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Research on the Behavior of Mechanical Parts from Equipment Used in Construction and Thermal Treatment with and without Vibration

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***Abstract* – The research performed and presented in this paper, shows how mechanical vibrations influence the mechanical properties of parts used in construction equipment subjected to heat treatment with and without vibrations.**

Keywords – construction, equipment, hardness, materials, microstructure, thermal treatment, vibration

1. INTRODUCTION

After analyzing the materials from which the parts of the equipment used in constructions are made, which can be thermal treated, it was established that the practical applications of heat treatment technologies with and without vibration of the analyzed materials to be developed on parts such as: bushings, nuts, wheels gears, bearings, joints and pressure regulator.

2. EXPERIMENT DESCRIPTION

The parts from the different equipment used in construction have been heat treated with different regimes with and without vibrations.

The thermal treatments with and without vibrations, applied to the considered parts have different parameters depending on the intended purpose.

2.1 Researches regarding the behavior of bushings at thermal treatment with and without vibration

For bushings it was considered CC 45 (OLC45) construction steel. These bushings were subjected at hardening thermal treatment at the temperature of 850 °C with water cooling and then returned at the temperature of 450 °C.

A batch of 26 bushings, out of a total of 40, were also vibrated during the heat treatment with a frequency f = 320 Hz and power P = 1200 W. This treatment has been performed on a heat treatment installation designed and physically made.

Research on these bushings was mainly based on metallographic analysis of them.

These researches made on microstructures are sufficient to draw conclusions about the benefits of using vibrations during thermal treatment.

After this thermal treatment presented above was made, in the microstructures shown in figure 1, without vibrations and in figure 2, with vibrations, major improvements of the microstructure of the material can be observed in the sense of its globular aspect. It turns out a more precise contouring of the grains, as well as the transformation of a larger amount of residual austenite into martensite, which leads to an increase in hardness, an effect that we want.

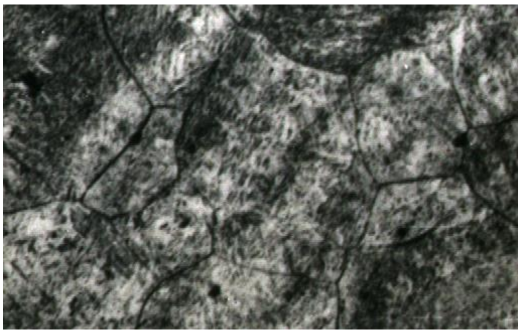

Fig. 1 Microstructure of thermal-treated and non-vibrated bushings - 200X nital attack

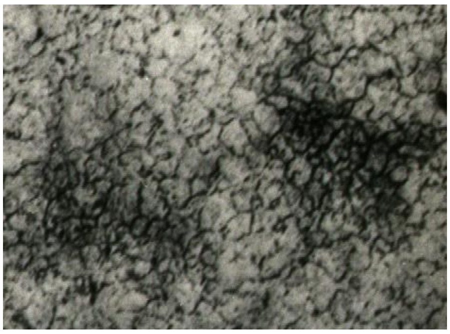

Fig. 2 Microstructure of thermal-treated and non-vibrated bushings - 200X nital attack

2.2 Researches regarding the behavior of nuts at thermal treatment with and without vibration field

It was used a molybdenum, chromium and nickel type 34 MCN 15 alloy steel for the nuts. This steel was hardened to an 1100 °C temperature with water cooling and then subjected to a return at the temperature of 550 °C.

A batch of 15 pieces out of a total of 25 were thermal treated and it was used also a vibrating field with a frequency f = 1000 Hz and a power P = 1500 W.

The effects on the microstructures of the nuts are shown in Figure 3 for non-vibrating nuts and in Figure 4 for vibrating nuts.

The non-vibrated structure shows a rolling strip structure and the grain boundary is not precisely defined. In the case of the vibrated steel, it appears a clear contouring of the grains and the almost complete disappearance of the rolling strips. All of these facts are contributing to an increase of the mechanical properties of these parts. When the austenitic-ferritic type stainless steel, for nuts, is subjected at hardening thermal treatment, the transformation of austenite in greater quantity into ferrite δ is noticed on vibration, and sometimes even in phase σ. This transformation leads to an increase in the hardness of the material, from which the nuts are made of, and this fact is desirable.

