbide ball and a load of 3000 kgf (29400N). The maximum deviation from the mean Brinell hardness

value in the thickness direction, measured in accordance with ASTM E10-01, wherein the minimum distance of the centre of the indentation from the edge of the specimen or the edge of another indentation shall be at least two and a half times the diameter of the indentation and the maximum distance shall be no more than 4 times the diameter of the
5 indentation.

The maximum deviation from the mean Brinell hardness value in the thickness direction was found to be less than 10 %.

10 EXAMPLE 4

In this example, the toughness of an ESR-remelted hot work tool steel according to the present invention was investigated. The steel was produced in an industrial scale in a 65 ton EAF followed by conventional secondary metallurgy involving vacuum degassing and cast into ingots, which were remelted in a PESR-unit.

15

The steel thus obtained had the following composition (in wt. %):

	C	0.36
	Si	0.21
20	Mn	0.48
	Cr	5.54
	Mo	2.12
	V	0.77
	Al	0.006
25	N	0.005
	balance iron and impurities.	

The steel was soft annealed in the same way as set out in example 3 and forged to a cross section of 799x273 mm and hardened from an austenitizing temperature of 1050 °C with
30 a holding time of 30 minutes followed by gas quenching with a cooling time in the temperature interval of 800 °C– 500 °C (t8/5) of 1000 s. The steel was thereafter subjected to tempering twice for two hours at a temperature of 620 °C (2x2h) which resulted in a hardness of 44.4 HRC. Surprisingly, the microstructure was fully martensitic.

The mean impact energy was measured in the LT direction of 6 samples using a standard Charpy-V test in accordance with SS-EN ISO148-1/ASTM E23, which resulted in a mean value of 18 J. Accordingly, the claimed steel has a high hardenability and a high toughness also in large cross sections and is therefore suitable for demanding HPDC-applications
5 such as for moulds used in mega-casting and giga-casting.

INDUSTRIAL APPLICABILITY

The tool steel of the present invention is particular useful in large dies for HPDC requiring a good toughness, a good hardenability and a good tempering resistance.

CLAIMS

1. A hot work tool steel for high pressure die casting, wherein the steel is obtainable by ESR and comprises the following elements in weight %:

5

C	0.28 – 0.39
Si	0.05 – 0.35
Mn	0.1 – 0.8
Cr	5.4 – 6.0

10

Ni	≤ 0.4
Mo	1.8 – 2.5
V	0.6 – 1.1
Al	0.001 – 0.03
N	0.001 – 0.01

15

S	≤ 0.004
P	≤ 0.05
Cu	≤ 0.5
Co	≤ 0.5
W	≤ 1

20

Nb	≤ 0.03
----	--------

balance Fe apart from impurities.

2. The hot work tool steel for high pressure die casting as defined in claim 1, wherein the hot work tool steel comprises one or more of the following elements in weight %:

25

C	0.33 – 0.37
Si	0.15 – 0.3
Mn	0.4 – 0.6
Cr	5.5 – 5.7

30

Ni	≤ 0.25
Mo	2.0 – 2.2
V	0.75 – 0.85
Al	0.001 – 0.02
N	0.001 – 0.009

5

S	≤ 0.001
P	≤ 0.010
Cu	≤ 0.12
Co	≤ 0.1
W	≤ 0.1
Nb	≤ 0.005

10

3. The hot work tool steel for high pressure die casting as defined in claim 1 or 2, wherein the hot work tool steel comprises one or more of the following elements in weight %:

15

20

C	0.34 – 0.36
Si	0.20 - 0.28
Mn	0.45 – 0.55
Cr	5.53 – 5.68
Mo	2.05 – 2.15
Ni	≤ 0.15
V	0.77 – 0.83
N	0.001 - 0.05
P	≤ 0.008
S	≤ 0.0007
Cu	≤ 0.10

25

4. The hot work tool steel for high pressure die casting as defined in claim any of the preceding claims, wherein the content of Mo and V in the hot work tool steel is adjusted to fulfil the requirement $Mo/V = 2.3-3.0$, preferably 2.5-2.7.

5. The hot work tool steel for high pressure die casting as defined in any of the preceding claims, wherein the cleanliness fulfils the following maximum requirements with respect to micro-slag according to ASTM E45-97, Method A:

30

A	A	B	B	C	C	D	D
T	H	T	H	T	H	T	H
1.0	0	1.5	1.0	0	0	1.5	1.0

and/or wherein the cleanliness measured in by scanning electron microscopy on an area of 6000 mm² fulfils the following requirements:

the ECD of at least 50 % of the number of all oxide particles is $\leq 10\text{ }\mu\text{m}$ and at least 50 % of the number of all oxide particles have an ECD of $\leq 50\text{ }\mu\text{m}$.

6. The hot work tool steel for high pressure die casting as defined in any of the preceding claims, wherein the cleanliness fulfils the following maximum requirements with respect to micro-slag according to ASTM E45-97, Method A:

A	A	B	B	C	C	D	D
T	H	T	H	T	H	T	H
0	0	1.0	0.5	0	0	1.0	0.5

and/or wherein the cleanliness measured in by scanning electron microscopy on an area of 6000 mm² fulfils the following requirements:

the ECD of at least 50 % of the number of all oxide particles is $\leq 10\text{ }\mu\text{m}$ and at least 50 % of the number of all oxide particles have an ECD of $\leq 50\text{ }\mu\text{m}$.

7. The hot work tool steel for high pressure die casting as defined in any of the preceding claims, wherein the mean impact energy measured in the LT direction of 6 samples using a standard Charpy-V test in accordance with SS-EN ISO148-1/ASTM E23 is at least 15 J, wherein the cooling time in the temperature interval of 800 °C– 500 °C (t_{8/5}) is 1000 s.

8. The hot work tool steel for high pressure die casting as defined in any of the preceding claims, wherein the steel is in the soft annealed condition, has a mean hardness of $\leq 230\text{ HBW}_{10/3000}$, has a thickness of at least 100 mm and wherein the maximum deviation from the mean Brinell hardness value in the thickness direction measured in accordance with ASTM E10-01 is less than 10 %, preferably less than 5 %, and wherein the minimum distance of the centre of the indentation from the edge of the specimen or the edge of another indentation shall be at least two and a half times the

diameter of the indentation and the maximum distance shall be no more than 4 times the diameter of the indentation.

9. The hot work tool steel for high pressure die casting as defined in any of the preceding
5 claims, wherein the hot work tool steel is provided as big block and/or as a large mould for casting large structural parts, wherein the block and/or mould has a thickness of at least 200 mm, a length of at least 1000 mm and a width of at least 400 mm and/or the sum of the thickness, length and width of the block and/or of the mould is at least 2000 mm and/or wherein the block or mould has a weight of at least 5 tons, at least 10 tons,
10 at least 15 tons at least 20 tons or at least 25 tons and/or wherein the block or mould has an ASTM Grain size of at least 7, preferably at least 8 more preferably at least 9.
10. A hardened and tempered hot work tool steel according to any one of claims 1-7 and 8,
15 wherein the microstructure comprises at least 98 volume % tempered martensite, preferably after an austenitizing in the range of 1020 - 1070 °C followed by quenching, wherein the cooling time in the temperature interval of 800 °C– 500 °C ($t_{8/5}$) is at least 1000 s, preferably at least 1248 s.