U.S. QUENCHING AND DIMENSIONAL STABILITY IN TIME OF 100Cr6 STEEL

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Abstract: *Due to the relatively high susceptibility to deformation and cracking, the bearings steel creates major problems to quenching, especially in the case of complex geometric configurations. On the other hand, the dimensional stability of bearing elements influences significantly bearing durability. In this paper, the authors present a series of experimental results on the dimensional time behavior of 100Cr6 steel for several martensitic volume quenching.*

Keywords: *quenching, bearing steel, dimension stability*.

1. General consideration

Sustainability of precision bearings largely depends on the dimensional time stability provided by the structure elements obtained from the final heat treatment. In this case the notion of structure defines the nature, form, size, distribution of phases and structural constituents also the size and sign of residual stresses induced in product following due to the heat treatment applied.

Martensitic quenching is a heat treatment of the technologies that induces stress and strain in dimensional stability with implications for long periods of time. The transformation of austenite into martensite in quenching induces large amounts of residual material stress, due to the difference in specific volume of the constituents (martensite has higher specific volume than austenite from which it came). Finally, on the quenching product surface tensile stress is formed which is summed algebraically with the tensions caused by thermal shock. Parts of the residual stresses are "downloaded" during its return through specific mechanisms. On the other hand in the structure of quenching steel the residual austenite and martensite phases are out of balance and so unstable over time. These phases tend to evolve over time, even at ambient temperature, the phase constituents close to balance or causing dimensional changes in some operational situations affecting the product behavior in exploitation.

Collective concerns of the thermal treatments laboratory FIMMM Suceava on optimization of heat treatment of bearing steel dates back to 1985. In the article are presented results of research regarding the influence of quenching regime for dimensional stability in time of 100Cr6 steel (symbolizing the ancient RUL1).

2. Research methodology

Typically, dimensional stability in time is expressed as relative linear strain variation over time; the measurements are made until the full stabilization of the dimensions. To study the dimensional stability in time was designed and implemented a device like in figure 1. With five workstations, the device allows embedding of cylindrical specimens with Ø10 x 150 mm, between a high rigidity wall and an elastic wall on that are bonded strain gauge.

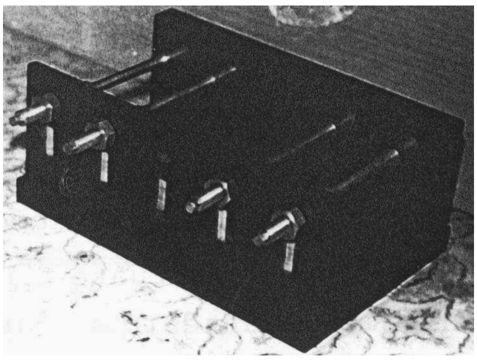


Figure 1. *Device for testing dimensional stability*

To limit thermal deformation caused by changes of ambient temperature environment after mounting the samples device are placed in a thermostatic chamber in which temperature is maintained at 20 °C with an accuracy of ± 0.2 °C. Strain gauges in full bridge are connected to five bridges N2305, selected in advance as stability while balancing adjustment. In order to ensure stable mechanical properties over time after implementation, the device was subjected to thermal stress relief treatment of 100 hours at 200 °C. Immediately after heat treatment, samples were mounted in the device, gathering performing with torque indicator handle wrench to maintain the same measurement conditions. After placing the device in the thermostat room and after temperature stabilization was done to balance each strain gauge bridge. Calibration of each station was done with a orthotest. We worked with lots of five specimens for each group thermal treatments are presented in Table 1. Austenitizarea for quenching was performed in a CARBOLYTE electric furnace heated to 850 °C, keeping time was 40 minutes. As cooling environment mineral oil Lubrifin MET 1 R type II was used, recommended for quenching bearing elements.

Tabel 1. *Quench cooling variants of the samples group*

Group code	Getting austenite	Mineral oil cooling (40 °C) *LUBRIFIN MET 1 R Tip II*	Draw back	Running maintenance
Cl	850 °C/40 minutes	Mechanical agitation	-	-
Cl + R	850 °C/40 minutes	Mechanical agitation	150 °C	2 h
Mg	850 °C/40 minutes	Continuous magnetic field 300 G	-	-
Mg + R	850 °C/40 minutes	Continuous magnetic field 300 G	150 °C	2 h
US	850 °C/40 minutes	Ultrasonic field 40,4 kHz and 4W/dm^2	-	-
US+R	850 °C/40 minutes	Ultrasonic field 40,4 kHz and 4W/dm^2	150 °C	2 h

For magnetic field quenching was used an oil tank with 40 dm^3 capacity, fiberglass located in the center of a DC powered coils. In the center of the basin is done a magnetic field strength of 300 Gauss, [1].