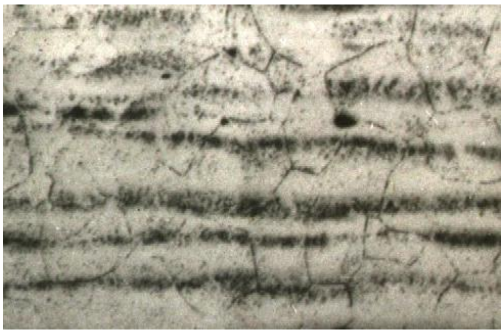

Fig. 3 Microstructure of thermal-treated and non-vibrated nuts - 200X

Fig. 4 Microstructure of thermal-treated and vibrated nuts - 200X

2.3. Researches on the behavior of bearings at thermal treatment with and without vibrations

The bearings are used to rotate the shafts and to protect the lubrication systems. These bearings are made of steel alloyed with boron and chromium 40 BC 10, which has been hardened to 850 °C and returned to 450 °C with water cooling. These tests were performed on a batch of 10 pieces, of which 7 pieces were heat treated in the vibrating field with a frequency f = 1250 Hz and a power P = 1450W. The effects on microstructures are shown in Figure 5 for non-vibrating bearings and in Figure 6 for vibrating bearings. In the case of non-vibrating parts, it is observed an unordered arrangement of the grains in the structure. During the vibration process, these grains acquire a globular shape and a more uniform arrangement in the structure. It is also found out that during the vibration process, it appears to be a more pronounced transformation of the residual austenite into martensite, which leads to increased hardness.

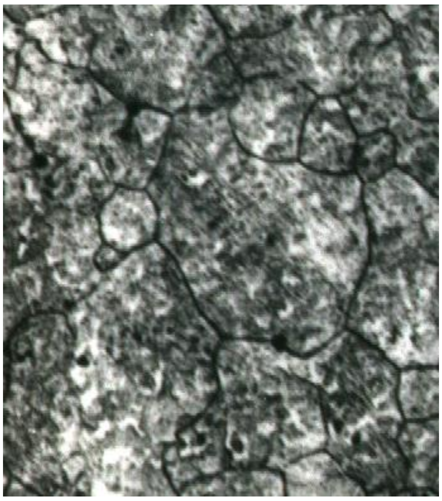

Fig. 5 Microstructure of thermal-treated and non-vibrated bearings - 200X nital attack

Fig. 6 Microstructure of thermal-treated and vibrated bearings - 200X nital attack

2.4. Researches regarding the behavior of gears at thermal treatment with and without vibrations

The material from which the gears are made is Y1 70 which has been hardened to 8600 C with oil cooling and return to 4500C. A number of 4 gears were made, of which 2 were heat treated in the vibrating field with the frequency f = 1725 Hz and the power P = 1500W. In Figure 7 it is presented the microstructure of the non-vibrated gears, and in Figure 8 that of vibrated gears. An uneven structure of impurities is found in the non-vibrated structure. The vibrated parts show a spheroidal aspect of the grains and a greater transformation of the residual austenite into martensite, fact which leads to an increased hardness and reduced deformation after heat treatment, because the residual austenite was converted in larger quantities during vibration. The parts intended for the equipment used in constructions after the heat treatment in the vibrating field have a much better dimensional stability and they are no longer requiring further mechanical processing.

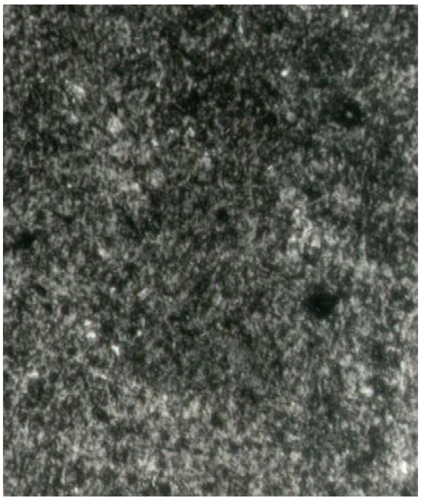

Fig. 7 Microstructure of thermal-treated and non-vibrated gears - 100X nital attack.

