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# THE INFLUENCE OF PRIOR HEAT TREATMENT ON NITRIDING OF AISI H13 STEEL

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***Abstract.*** *H13 steels are widely used for die casting molds, and nitriding is employed in order to increase the life of the tools, by reducing wear and thermal fatigue. For such application, nitriding is made after quenching and tempering heat treatments, and case depths of about 0.1mm are normally specified. In this work, the influence of quenching an tempering heat treatment made before nitriding was evaluated. In order to achieve different core hardness, different austenitizing and tempering temperatures were used, and specimens were submitted to one nitriding cycle. Nitrided layers were analyzed in terms of effective depth, surface hardness, and scratch hardness by means of scratch tests. Results showed that the depth and surface hardness of the nitrided layer did not vary with prior heat treatments, but it was observed that the scratch hardness is not only a function of the nitrided layer hardness and depth; it also depends on the prior heat treatments carried out on the steel.*

***Keywords:*** *AISI H13, nitriding, heat treatment, scratch test.*

## 1. INTRODUCTION

The aim of this work was to evaluate the influence of quenching and tempering heat treatments on the nitrided layers produced by plasma nitriding in AISI H13 steels. Nitriding is employed to improve wear and thermal fatigue resistance of molds in die casting applications (Torres, *et al*., 2015), and it is made after heat treatment. The tool life depends on a great extent on the properties of the nitrided layer (Kang, *et al*., 1988; Karamis, *et al*.,1991). In this work, different heat treatments were made before plasma nitriding, and the nitrided layers were evaluated in terms of case depth and surface hardness. Scratch tests were also made in order to evaluate scratch hardness and wear resistance of different combinations of heat treatment and nitriding conditions.

## 2. EXPERIMENTAL PROCEDURE

After cutting, AISI H13 steel specimens were quenched and tempered according to the parameters shown in Table 1. Austenitizing time at temperature was 20 minutes, and specimens were quenched in oil at room temperature. Double tempering at indicated temperatures (2+2 hours) was made for all specimens. After heat treatment, specimens were plasma nitrided with the following parameters: atmosphere of 15% $N_2$ + 85% $H_2$, temperature of 500°C, duration of 4 hours. A microhardness tester was used to measure case depth and surface hardness of the nitrided layers, and a tribometer was used to perform scratch tests with a constant load of 100N. Scratch hardness was determined according to ASTM G171-03 Standard.

Table 1 - Heat treatment parameters

| Specimens | Austenitizing temperature (°C) | Tempering temperature (°C) |
|---|---|---|
| 1.1 | 1000 | 500 |
| 1.2 | 1000 | 550 |
| 1.3 | 1000 | 600 |
| 2.1 | 1030 | 500 |
| 2.2 | 1030 | 550 |
| 2.3 | 1030 | 600 |
| 3.1 | 1060 | 500 |
| 3.2 | 1060 | 550 |
| 3.3 | 1060 | 600 |

## 3. RESULTS AND DISCUSSION

Figure 1 shows core hardness of specimens after heat treatments as a function of both austenitizing and tempering temperatures. Figures 2 and 3 shows the surface hardness and case depth of the nitrided layers as function of heat treatment parameters, and Fig. 4 shows the scratch hardness of specimens. It is important to state that there was no formation of white layer in the nitriding process for all heat treatment conditions. For tempering temperatures of 500°C and 550°C, the surface hardness of the nitrided layer did not change significantly. The case depth varied from 0.9 to 0.1mm for all conditions, which shows that the prior heat treatments did not affect these properties of the nitrided layer in general. However, when it comes to the scratch hardness, one can note that this property changes as a function of the parameters used in the heat treatments previously made on the specimens, indicating that wear resistance might be associated not only with the nitrided layer itself, but also with prior heat treatments of the steel. The depth of the scratches on the surface of nitrided layers lied in the range of 5 to 10mm, which is much smaller than the case depth (0.1mm). Even though the scratches only affected the nitrided layer, not reaching the substrate, the scratch hardness was affected by the substrate hardness.

