**11th International Research/Expert Conference**
**"Trends in the Development of Machinery and Associated Technology"**
**TMT 2007, Hammamet, Tunisia, 05-09 September, 2007.**

# SOME ASPECTS OF LARGE DIAMETER BEARING RING PRODUCTION

**Nikola Kuprešak, Antun Stoić**
**Faculty of Mechanical Engineering, University of Osijek,**
**Trg I. B. Mažuranić 2, 35000 Slavonski Brod, Croatia**

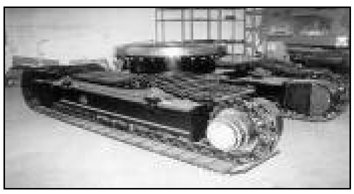
**Janez Kopač**
**Faculty of Mechanical Engineering, University of Ljubljana,**
**Aškerčeva 6, Slovenija**

**ABSTRACT**
*A major inefficiency in the manufacturing of large diameter bearings incorporating the geared surface on outer diameter is the number of phases and processes needed for production. The raceway of a roller bearing race for cylindrical rollers having two concentric cylindrical surfaces (one surface being the raceway and the other cylindrical surface comprise elastic loads of seating). The current method of producing of bearing races surfaces involves annealing, rough turning, hardening (2 mm in depth on 56 $^{+3}$ HRc), hard turning and gear machining. Therefore, there has been an economic motivation to study methods of extending one process or one machine tool's capability so that other processes in the production sequence can be eliminated, thus, reducing set-up time and the complexity of manufacturing scheduling, and system efficiency. There is an additional problem disturbing hard machining called hot spot ( after induction hardening there is a arch length of some 35 mm with very high hardness drop 750 to 200 HV) which is a source of load impacts on cutting tool. Tests were performed on bearing rings produced of Ck45N which has to be mounted on a heavy duty machines (lifts, bulldozer, loader etc.).*

## 1. INTRODUCTION

By manufacture of bearing rings with large dimensions, concerning their use, it is necessary to apply new technologies which increase efficiency and costs of manufacturing. Picture 1.1 demonstrates the bearings, and their use in exploitation picture 1.2.

*Picture 1.1. Single row ball bearings [1]*

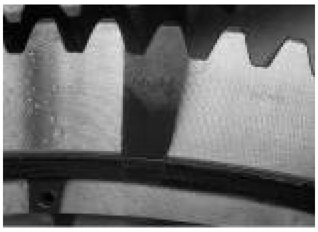
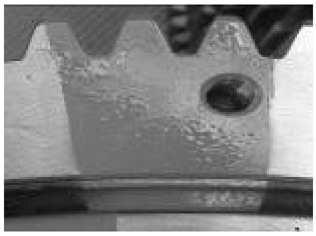


*Picture 1.2. Frame of dredger [1]*

The basic production requests for roller single row ball bearing chosen for investigation shown in pictures 1.3 to 1.5 are:

- roller bearing races of rings is necessary to temper inductively to the depth of 2 mm with the hardness 56 $^{+3}$ HRc
- to mark soft location (place) MM on the rings (place which is not tempered) with red colour.
- to mark the maximum eccentricity of teeth with green colour (three teeth) and with symbol „+“ mutually.

- allowed clearance of bearing( radial 0,15 – 0,35 mm, axial 0,20 – 0,40 mm)

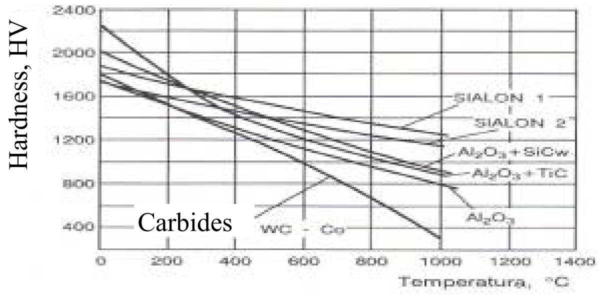




*Picture1.3. Intersection after tempering* *Picture1.4. Soft spot* *Picture1.5. Max. eccentricity of teeth*

