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STUDY ON CHARACTERISTICS MODIFICATION OF RUL 1 STEEL

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Abstract

The paper shows a study about the structural modifications induced on RUL 1 sample, through classic heat treatments. The initial semi-product provides from a laminated bar. It is applied a annealing primary heat treatments, also and quenching and low tempering finally heat treatments. The efficiency of applied thermal processing was evaluated through hardness measurements and micro-structural analyses.

Keywords: *steel, bearing, characteristics, durability*

Introduction

The safety exploitation of bearings is assured by the high breaking and fatigue resistance, and also the dimensional stability. One of the most important characteristics of bearing steels is the hardness obtained after the improving heat treatment.

The bearing durability drops with the rising of tempering temperature or usage temperature. The lower tempering temperature is the higher the hardness, but also the quantity of residual austenite. This fact affects the dimensional stability and fatigue resistance.

Is recommended the appliance of cryogenic treatment, at -70°C, after oil martensitic quenching, with the purpose of decreasing the quantity of residual austenite, followed by a low tempering for stress relief.

The RUL1 steel is used at manufacture of small bearing and tools: dies, reamers, punches, calibers. It can be delivered as laminated form, laminated-annealed, bars, wires.

The bearings are formed, usually, from 2 rings or washers, a number of rolling bodies and a cage. The rings, interior and exterior, meet at radial bearings, meanwhile the washers, the spindle and the housing, meet at axial bearing. On the rings and also the washers are processed, towards the interior of the bearing, the running paths.

The rolling bodies (balls or rolls) are in direct contact with the two rings through the running paths. Through the rings or the washers is realized the direct connection of the bearing with the ensemble in which is mounted; the interior ring is mounted on ax; the exterior ring in housing. At the axial bearings, the spindle washer is mounted on spindle, and the washer is mounted in housing.

The cage has the role of maintaining fixed distances between the rolling bodies. There are bearing constructions which can lack one or many components.

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The usually bearings are used at majority of machinery. The special bearing contain: bearing for apparatus and instruments, high precision bearing, large dimensions bearing, linear movement bearings, self-lubricated bearings, low precision bearing.

The requests and deterioration phenomena as which the bearing are submitted, have set the establishment of connection between the following mechanical and physical properties:

- Durability at contact fatigue request
- Hardness at ambient and high temperature
- Expansion coefficient
- Tenacity
- Corrosion resistance
- Metallurgical transformation characteristics

For bearings manufacturing is used a high carbon steel (1%), alloyed with chrome, also containing manganese, silicon, nickel, copper, molybdenum. In Romania, exists RUL1, RUL2 and RUL3 marks, differing through the manganese content, higher in RUL2 and RUL3 marks.

The cementing steels meet rarely in the manufacturing of bearing with rolls. The material is characterized through a hardened surface (58-63 HRC) and a soft core (25-40 HRC)

The bearing which work in contact with aggressive environment, are made from stainless steels for integral quenching. The high reliability bearings are made from steels with well established chemical composition, using the elaboration process through multiple melting in vacuum.

The bearing cage has the role to prevent the direct contact between the rolling bodies. In the case of bearings with rolls, the cage does the guidance of the rolls, and at the bearing with separable rings, the cage retains the rolling elements, so that these can´t fall when the mounting or dismantling of the bearing is realized.

The bearings with small or medium dimensions are usually equipped with molded cages, from steels with low carbon content or cages of brass. Also are used cages from plastic products, these having a series of properties favorable to the specific conditions of the cage. Higher temperature of 130-140°C can be tolerated, for shorter period, followed by longer periods with functioning at lower temperatures.

Experimental

Determination of chemical composition

The determination of alloying elements was made on an optical spectrometer, type Foundry Masters. For measurements, are used samples with small dimensions, prepared through polishing on abrasive paper.