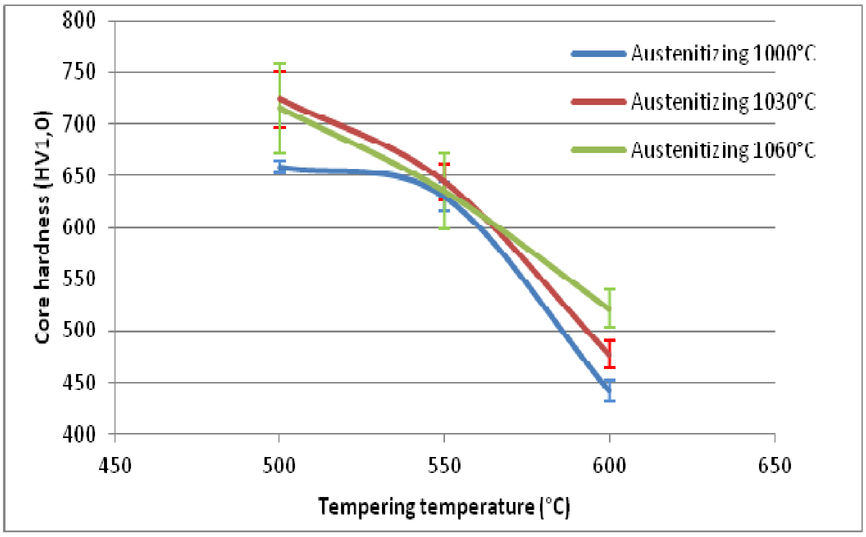


Figure 1. Core hardness as a function of heat treatment parameters (H13 steel)

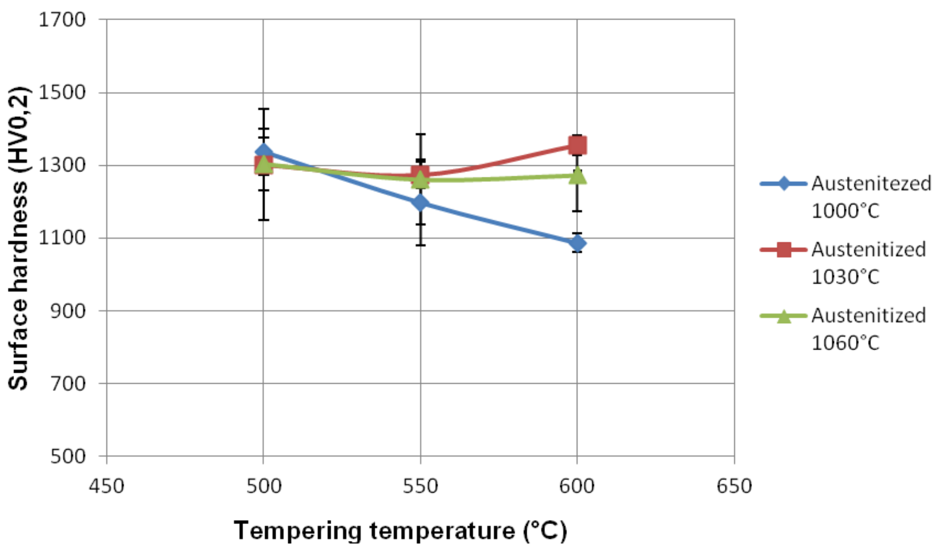


Figure 2. Surface hardness of the nitreded layer as a function of both austenitizing and tempering temperature

