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Increasing The Efficiency Of Thermal Processing Under The Influence Of Magnetic Fields

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ABSTRACT

In this article it is proposed to increase the impact resistance of alloyed stamped steels during magneto thermal treatment without changing the hardness. Determination of the optimal technological parameters for magneto thermal treatment of steels 5ХНМ, 3Х3М3Ф, 4Х5МФС, 4Х5В2ФС. It is recommended to increase the impact toughness when processing steel 4Х5В2ФС with a cyclic magnet in the vertical direction of the samples during magneto thermal treatment.

KEYWORDS

Alloying, stamping steel, magnetic field, heat treatment, stamping, pressing, alloy, carbide, viscosity, quenching, loosening, heating.

INTRODUCTION

Improving the performance of parts and tools is an urgent problem in the metallurgical industries. A feature of modern technological processes for the manufacture of high-quality dies, pressing, threaded and blade tools, is the use of combined methods, including traditional thermal, thermo mechanical, ultrasonic, laser and chemical-thermal processing in combination with exposure to strong electric, ionic and other types of fields.

Heat treatment in the magnetic field and its type - magneto-thermal processing involves achieving a high level of properties of tool steels in comparison with other types of combined processing. However, changes in the mechanical properties that occur during heat treatment using the laws of microstructure formation, phase conversion mechanisms, and magnetic fields hinder the realization of these advantages.

To achieve this goal, the following tasks were set and solved: to study the mechanism of changes in steels caused by strong magnetic fields; development of technological modes of stamping and pressing tools from magneto-thermally treated alloy steels; study of the effect of magneto-thermal treatment of carbides on high chromium steels; study of the effect of magneto-thermal treatment on the microstructure and properties of high-strength steels; to study the effect of magneto-thermal treatment on the condition of the existing and nitride layers of stamping and pressing devices.

MATERIALS AND METHODS

Traditional thermal, thermo-mechanical, ultrasonic, laser and chemical-thermal processing combined with the influence of strong electric, ionic, magnetic and other types of fields is a feature of modern technological processes for the production of high-quality dies, presses, threaded and knife tools is to use a combination of methods such as.

Obtaining high-strength, service-resistant products from pressed steel is the most important task of materials science. This work is carried out in the following main areas: the acquisition of new materials and the improvement of traditional methods of their production and the improvement of their mechanical properties. The use of different types of processing in combination with heat treatment without changing the composition of the existing complex alloy materials should be considered as promising and effective methods.

Heat treatment in the magnetic field and its type - magneto-thermal processing allows to achieve a high level of mechanical properties of tool steels in comparison with other types of combined processing.

Inadequate knowledge of this method hinders the realization of these advantages in practice. Theoretical bases and practical application of magnetic fields in transformations in steel are published in the works of M. L. Bernstein, B. V. Malygin. It can be seen that if at least one of the components of the phases is ferromagnetic, the effect of the external magnetic field can be significant.The effect of magnetic fields on steel components differs in their magnetic properties. Thus, austenite is not absolutely magnetic, ferrite is magnetic up to quyui temperature, i.e., below 768°C, cementite is magnetic at temperatures below 217°C, perlite, sorbitol, troostite, bainite and martensite are magnetic, Cr and Mn are antiferromagnets. Alloying elements of steels V, Cr, Mn, Mo, W and others, as well as their carbides have different magnetic susceptibility.

The most commonly used stamp steel with different properties was selected as the object of study. Stamping and pressing steels were used to study the effect of magneto-thermal treatment on mechanical properties.

For heat stamping (GOST 5950-73) 5XHM steels with average heat resistance and high elongation were selected; as well as 4X5MФC, 4X5B2ФC, 3X3M3Ф, steels are distinguished by heat resistance.

In these steels, alloying elements (carbide-forming elements (W, V, Mo, Cr) and non-carbide-forming elements (Si and Ni) increase the resistance of iron to contact with hot metal. Nickel is added to 5XHM steel used for punches subjected to impact loads to increase its viscosity and hardness, and molybdenum is added to increase its heat resistance. The chemical composition of these steels is given in Table 1.