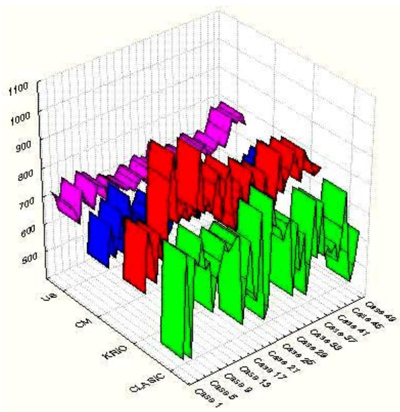
Ultrasonic field quenching was made in a tank with a capacity of 40 dm^3, stainless steel sheet, in which at the bottom was placed a piezoelectric transducer with U.S. power of 200 W and the resonant frequency of 40.4 kHz. Power transducer was made from an electronic generator, developed in the laboratory, capable of ensuring a U.S. field strength of 4 W/dm^2, [1].

Quality assessment was done by measuring the heat treatment hardness.

3. Experimental results

Figures 2.a. and 2.b. are the results of hardness measurements and their statistics. From their analysis results the superiority of U.S. quench field over other hardening technologies experienced.

Measurement of dimensional stability in time was made in a period of 204 hours. After this time installation was found to stabilize the specimens dimensional. Measurement results are presented in Table 2 and chart in Figure 3.



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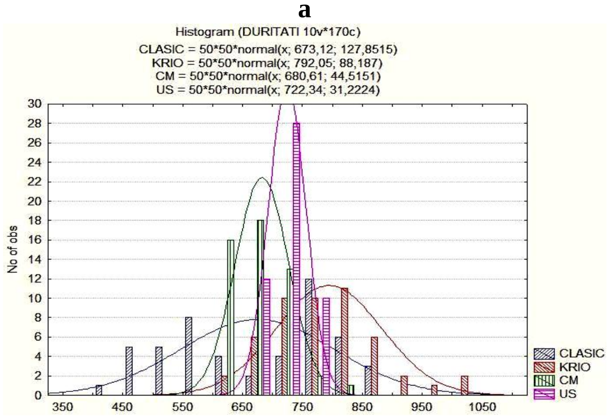


b

Figure 2. *Results of hardness measurements for heat-treated groups: a) hardness values chart; b) statistical measurements.*

Tabel 2. *Dimensional sability over time for different variants of heat treatment [μm]*

Time[h]	Cl	Cl.+R.	US	US+R.	Mg	Mg+R
0	1,33	1,33	0,66	0,66	1,33	1,33
12	2,66	2,66	0,66	2,66	2,66	4,00
24	4,00	2,66	0,66	2,66	2,66	4,00
36	4,00	4,00	1,33	3,33	4,00	5,33
48	5,33	5,33	1,33	4,00	4,00	6,66
60	5,33	6,66	2,66	4,00	4,00	8,00
72	6,66	6,66	4,00	5,33	5,33	8,00
84	6,66	6,66	5,33	5,33	5,33	8,00
96	6,66	6,66	5,33	6,66	6,66	8,00
108	8,00	8,00	6,66	6,66	6,66	8,00
120	9,33	9,33	6,66	6,66	6,66	9,33
132	10,66	9,33	8,00	8,00	8,00	9,33
144	10,66	10,66	9,33	8,00	9,33	9,33
156	12,00	10,66	10,66	8,00	9,33	9,33
168	13,33	12,00	11,33	8,00	10,66	10,66
180	13,33	13,33	12,00	8,00	10,66	10,66
192	13,33	13,33	12,00	8,00	10,66	10,66
204	13,33	13,33	12,00	8,00	10,66	10,66