**2. BEARINGS MANUFACTURE TECHNOLOGY**

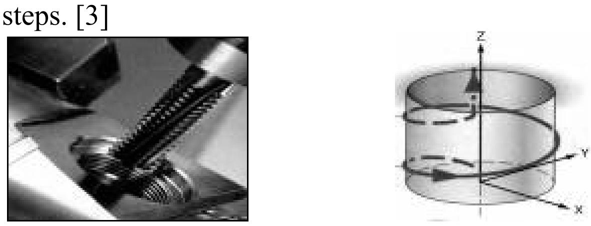
The material of the rings is steel DIN CK 45 N, what is in national steel classification standard in Croatia approximately equal with Č 1531 annealed steel (in normalized condition). Structure and mechanical features are: contents C 0,42 – 0,5 %; contents of Mn 0,5 – 0,8 %; Si 0,15 – 0,35 % ; P,S 0,35 % ; hardness max. 207 HB (217 HV); yield strength $Rp_{0,2}$ – 420 N/mm$^2$ ; tensile strength 670 – 820 N/mm$^2$ . In the manufacture of rings both carbide and ceramic inserts are used, as presented in the picture 2.1. Big disadvantage of hard metals is the decrease of hardness at high temperatures, while this problem is mainly annulated with ceramics. Picture 2.2 presents the change of hardness depending on the temperature increase. It is visible that with the hard metals the hardness decreases at 1000°C which is remarkable in relation to ceramic. [2] By using ceramic cutting plates the cutting speed is increased, the processing is performed without coolant, and hereby quality processed surface of rings is achieved.

*Picture 2.1. Ceramic inserts [1]*




*Picture 2.2. Changing of hardness depending on temperature some kind of ceramics and hard metals [2]*

Thread making is applied as shown in the picture 2.3, which contributs to production time decrease. During thread making, the tool is positioned on the bottom of the hole, and afterwards it is moved counter clockwise upwards in a track of 360°, during which each tooth makes one pace of thread. The cycle is carried out in six steps. [3]




*Picture 2.3 Outline of tread making*

**3. EXPERIMENTAL INVESTIGATION**

The experiments have been carried out in the laboratory for testing of materials at the Faculty of Mechanical Engineering as well as in the production plants of Machining. The hardness testing procedures have been carried out radially on the material steel Ck 45 N (surface hardness, by Vickers's method HV30) and spherically (into the depth of the processed material by Vickers's method HV1), after the induction tempering. The main feature of induction heating is the occurrence of heat directly in the processed material. With the conventional procedures of heating on the processed material surface, a heat flow of 0,5 to 20 W/cm$^2$ is led in, and with the induction tempering it measures from 10000 to 30000 W/cm$^2$. [4]

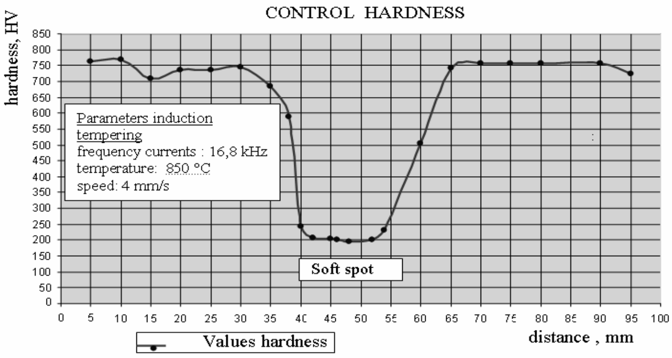
*Picture 3.1. Ring heating [1]*

After the process of induction tempering has been carried out, there is a soft spot left on the processed material due to the interruption of induction tempering. The aim of the testing is to determine the differences in hardness of the soft and the tempered spot of the processed material.

### 3.1. Surface hardness testing

Surface hardness of the test sample is measured by a universal device for hardness testing (Brinell, Vickers, Rockwell), on the test sample picture 3.2. The picture 3.3 clearly shows substantial hardness deviation on the spot of induction tempering interruption for about 500 HV on the length of 30 mm.

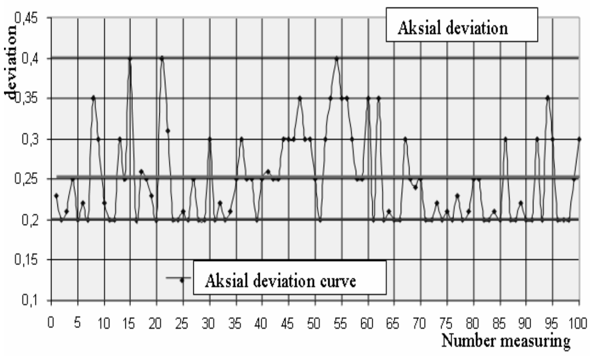
*Picture 3.2. Outer ring test sample*



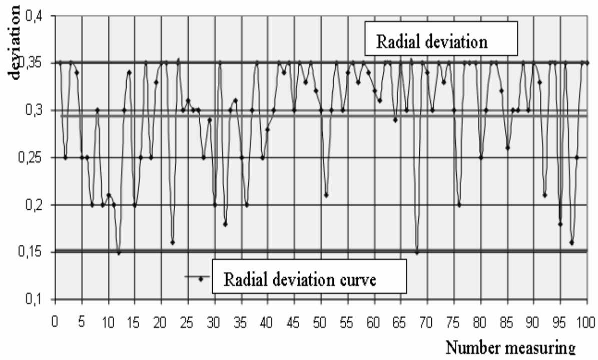

*Picture 3.3. Hardness curve outline*

### 3.2 Control of radial and axial deviation

The control of axial and radial deviation of the bearing has also been carried out in the experimental part, on the series of 100 products, represented in the diagram in the pictures 3.4 and 3.5.




