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EFFECTS OF THERMOCHEMICAL TREATMENTS ON ABRASIVE RESISTANCE OF MARAGING STEEL

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ABSTRACT
Maraging steels are used for manufacture of diverse construction components and, more and more, in manufacture of molds (i.e. for processing of polymers, for pressure casting, etc.) where pronounced abrasion wear is emphasized. In the paper, appropriateness of maraging steel for ordinary procedures of thermo chemical treatment like carburizing, nitriding and boriding, in order to improve wear resistance, has been examined. Abrasive wear differences of MARAGING steel in annealed, aged and thermo chemically treated (carburizing, nitriding and boriding) conditions have been established experimentally.
Keywords: maraging steel, carburizing, nitriding, boriding, abrasive wear

1. INTRODUCTION
Ultra strong steels maraging delivered in solution annealed state have relatively soft and ductile qualities which make them suitable for exposure to work treatment. They are strengthened by simple annealing procedure (aging), with results of almost double hardness and tensile strength values (compared with dissolute, annealed state). The annealing also yields some advantages such as rework to final measure prior to aging, no danger of dis-carbonization (because carbon content amounts up to 0,05 %) and lack of oxidation [1,2].
These listed advantages give an explanation for wide range of application of these steels for designing purposes (airplane and helicopter parts; this was initial field of application of maraging steels, such as driving axle, springs, armour, tanks for liquid fuels, parts of hydroplanes, etc). In the meantime the practice of their application for production of tools (first of all molds and forging appliances) was widely introduced [2].
The most serious weakness of tool steels maraging is low wear resistance. The scope of this research is to examine possibility to remove this weakness by means of thermo chemical heat treatment. In order to improve wear resistance and not to lose "distortionless" property, appropriateness of these alloyed and practically carbon – free steels for ordinary procedures of thermo chemical treatment like carburizing, nitriding and boriding was examined [3, 4].

2. EXPERIMENT
Maraging steels are more and more used for manufacture of molds where pronounced abrasion wear is emphasized. This paper presents effects of thermo chemical treatment (carburizing, nitriding and boriding) on improvement of wear resistance.
Maraging steel grades of type 18-9-5 (VDEh: X2NiCoMo18-9-5; WNr. 1.6358) was used in testing. All samples (eight of them) were ∅6x18 mm sized. Samples were annealed at 820^{o}C for 0,5 h, and then treated in accordance with test plan (Table 1).

Table 1. Heat treatment plan

sample	heat treatment
1.	Solution annealed state
2.	Aging (ϑ_A=500°C; t_A= 4 h)
3.	Carburizing (ϑ_C=900°C; t_C= 8 h)
4.	Carburizing (ϑ_C=900°C; t_C= 8 h) + Aging (ϑ_A=500°C; t_A= 4 h)
5.	Boriding (ϑ_B=900°C; t_B= 6 h)
6.	Boriding (ϑ_B=900°C; t_B= 6 h) + Aging (ϑ_A=500°C; t_A= 4 h)
7.	Nitridnig (ϑ_N=580°C; t_N= 2 h)
8.	Nitriding (ϑ_N=580°C; t_N= 2 h) + Aging (ϑ_A=500°C; t_A= 4 h)

After completion of heat treatment, each sample was subjected to hardness and abrasion wear testing.

2.1. Results of hardness testing

Hardness has been tested by Vickers method.

After solution annealing, the same hardness value (320 *HV*1) has been measured on each sample.The average hardness value measured on specimen that was aged (ϑ_A=500°C; t_A= 4 h) after solution annealing was 580 *HV*1.

Figures 1.a) to 1.c) show hardness distribution in the cross – section after heat treatments (cementing, boriding and nitriding) on X2NiCoMo 18-9-5 steel in aged and non – aged state.