Table 1. Determined chemical composition

Fe	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
95.6	1.05	0.171	0.726	0.0336	0.0363	1.54	0.0842	0.173	0.0048	0.0086

Cu	Nb	Ti	V	W	Pb	Sn	B	Ca	Zr	As
0.178	0.0064	0.0020	0.192	0.104	0.025	0.0201	0.0062	0.0006	0.0045	0.0196

It was made 3 measurements on sample surface; in table 1 are present the average values recorded for a series of chemical elements from structure of analyzed steel. The sample is part of low alloyed steels category, for bearings; the analyzed steel is RUL 1 type (AISI 1.3505 mark). The principal mechanical characteristics are present in table 2.

Table 2. Mechanical properties

Type	State	Rp0.2 [daN/mm2]	KCU [J/cm2]	HB	HRC
RUL 1	A	600-750	-	170-207	-
	QT	2500-3300	30	-	59-63

A – Annealed; QT – Quenched and tempered.

Heat treatments

The significant modifications of the analyzed samples structure, is obtained through various heat treatments (table 3).

Table 3. Recommended parameters for heat treatments of RUL 1 steel

Annealing		Normalization		Quenching		Tempering	
T, [°C]	Environment	T, [°C]	Environment	T, [°C]	Environment	T, [°C]	Environment
760-800	Furnace	890-910	Air	830-870	Oil	150-180	Air

For the presented thermal processing in the paper, I used an electrical furnace, with resistors and fixed heath, type UTTIS CE12, controlled for heating and maintaining stages (table 4) through PROTHERM 100 software. The heating and maintaining environment is ambiance; the cooling was realized in the air/water specific environment of the heat treatment.

Table 4. Adopted parameters for heat treatments of RUL 1 steel

Annealing		Quenching		Tempering	
T, [°C]	Environment	T, [°C]	Environment	T, [°C]	Environment
780	Furnace	850	Oil	180	Air

Hardness measurements

Through heat treatment of metallic alloys is possible the properties modification if their components forms a series of solid solution at which the solution grade is modify with temperature variation. The effect of heat treatment depends by the quantitative the phase content, by quantity of different phase separations and their mutual position.

The properties modifications of alloys after quenching and tempering can be highlight through hardness measurements, made on WILSON WOLPERT 751N universal hardnessmeter. For hardness determination is used Rockwell method, using a conical penetrator from diamante, with 150 kgf pressure weight and 12.5 seconds pressing time.

Table 5. Measured values of the hardness

State	#	Rockwell Hardness	Average
After annealing	1	20.7	21.6 HRC
	2	21.9	
	3	22.3	
After martensitic quenching	1	61.3	61.5 HRC
	2	61.4	
	3	61.9	
After low tempering	1	60.2	60.6 HRC
	2	61.1	
	3	60.7	

The structural hardening is obtained through quenching heat treatment, followed by a new heating or maintaining for a long time at ambient temperature.

In the case of metallic alloys, at which the solubility of components varies with temperature, can obtain high hardness through quenching, meaning a structural hardening due to quenching.

Structural analysis

The micro-structural analysis of the samples was made on Zeiss AxioObserver D1m optical microscope. The samples have been rectified, polished and attacked wick chemical reactive (Nital 4%) to enhance the structural constituents.

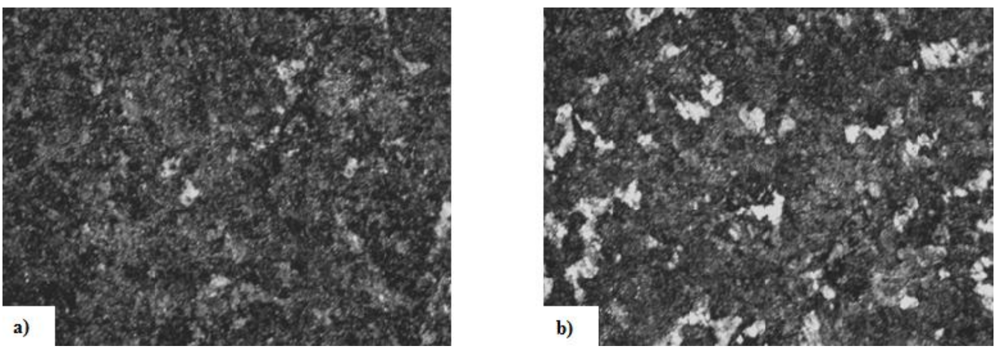

Fig.1. Microstructures of samples after annealing heat treatment - magnitude: a) 200X; b) 100X.