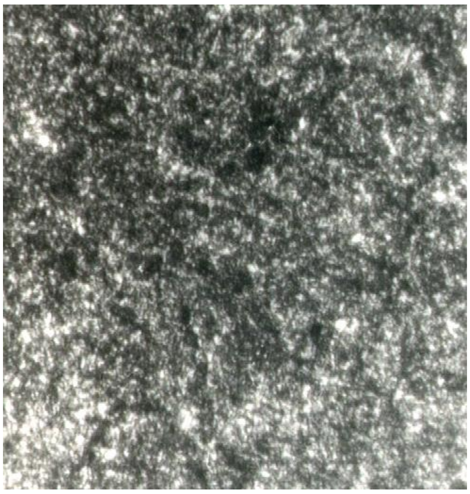

Fig. 8 Microstructure of thermal-treated and vibrated gears - 100X nital attack.

2.5. Research regarding the behavior of joints at thermal treatment with and without vibrations

The material from which the joints were made is steel alloyed with boron and chromium 40 BC 10, which has been hardened to 850 °C and returned to 550 °C with water cooling. The joints were also subjected to a heat treatment in the vibrating field with the frequency f = 980 Hz and the power P = 1050W, on a batch of 3 pieces out of a total of 6 pieces. The microstructure has undergone significant changes through a more homogeneous redistribution of sorbite in the structure, as seen in Figure 9 vibrated compared to the non-vibrated in Figure 10. Through this uniform redistribution of sorbite, the mechanical properties of the heat-treated parts in the vibrating field are increasing.

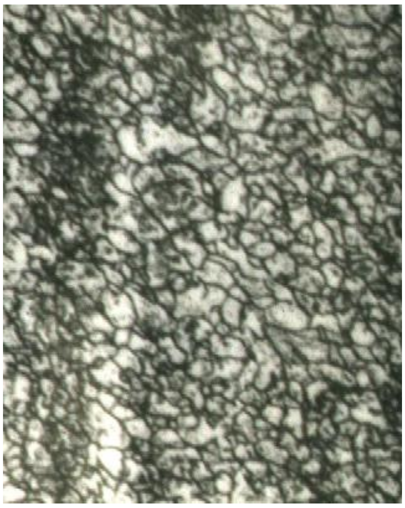

Fig. 9 Microstructure of thermal-treated and non-vibrated joints - Nital attack. 100X

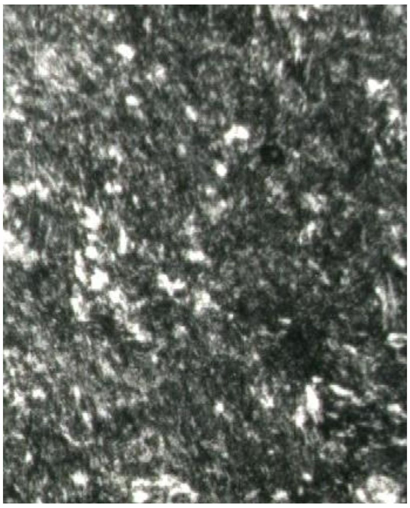

Fig. 10 Microstructure of thermal-treated and vibrated joints - Nital attack. 100X

3. RESULTS AND DISCUSSION

In the case of the use of vibrations during heat treatments, a significant increase in the hardness of the heat-treated surfaces was observed. As a result, a batch of 25 pieces heat-treated in a vibrating field was used. The parameters used for the parts in this batch were: frequency f=1000 Hz and power P=1500 W.

The first significant observation occurred in the microstructures of this part. In non-vibrated structures, it can be observed a structure in lamination bands and the grain boundary are not precisely outlined.

In the case of vibrated steel used in construction field, it appears a beginning of a clear contouring of the grains, as well as the almost complete disappearance of the lamination bands. All this contributes to the increase of the mechanical characteristics of the steel.

The first important significance in the case of the use of mechanical vibrations during heat treatments is the important increase in the hardness of heat-treated surfaces.