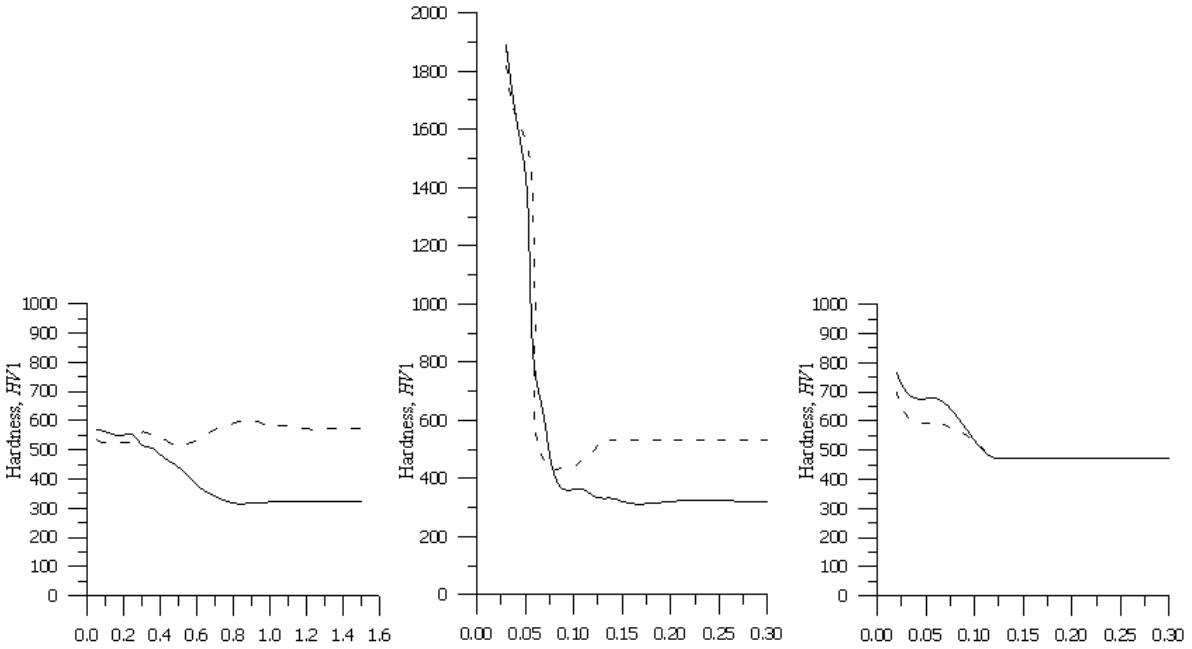

Figure 1. Hardness distribution in the cross – section X2NiCoMo18-9-5 steel in non – aged (__) and aged (- - - -) state: a) carburizing; b) boriding; c) nitriding

It may be concluded from the analysis of measured hardness:

- After solution annealing, the same hardness value of 320 *HV*1 was measured on all samples
- After solution annealing and aging process hardness value was about 580 *HV*1
- Attainted surface hardness values were about: 570 *HV*1 after carburizing, 1800 *HV*0,2 after boriding and 770 *HV*0,2 after nitriding
- Aging has reduced surface hardening for about 50 – 100 *HV*, while the core hardness on cemented and borided samples was increased from 330 *HV* to app. 532 *HV*.

2.2. Results of tribologic testing

Tribological tests were carried out on "Taber-abrazer" device type 503, and emery paper of gradation 150 was used. Test samples were loaded with force of 9,81 N. Each sample was abraded by the friction disc during 7000 revolutions. After testing to abrasion wear, wear weight loss subscript ($i_{\Delta m}$) has been calculated (1):

$$i_{\Delta m} = \frac{\Delta m \cdot 1000}{n} \tag{1}$$

$i_{\Delta m}$ – wear weight loss subscript
Δm – weight loss, mg
n – revolution rate, rev

Figure 2 shows calculated values of wear weight loss subscripts for all specimens of steel X2NiCoMo 18-9-5 after abrasion wear

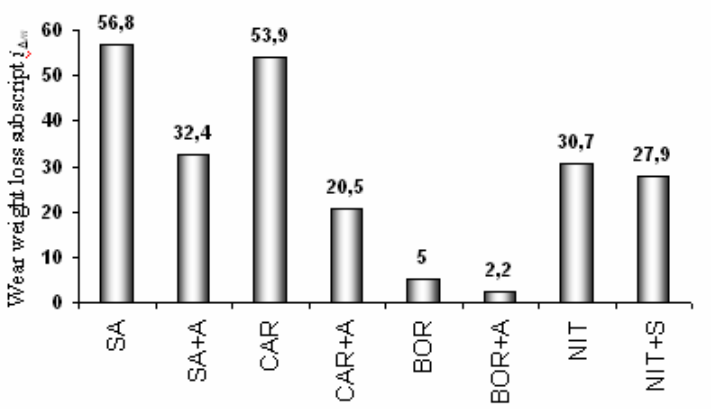

Figure 2. Calculated values of $i_{\Delta m}$ after abrasion wear of steel X2NiCoMo18-9-5

It may be concluded:

- Comparing the results of measured weight losses, it is obvious that thermo chemical treatments increase wear resistance, and increment is even bigger if aging was carried out after thermo chemical treatments
- Best wear resistance is achieved by combining boriding and aging processes.

3. CONCLUSION

From all mentioned, it can be concluded that maraging steel can be thermo chemically treated, and combination of thermo chemical and aging treatments improves abrasion wear resistance.
Reason for that probably lies in the fact that aging of maraging steel increases hardness (strength) of matrix which has significant influence on abrasion wear resistance.

4. REFERENCES

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