Table 1. Chemical composition of steels for hot stamping (GOST 5950-73)

Steel stamps	Chemical composition of steels, %							
	C	Mп	Si	Cг	W	V	Mo	Ni
5XHM	0,50-0,60	0,50-0,80	0,10-0,40	0,50-0,80	-	-	0,15-0,30	1,40-1,80
4X5MФC	0,32-0,40	0,20-0,50	0,90-1,20	4,50-5,50	-	0,30-0,50	1,20-1,50	
4X5B2ФC	0,35-0,45	0,15-0,40	0,80-1,20	4,50-5,50	1,60-2,20	0,60-0,90	-	
3X3M3Ф	0,27-0,34	0,30-0,60	0,20-0,40	2,80-3,30	-	0,40-0,60	2,50-3,00	

Magnetic processing of steel samples and products was carried out using a strong stationary electromagnetic СП58Б, which is a cooled magnetic coil. The adjustable intensity range of the permanent magnetic field H is 0 to 23.9 • 105A/m.

Steel rods with a square section of 10x10 mm and a length of 55 mm (GOST 945478-78) and 30x30 mm samples with a length of 70 mm were used as samples for the study. Steel products of the required size were produced for industrial testing. The samples were heated in electric furnaces of СНОЛ-1.1,6/12-М3-4.2 type, voltage 220 V, power 2.5 kW, frequency 50 Hz with automatic control of the following electrical properties.

Heat treatment of samples and products is carried out in accordance with the mode determined and selected depending on the steel grade. In this case, it is carried out simultaneously with the passed and magnetically untreated samples. The technological process of heat treatment consists of hardening and softening. The annealing process is carried out step by step by heating the samples once or intermittently to heat the sample. Samples are quenched in oil and then washed in water. The samples are then emptied one or more times and then cooled in air. The heat and rotational motion temperatures are set according to the steel grade.

After magnetic treatment, 3X3M3Ф steel is subjected to heat treatment according to the regime, which includes annealing at 1060°C, re-annealing with heating at 880°C, and double softening at 580°C and 540°C. (Table 2).

Table 2. Results of magneto-thermal treatment of 3X3M3Φ steel

Steel stamps	Magneto-thermal processing parameters							Mechanical properties	
	H 10^5, A/м	τ, min	t_{ref1}/τ_{ref1}, °C/min	t_{heat1}/τ_{heat1}, °C/min	t_{ref2}/τ_{ref2}, °C/min	t_{rel1}/τ_{rel1}, °C/min	t_{rel2}/τ_{rel2}, °C/min	KCU, J/sm^2	HRC
3XM3Φ	maydonsiz		1060/60	880/20	1060/25	580/60	540/60	42,7	48
3XM3Φ	20,7	5	1060/60	880/20	1060/25	580/60	540/60	57,3	48

t_{heat}, t_{ref}, t_{rel} - heating temperature, heating, discharge.

τ, τ_{heat}, τ_{ref}, τ_{rel} - magnetization time, heating, curing, discharging.

The orientation of the samples relative to the magnetic field lines is studied in 5XNM molded steel as an effect on the mechanical properties of the steels. Heat treatment and melting of steel involves heat treatment. The samples were performed for 5 min in an area with a magnetic tension H 16.9•105 A/m, the samples were oriented (a) across the field or (b) in the direction of the magnetic field lines (Table 3).

Table 3. Results of magneto-thermal treatment of 5XHM steel

Steel stamps	The direction of the magnetic field	Magneto-thermal processing parameters					Mechanical properties	
		H 10^5, A/м	τ, min	t_{heat1}/τ_{heat1}, °C/min	t_{ref2}/τ_{ref2}, °C/min	t_{rel1}/τ_{rel1}, °C/min	KCU, J/sm^2	HRC
5XHM	A	16,9	50	720/20	850/25	550/60	25	40
5XHM	Without magneto-thermal treatment			720/20	850/25	550/60	12	38

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5XHM	Б	20,7	5	720/20	850/25	550/60	50	39
5XHM	Without magneto-thermal treatment			720/20	850/25	550/60	20	38

a - the direction of the magnetic field lines in the sample

b - is the direction of the magnetic field lines in the sample
t_{heat}, t_{ref}, t_{rel} - heating temperature, heating, discharge.
τ, τ_{heat}, τ_{ref}, τ_{rel} - magnetization time, heating, curing, discharging.