This increase in hardness at the steels used in the construction field occurs only when certain vibration parameters are used; therefore a lot of experimentation is required to use an appropriate vibration regime.

4. CONCLUSION

As a result of this present research on materials from construction equipment, it can be confirmed with certainty, that the mechanical vibrations contribute to the improvement of the mechanical properties of thermal-treated parts in the vibrating field. Also, it can be seen in the detailed presentation, the fact that mechanical vibrations contribute to a more uniform distribution of the thermal field.

The heat treatment is differentiated according to the material from which the mechanical part is made of.

Regarding the production of vibrations, they are produced by mechanical vibrators, which have different powers, depending on the spot where they are used. Vibration frequencies are also variable so that they can resonate with the material they are vibrating. The best effect is ensured when the vibrations are applied during the solidification process. If the vibration is applied during the solidification process, then the structure is finer, because the vibrations contribute to the formation of several crystallization centers. Also, the state of the trail stresses is more uniform, and the thermomechanical influenced area, is narrower. In these conditions, no constituents are formed outside the equilibrium zone. As a result of this fact, cold cracking is no longer possible.

The production of vibrations is largely determined by the power of these mechanical vibrators. The differences between the power of these mechanical vibrators and the vibration frequencies used are noticed especially within the obtained microstructures.

5. REFERENCES

[1] Bogdan Novac - *Electromagnetic Vibration System Designed for De-Stressing Welded Joints from Large Metal Constructions,* RECENT Journal, Vol.21, Nr. 2/2020, ISSN 1582-0246

[2] Gheorghe Novac, Bogdan Novac - *Contributions Regarding the Use of Mechanical Vibrations in Order to Improve the Properties of Steels and Welded Joints Used in Metal Constructions*, RECENT Journal, Vol 21, Nr 2/2020, ISSN 1582-0245
[3] Tomescu D., Mariu V., Mitroi C, (1971) *Reconditioning and increasing the wear resistance of agricultural machinery parts,* Ed. Ceres, Bucharest
[4] Zhengyi J. (2010) *Manufacturing science and engineering.* Ed. Advanced Materials Research
[5] Safta Voicu, (2006) *Technological and strength tests of welded or attached joints,* Ed. Sudura Timișoara
[6] Novac Gheorghe, Novac Bogdan, (2009) *Welding of boron and titanium micro alloyed steels.* International Conference and Engineering, ISBN 973-635-454-7, February 26
[7] Novac Bogdan, (2011), *Contributions regarding the use of mechanical vibrations at the heat treatment and thermochemical treatment of the irons used in precision mechanics*, Thesis, Transylvania University of Brasov. Romania
[8] Buslă (Ion) A. – „*Static analysis of the hull plate using the finite element method",* ModTech International Conference, Modern Technologies in Industrial Engineering 17-20 June 2015
[9] Novac Gheorghe, Novac Mariana, Novac Bogdan (2012): *The influence of stress relief heat treatment on the properties of rotor Pelton, reconditioned through welding.* Metalurgia International, ISSN 1582-2214, Vol XVI/2012, nr 1
[10] Chiriacescu T.S. (1984): Vibrațiile Mașinilor-Unelte, Editura Universitatea din Brașov, Brașov
[11] Bogdan Novac. - *Experiments on Obtaining Silicified Welded Joints Using Mechanical Vibrations*, RECENT Journal, Vol 21, Nr 3/2020, ISSN 1582-0246
[12] Bejinaru, Gheorghe; Novac, Bogdan; Novac, Gheorghe. Productivity and degree of crush influence on specific surfaces for crush operations. Metalugia International (2011), Vol. 16, nr. 3, ISSN 1582-2214
[13] Marin Cornel, (2008) *Mechanical Vibrations. Applications. Problems.* Ed.Bibliotheca
[14] Graham Kelly S. (2012): *Mechanical Vibrations: Theory and Applications*, Ed. Cengage Learning, Stamford, USA
[15] Buslă (Ion) A., Ticu I. - „*Finite element method for calculating marine structural design"*, ModTech International Conference Modern Technologies in Industrial Engineering 17-20 June 2015

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