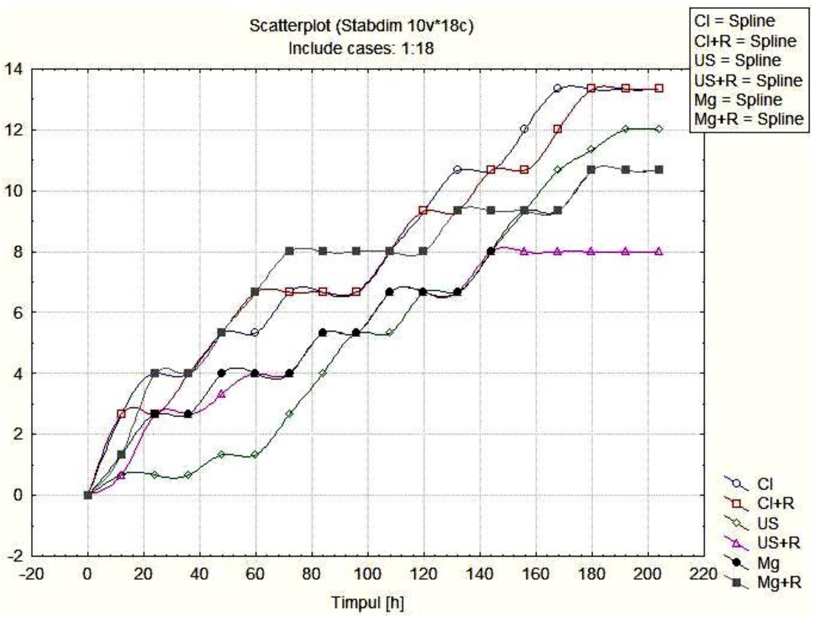
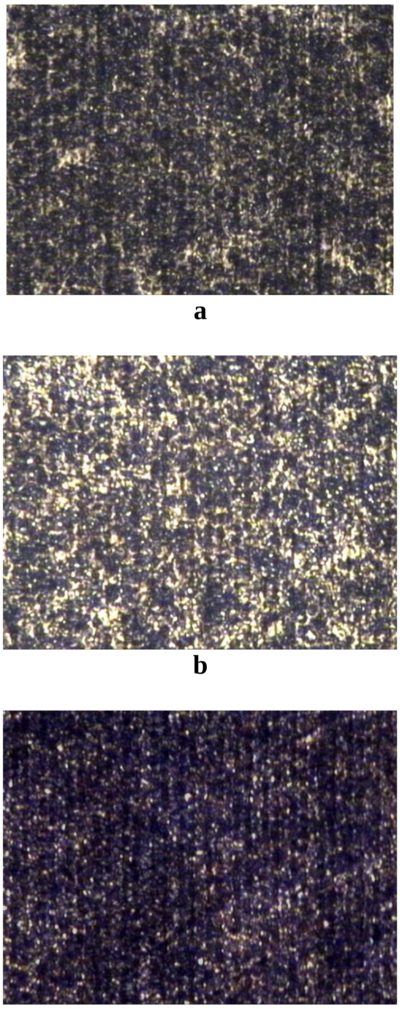


Figure 3. *Variation of dimensional changes in time of the specimens heat treated [μm].*

4. Conclusions

1. Quenchig technologies significantly influence the structure and properties of bearing steel. The amount of residual austenite in the structure, characteristics and size of residual stress of martensite is directly influenced by the parameters of the cooling operation. Metallographic structural analysis for various quenching regimes tested (Figure 4) is clearly observed differences between the quantity and distribution phases.



a

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Figure 4. *Metallographic structure of quenched samples: a) classic quenching b) magnetic field quenching, c) U.S. quenching field. MO x 400*

2. Activating U.S. cooling environmental drastically reduce calefaction on cooling and uniform heat exchange intensity in the first part of cooling, as confirmed by less dispersion of hardness values, as apparent from Figure 2.b. Furthermore, the U.S. vibration frequency of the fluid cooling determines the cooling capacity growth, and hence the cooling rate directly affects the amount of residual austenite in the structure. Compared with other types of heat treatment, U.S. quench ensure sensitive reduce of the residual austenite amount. (Figure 4.c.).

3. Mineral oil used as a cooling environment can be considered incompressible and ensure transfer of mechanical energy from the transducer to the product. Additional energy intake determines the transformation of additional austenite quantities into martensite at quench with direct implications on the content of residual austenite, [2, 3].

4. Following the additional energy intake, even during the quench, product stress relief is realized, phenomenon confirmed by experimental research, [1].

5. Dimensional stability over time is directly influenced by the proportion of phases and constituents in the metallographic structure. In bearing steel case is mainly on the amount of residual austenite in the structure, [1]. Among variants examined by heat treatment, the U.S. quenching ensures the most dimensional stability in time by dramatically reducing the amount of residual austenite in the structure in the first place.

6. As an alternative technology at industrial scale, the U.S. quenching has the advantage that it not requires major investment or significant changes in heat treatment lines or excessive energy consumption.

7. U.S. heat treatment oil activation reduces the negative effect of waste water and increases its use.

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