

« Method for producing steel for large molds » ✓

FIELD OF THE INVENTION

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Mold makers and plastic material transformers, forced by the needs of the motor industry and industry in general by the development of « plastic » technical applications in the ever-expanding motor vehicle sector and increasing technico-economic challenges, are increasingly requiring a steel for molds making it possible to obtain
10 molds having a homogeneous hardness concerning thickness (from 30 to 35 Hrc), a thickness possibly extending up to 700 mm or even more.

BACKGROUND OF THE INVENTION

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The outgoing production times for a vehicle, always becoming shorter and shorter, also pose problems as regards the management of real time modifications, as well as machinability and weldability.

SUMMARY OF THE INVENTION

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The present invention concerns a method for producing a steel for large molds making it possible to obtain a steel resolving these difficulties.

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This method is characterized in that the steel is obtained by being melted in an electric furnace followed by a secondary metallurgical operation in a heating ladle, this operation being followed by an under vacuum degassing of less than 1 torr, in fact 0.2 torrs, of a mixture having the following weighted composition :

		Preferred bracket	Wide bracket
	Manganese	1.50 - 2%	1 to 3%
	Silicon	0.050-0.150%	≤ 0.400%
5	Phosphorus	≤ 0.008%	≤ 0.015%
	Chromium	2 to 2.40%	1.50 to 3.5%
	Molybdenum	0.35 - 0.50%	0.25 to 1%
	Niobium	0.100 - 0.150%	0.100 - 0.250%
	Titanium or zirconium	100 to 200 ppm	100 to 300
10	ppm		
	if necessary		
	Copper	≤ 0.100%	≤ 0.300%
	Nickel	≤ 0.200%	≤ 0.300%
	Nitrogen	≤ 30 ppm	< 80 ppm
15	Oxygen	≤ 20 ppm	≤ 80 ppm
	Calcium	5 to 20 ppm	≤ 30 ppm
	Boron	20 to 30 ppm	15 to 50 ppm
	Carbon	0.15 to 0.20%	0.10 to 0.25%
	Sulfur	≤ 0.005%	≤ 0.050%
20	Aluminum	≤ 40 ppm	≤ 250 ppm

The complement is iron and the impurities characteristic of the production of steel.

It is subsequently possible to submit the ingot obtained after degassing to a remelting process by a consumable electrode under vacuum or under slag, the ingot being used as a consumable electrode.

It is also possible to submit the ingot to a first vacuum remelting and then to a second slag remelting process.

The invention also concerns a steel for molds, wherein it has the following weighted composition :

		Preferred bracket	Wide bracket
	Manganese	1.50 - 2%	1 to 3%
	Silicon	0.050-0.150%	≤ 0.400%
5	Phosphorus	≤ 0.008%	≤ 0.015%
	Chromium	2 to 2.40%	1.50 to 3.5%
	Molybdenum	0.35 - 0.50%	0.25 to 1%
	Niobium	0.100 - 0.150%	0.100-.250%
	Titanium or zirconium	100 to 200 ppm	100 to 300
10	ppm		
	if necessary		
	Copper	≤ 0.100%	≤ 0.300%
	Nickel	≤ 0.200%	≤ 0.300%
	Nitrogen	< 30 ppm	≤ 80 ppm
15	Oxygen	≤ 20 ppm	≤ 80 ppm
	Calcium	5 to 20 ppm	≤ 30 ppm
	Boron	20 to 30 ppm	15 to 50 ppm
	Carbon	0.15 to 0.20%	0.10 to 0.25%
	Sulfur	≤ 0.005%	≤ 0.050%
20	Aluminum	< 40 ppm	≤ 250 ppm

The complement is iron and the impurities characteristic of the production of steel.

In the steel of the invention, the manganese sulfides appear in the form of fully distributed globes and the globular oxides are preferably encapsulated by calcium sulfides. This steel possesses double hardening, a primary hardening by hardening the solid solution by inserting boron during austenitization and precipitation during the quench hardening of M₂₃ type boron-carbides (B.C) 6. These extremely fine precipitates germinate during the extremely energetic quench hardening to the austenite grain boundaries owing to their cubic structure with centered parameter faces $a \approx 10.6 \text{ \AA}$.