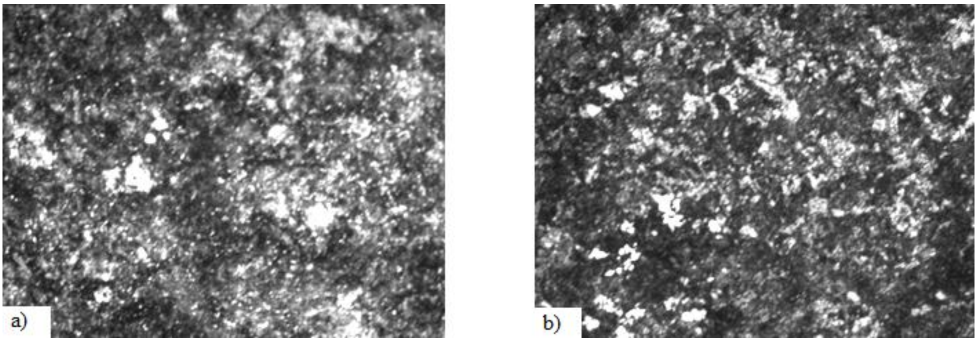

Fig.2. Microstructures of samples after martensitic quenching heat treatment - magnitude: a) 200X; b) 100X.

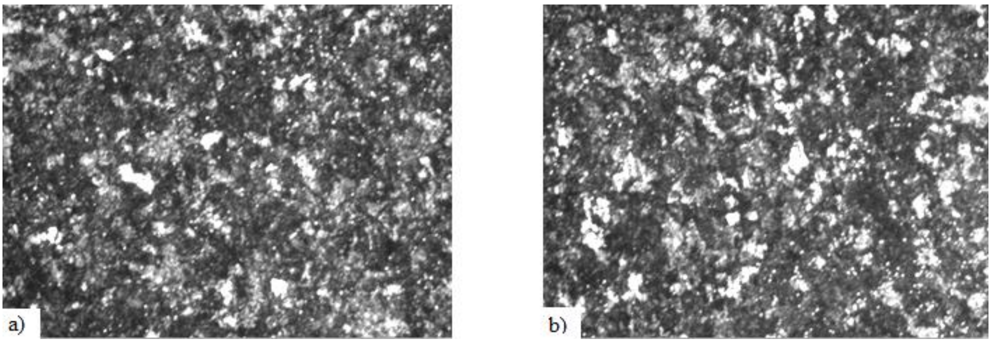

Fig.3. Microstructures of samples after low tempering heat treatment - magnitude: a) 200X; b) 100X.

The RUL 1 steel, in laminated state, present a sorbite structure with fine grains, in the case in which the final laminating temperature was low and if the cooling after laminating was rapid.

If the laminating is ended at high temperature and the cooling was slow, the structure is formed from pearlite and a cementite network. This structure is unfavorable to the subsequent processing through machining and that's why is recommended an annealing.

After quenching heat treatment, with oil cooling, in the structure of RUL 1 steel is found fine martenite and uniformly dispersed carbides.

Conclusion

For appropriate choice of materials, from which are manufactured bearing for automotive industry, is recommended alloyed steels, with improved physical-mechanical properties.

The studies of usage phenomena, which appear at bearings, become a necessary condition in the choice of steel mark, steel which ensures a good reliability.

The material usage will lead to modification of the dimensions and geometrical shape for the bearings contact surface and implicitly decreasing the yield of the bearing. Redesigning of the system is necessary.

The experiments made on RUL1 steel, recommends the usage of bearing steels, with the conditions of heat treatments regimes optimization.

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