*Picture 3.4. Axial deviation curve*




*Picture 3.5. Radial deviation curve*

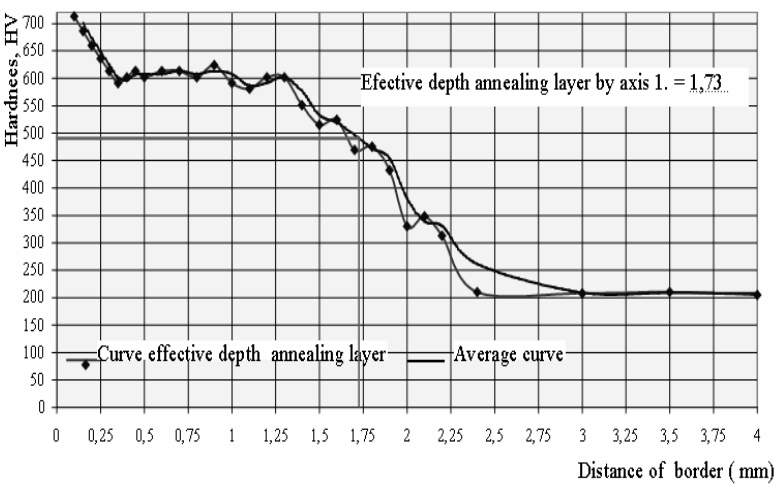
### 3.3 Determination of the effective depth of tempered layer (DIN 50190)

The effective depth of the tempered layer (DS) is determined after the surface tempering. DS is the vertical distance between the edge of the tempered layer and the spot where hardness by Vickers (HV1) under strain (9,81 N) is equal to the value of border hardness. The border hardness depends on the requested minimal surface hardness set by the customer and it is: 56 HRC (615 HV), and is determined by the following expression [5]

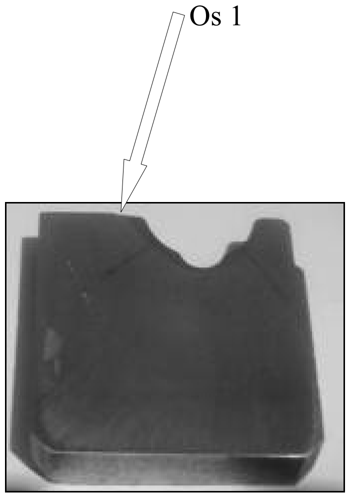
Border hardness (HG) = 0,8 x minimal surface hardness (HV). … (1)

$$HG = 0,8 \times 615 = 491 \text{ HV}$$

If this result is incorporated into the diagram in the picture 3.6, we come up with the effective depth of the tempered layer by axis 1 picture 3.7 of DS = 1,73 mm.




*Picture 3.6. Hardness curve outline*




*Picture 3.7. Measured sample*

## 4. CONCLUSION

By analysing the technology of the production of bearing rings of bigger dimensions we can see that hard processing of the rolling surfaces that have previously been thermally hardened by induction tempering is represented. Besides hard metal cutting materials, ceramic cutting materials have been used. From the diagram and table outline in the experimental part of the degree essay the following can be concluded:

1. The measuring of the surface hardness demonstrated the decline of hardness in the amount of 500 HV at the distance of cca. 30 mm. The tool blade is more inclined to “easier” penetration into material due to decreased passive force, at this point it is exposed to higher dynamical strain which are transferred to the holder, as well as to the other parts of the device. The expected result is higher radial deviation, wearing out of the tool blade when it is in closer contact with the material.
2. By the analysis of the results of radial and axial deviation it can be concluded that the average radial deviation is 0,30 mm closer to the upper limit, the reason for this can be the interruption of tempered layer as well as the impact that emerges during processing of the rolling surface.
3. The achieved effective depth of the tempered layer does not fulfil the preset request on hardness $56^{+3}$ HRC at the depth of 2 mm. The reason for this could be the incorrect choice of parameters during the induction tempering. The expected result is the decrease of the hard layer after the process of separation as well as decrease life expectance of the bearing.

## 5. REFERENCES


[1] http://www.strojna-obrada.hr/production_program/slewing_rings/default.aspx,pristupljeno 3.veljače 2007.
[2] Ekinović Sabahudin : Obrada rezanjem, vlastito izdanje Zenica, 2001.
[3] Sandvik Coromant : Metalcutting Technical guide, Sandviken, Sweden, 2005
[4] Landek Darko : Postupci modificiranja površina, podloge za vježbe, FSB,Zagreb, 2004.
[5] Vitez Ivan. : Ispitivanje mehaničkih svojstava metalnih materijala, Slavonski brod, 2006.