With different orientations of the samples in the magnetic field, their mechanical properties change. The previous magnetic treatment has little effect on the change in hardness, but helps to increase the impact viscosity. In addition, after the magneto-thermal treatment of the samples, when they are oriented in the direction of the magnetic field lines, the impact viscosity increases 2.5 times (from 20 to 50 J/cm2), the direction of the magnetic field lines of the samples when oriented along, the impact viscosity only doubles (from 12 to 25 J/cm2). Only compared with samples that have undergone thermal processing. The first cyclic magnetic treatment is used on 4X5MFS steels. The steel is first heated by heat treatment and then discharged twice (Table 4).

Table 4. 4X5MΦC Results of magneto-thermal treatment of 4X5MΦC stamping steel

Steel stamps	Magneto-thermal processing parameters						Mechanical properties	
	H 10^5, A/м	τ, min	t_{heat1}/τ_{heat1}, °C/min	t_{ref2}/τ_{ref2}, °C/min	t_{rel1}/τ_{rel1}, °C/min	t_{rel2}/τ_{rel2}, °C/min	KCU, J/sm^2	HRC
4X5MΦC	Without magneto-thermal treatment		750/20	1030/45	560/60	520/60	13	44
4X5MΦC	4,8	3 in the cycle					26	44
4X5MΦC	16,9						27	45

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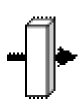
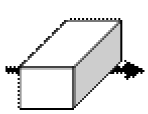
t_{heat}, t_{ref}, t_{rel} - heating temperature, heating, discharge.

τ, τ_{heat}, τ_{ref}, τ_{rel} - magnetization time, heating, curing, discharging.

The transfer of samples from 4X5B2ΦC steel with a cyclic magnet was carried out in different directions in a magnetic field with a force of 16.9 • 105A/m and 3 cycles of 2 cycles of magnetization time. It is then cured by first heating during heat treatment and then emptied twice.

Table 5. Results of magneto-thermal treatment of 4X5B2ΦC steel depending on the direction of the magnetic field of the samples

Steel stamps	Magneto-thermal processing parameters						Mechanical properties	
	H 10^5, A/м	τ, min	t_{heat1}/τ_{heat1}, °C/min	t_{ref2}/τ_{ref2}, °C/min	t_{rel1}/τ_{rel1}, °C/min	t_{rel2}/τ_{rel2}, °C/min	KCU, J/sm²	HRC
Without magneto-thermal treatment	-		88020	1080/45	580/60	540/60	35	47
	16,9	3 in the cycle *2					75	48
							65	49

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t_{heat}, t_{ref}, t_{rel} - heating temperature, heating, discharge.

τ, τ_{heat}, τ_{ref}, τ_{rel} - magnetization time, heating, curing, discharging.

The mechanical properties of steel samples also depend on their orientation in the magnetic field. The greatest effect is achieved when the samples are oriented vertically to the magnetic field. The impact force increases from 35 to 75 J/cm. In this case, the hardness is almost unchanged. As the direction of the samples changes from vertical to longitudinal, the stiffness increases slightly (from 48 to 49 HRC) and the impact force decreases to 65 J/cm2.

CONCLUSION

Thus, in magneto-thermal processing, the alloy stamp leads to an increase in impact resistance without changing the hardness of the steels. 5XHM The impact resistance of 5XHM steel is more than doubled. 5XHM, 3X3M3Ф, 4X5MФC, 4X5B2ФC Optimal technological parameters of magneto-thermal processing for 5XHM, 3X3M3Ф, 4X5MФC, 4X5B2ФC steels are determined.

During magneto-thermal machining, the impact viscosity rises to 75 J/cm2 when machining 4X5B2ФC steel cyclic magnets in the vertical direction of the samples.

The maximum effect of stamped steels in magneto-thermal processing is achieved by using the optimal parameters of the magnetic field for each steel grade using the desired direction of the samples and the mode of magnetization. If the technological modes of heat treatment of steels are violated, the efficiency of magnetothermal processing decreases.

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