These boron-carbides are in orientation relation and in coherence with the austenite of one of the two grains. This primary hardening is followed by a secondary hardening due to a dispersion mainly of carbides, nitrides, fine niobium carbo-nitrides precipitated homogeneously during an annealing. The niobium, an essential dispersoid element, introduced as part of producing the steel of the invention, takes part in the control of the size of the grains and also at the time of reheating during recrystallization phenomena. It increases the hardenability of the steel of the invention and provokes a secondary hardening. The role of the niobium, allied to that of the boron, is fundamental in manufacturing the steel of the invention and for obtaining the mechanical characteristics mentioned below.

The steel of the invention possesses excellent aptitude to chemical granulation on machining and is electroerosive. It is also suitable for quality polishing (grain >1200 followed by a grain diamond polishing of 8μ or indeed 3μ). It can be nitride-hardened, hardness > 60 Rc.

The mechanical characteristics obtained for the product treated by hardening and precipitation between 400°C and 600°C are the following :

Resistance to traction $\geq 950 \text{ N/mm}^2$

Elastic limit 0.2% $\geq 800 \text{ N/mm}^2$

Elongation, thickness direction $\sim 10\%$ min 5%

Resilience - value in KU, thickness direction ~ 10 min Joules : 5 Joules

Brinell hardness in $\varnothing = 10 \text{ mm}$ / 3.000Kg - 290 to 330 -

This steel meets two fundamental properties for molds : for the most part polishability and granulability linked to the homogeneity of its structure and as regards its inclusionary property.

For all shaping cases, its shaping is preferably carried out by thermo-mechanical transformation, such as forging, rolling or molding.



5 **WHAT IS CLAIMED IS :**

1. Method for producing a steel for large molds, wherein it is obtained by melting it in an electric furnace followed by a secondary metallurgical operation in a heating ladle, this operation being followed by a vacuum degassing of less than 1 torr,
10 in fact 0.2 torrs, of a mixture having the following weighted composition :

	Manganese	1 to 3%
	Silicon	$\leq 0.400\%$
	Phosphorus	$\leq 0.015\%$
15	Chromium	1.50 to 3.5%
	Molybdenum	0.25 to 1%
	Niobium	0.100 - 0.250%
	Titanium or zirconium	100 to 300 ppm
	if necessary	
20	Copper	$\leq 0.300\%$
	Nickel	$< 0.300\%$
	Nitrogen	≤ 80 ppm
	Oxygen	< 80 ppm
	Calcium	≤ 30 ppm
25	Boron	15 to 50 ppm
	Carbon	0.10 to 0.25%
	Sulfur	$\leq 0.050\%$
	Aluminum	≤ 250 ppm



The complement is iron and the impurities characteristic of the production of steel.

2. Method according to claim 1, wherein the ingot obtained is subjected by degassing to a remelting by consumable electrode under vacuum or under slag, the ingot used as an electrode.

3. Method according to claim 2, wherein the ingot obtained after degassing is subjected to a first remelting by a consumable electrode under vacuum and to a second remelting by a consumable electrode under slag.

4. Method according to one of the preceding claims, wherein shaping is carried out by thermo-mechanical transformation.

5. Steel for large molds, wherein it has the following composition :

Manganese	1 to 3%
Silicon	$\leq 0.400\%$
Phosphorus	$\leq 0.015\%$
Chromium	1.50 to 3.5%
Molybdenum	0.25 to 1%
Niobium	0.100 - 0.250%
Titanium or zirconium	100 to 300 ppm
if necessary	
Copper	$\leq 0.300\%$
Nickel	$\leq 0.300\%$
Nitrogen	< 80 ppm
Oxygen	≤ 80 ppm
Calcium	≤ 30 ppm
Boron	15 to 50 ppm
Carbon	0.10 to 0.25%
Sulfur	$\leq 0.050\%$
Aluminum	≤ 250 ppm



The complement is iron and the impurities characteristic of the production of steel.

6. Steel for large molds according to claim 5, wherein it has the following composition :

5	Manganese	1.50 - 2%
	Silicon	0.050-0.150%
	Phosphorus	$\leq 0.008\%$
	Chromium	2 to 2.40%
10	Molybdenum	0.35 - 0.50%
	Niobium	0.100 - 0.150%
	Titanium or zirconium	100 to 200 ppm
	if necessary	
	Copper	$\leq 0.100\%$
15	Nickel	$< 0.200\%$
	Nitrogen	≤ 30 ppm
	Oxygen	≤ 20 ppm
	Calcium	5 to 20 ppm
	Boron	20 to 30 ppm
20	Carbon	0.15 to 0.20%
	Sulfur	$\leq 0.005\%$
	Aluminum	≤ 40 ppm

25 The complement is iron and the impurities characteristic of the production of steel