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Structural and phase transformation in stainless steels after rotary burnishing process

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Increasing the strength of austenitic stainless steels is possible especially by cold work. Deformation in range ε=30% causes threefold increasing of yield stress and 1,3 times increasing of tensile strength. The cold work in whole volume of elements is too expensive, so it's advantageous to use a local burnishing. Burnishing of austenitic stainless steel, such as AISI 304, causes increasing of yield stress by 70% and also the Re/Rm ratio from 0,3 to over 0,7. The plastic parameters slightly decrease with increasing of burnishing force.

The cold work of austenitic stainless steel leads to considerable structural changes such as increasing amount of slip bands and twinning deformation, texture or martensitic transformation, which may change the corrosion resistance. In this paper there was presented results of structural and phase transformations research after rotary burnishing process.

1. INTRODUTION

Stainless steels, which especially are used in construction for food processing industry, should meet the highest sanitary requirements and corrosion resistance and specifications [1,2]. These materials are used as quenched or cold rolled with a slight deformation ($\varepsilon \leq 5\%$). In such state stainless steels have low strength, especially the yield stress (on level 200 MPa). Increasing the strength of austenitic stainless steels is possible mainly by cold work [3÷5]. Burnishing of austenitic stainless steel, such as AISI 304, causes increasing of yield stress by 70% and also the Re/Rm ratio to the value over 0,7. The plastic parameters slightly decrease with increasing of burnishing force [6].

The cold work in whole volume of elements is too expensive, so it's advantageous to use a local burnishing. This process is advantageous also in increasing fatigue strength and fatigue corrosion, which is caused by state of own squeeze stresses produced in surface layer and it's also effect of structural changes. Burnishing, as a method of machining, improves also smoothness of surface [4,6].

2. THE BURNISHING PROCESS

The rotary burnishing process was realized on milling machine equipped with 2-ball head with the force adjusted by a coil spring (Fig. 1). In this research there was used an AISI 304 type stainless steel as samples in dimension (width x thickness x length) 15x4x100 mm respectively, the burnished force was 1600N, 1800N, 2000N and 3000N. After processing the microstructure and diffraction researches were performed.

Figure 1. The milling machine with the rotary burnishing head.

3. THE MICROSTRUCTURE RESEARCH

The microstructure research was conducted on optical microscopy in bright field area. Cross sections of specimens after polishing were etched in nitrohydrochloric acid. Micrographs are presented on fig. 2.

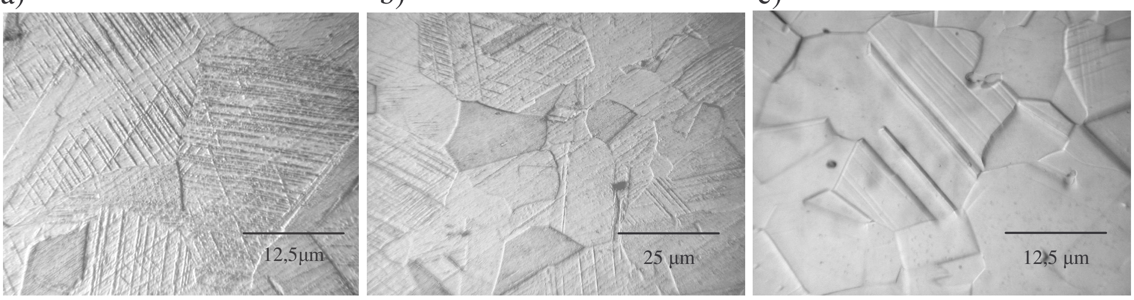

Figure 2. The microstructure of burnished AISI 304 steel: a) the subsurface zone, b) the intermediate zone, c) the core.

In the core there is visible austenite structure with primary precipitates and twins (Fig. 2c). After burnishing there was observed increasing of slip bands, dislocations density and twinning deformations with approaching to the surface.

The high state of deformations is the reason of phase transformation and formation of two-phase structure (γ+α) [3,4].

4. THE PHASE TRANSFORMATION RESEARCH

The X-ray diffraction patterns were performed on the Philips Diffractometer X'Pert (PW 3040/60) with the copper radiation (λCu K_α=1,5418 Å) and the graphite monochromator on the diffracted beam in a range 2θ of 30 ÷ 90º.

The results obtained for AISI 304 samples are presented in Fig. 3. It can be seen that the diffraction lines of Fe-α are detected in the sample and the content of Fe-α phase is increasing with the burnishing force. The distinct rise of Fe-α phase content is beginning for the burnishing force of 2000 N.

Moreover, the intensities of (111) and (220) diffraction lines of Fe-γ phase in AISI 304 steel do not correspond to the standard intensities, so it could be concluded that the effect of texture of Fe-γ phase is observed [7]. This problem is currently the subject of intensive research.

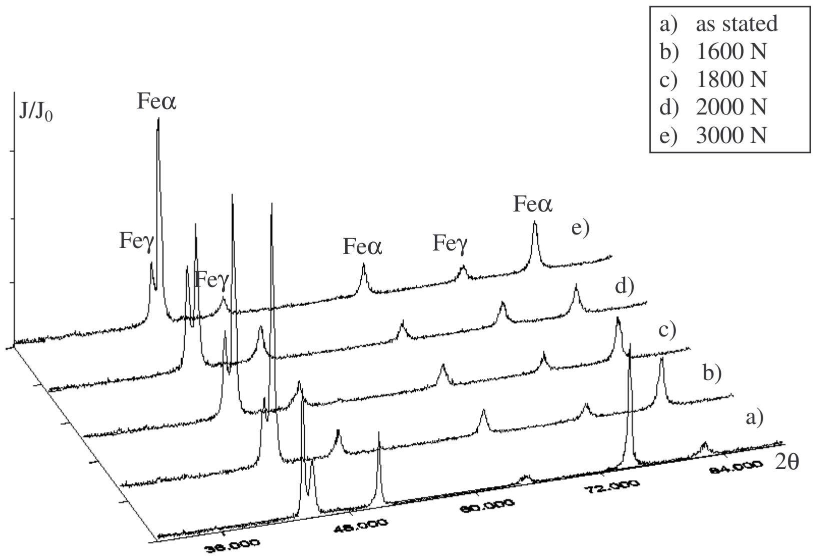

Figure 3. The X-ray diffraction patterns for AISI 304 stainless steel after annealing (a) and burnishing (b÷e)

5. CONCLUSIONS

- Burnishing increased the yield stress by 70% and also the Re/Rm ratio from 0,3 to 0,7. The plastic parameters slightly decreased with increasing of burnishing force.
- There was worked out parameters of rotary burnishing to obtain the thickness of burnished layer 1,8 mm and high smoothness of surface.
- It's necessary to conduct a research of corrosion – erosion resistance of obtained structures and also the influence of texture on mechanical and corrosion behaviour.

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