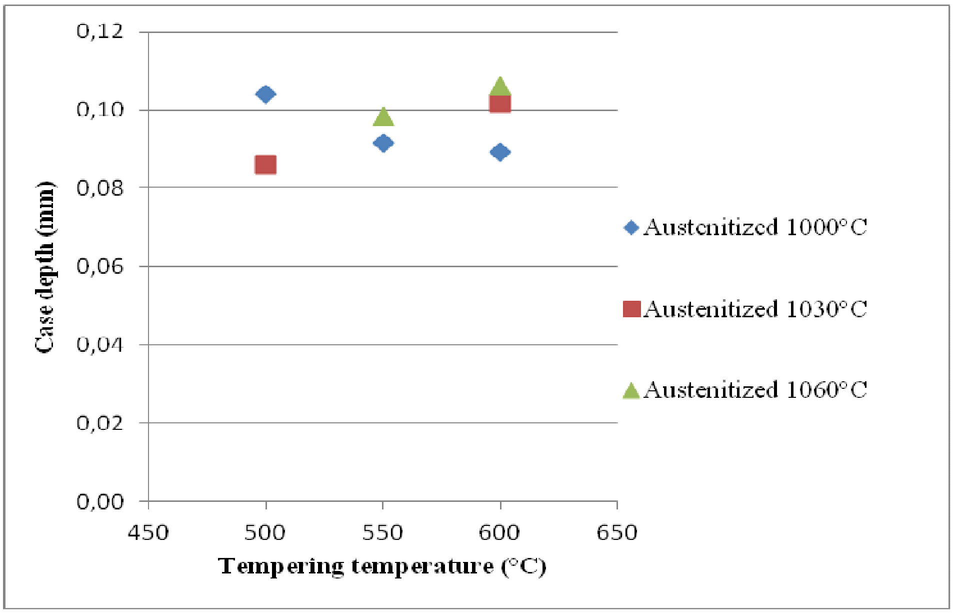


Figure 3. Nitrided layer properties. (a) surface hardness; (b) case depth

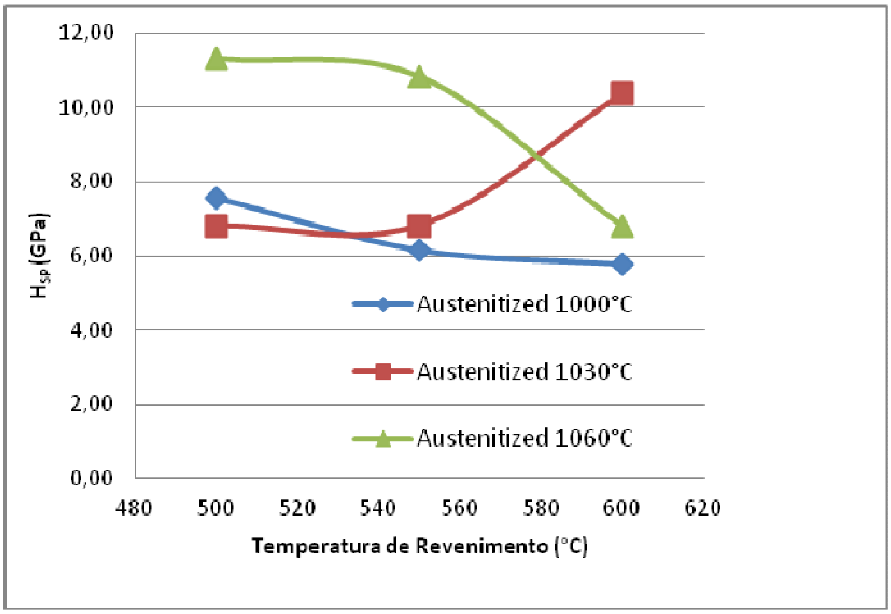


Figure 4. Scratch hardness after nitriding as a function of heat treatment parameters

## 4. CONCLUSIONS

From the results obtained in this work, it was possible to conclude that the heat treatments made before plasma nitriding did not affect the surface hardness and case depth of the nitrided layers, specially for lower tempering temperatures. However, the scratch hardness (and possible wear results) varied with core properties, even though the depth of the scratches was much smaller than the case depth. This should be investigated in more detail, and factors such as residual stresses, retained austenite and carbides formation may play a role in this case.

## 5. REFERENCES

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