# HEATING OF WATER PUMP BEARINGS AND COUNTERMEASURES

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**Abstract:** This article makes an analysis on heating of water pump bearings in a conti-caster mold in the steelmaking sector of LY's Bar Plant, and gives measures to tackle it.

**Keywords:** water pump of mold, heating of bearing, concentricity, radial gap, axial gap

## 1 Foreword

The water pump of mold is a key equipment in steelmaking plants and acts as driving mechanisms in cooling systems of molds, having significant effects on quality of slabs, even on steelmaking process. In the steelmaking sector of the Bar Plant lie 2 water pumps, with one of them as standby and another for use. Since them starting operation in early 2004, the 2 pumps have had frequent troubles, and bearings in the pumps have been having short life of mere 2 months on average, sometimes less than 1 month, which increased labor intensity of maintenance workers greatly on one hand, and on the other hand resulted in growing maintenance expenses, having negative influences on production.

## 2 Technical performance of water pumps and their troubles

The two water pumps of mold 250XNSZ-160B, named Pumps 4# in the plant, are produced by Chengdu Xinan Pump Plant, with matched electric motors Y355-L2. Fig.1 is the pumps' structural diagram, Table 1 shows the pumps' technical performance parameters, Table 2 gives type number and structural dimension of the pump bearings. Table 3 shows measurements of the bearing temperatures during pump running. Axial fans were used to make external cooling for the pumps when heating occurred in the bearings.

| Pump type | 250XNSZ-160B |
|---|---|
| Flow, $m^3/h$ | Q=568 |
| Lift, m | H=140 |
| Rotary speed, r/min | n=2950 |
| Pump power, Kw | Pa=278 |
| Electric moter power, Kw | P=315 |
| Efficiency, % | η=77% |
| Rated current, A | I=544 |

Table 1: performance parameters of water pumps

| bearing type | Angular contact bearing 6310 |
|---|---|
| Inside diameter:㎜ | d=50 |
| Outside diameter:㎜ | D=110 |
| Width of outside lap:㎜ | B=27 |

Table 2: type and structural dimension of water pump bearings

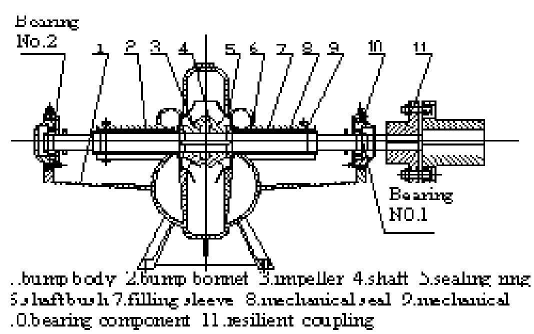


Fig.1: structual diagram of water pumps

| Bearings measured | Bearing 1# | | | Bearing 2# | | |
|---|---|---|---|---|---|---|
| | on electric motor side | Top side | on pump side | Inside pump | Top side | outside pump |
| Actural temp., ℃ | 45 | 38 | 42 | 55 | 45 | 62 |
| Room temp.,℃ | 20 | | | | | |
| More than room temp., ℃ | 25 | 18 | 22 | 35 | 25 | 42 |

Table 3: temperature measurements of bearings

Table 3 shows, although axial fans were used to cool the bearings externally, the temperature of Bearing 2# was 42℃ higher than room temperature yet, 12℃ higher than specific standard, and great vibration occurred in the whole pumps.

## 3 diagnosing and measures taking on Bearing No.2

### 3.1 items tested on Bearing No.2

| items | Aims |
|---|---|
| To measure radial and axial deviations between the electric motor and running water pump using dial gauge and block gauge | To check if concentricity is beyond standard |
| To measure axial movement value of the pump shaft | To check the value |
| To check the fit between journal of pump shaft and the inner ring of the bearing | To check the fitting |
| To check the fit between outer ring of the bearing and the inner bearing housing | To check the fit |
| To check the fit between the inner and outer bearing housings | To check the fit |
| To check bearing clearance（including assembly axial clearance） | To check if bearing clearance is line with specification |
| To check if bearing is broken and if lubrication is good | To check the surface quality of bearing and lubrication of the bearing |

### 3.2 Testing methods and results

**3.2.1 Assembly concentricity between the motor and the running pump measured with dial gauge and block gauge**

The following diagram shows the measured radial tolerance between couplings of the motor and the running pump,measured with a dial gauge.

5.0

5.36 —┼— 5.34

5.69

Note: The magnet base of the dial gauge is installed on the motor shaft.

The following diagram shows alignment between couplings of the motor and the pumps,measured with a block gauge.

2.32

┼

2.42

According to the data measured in both radial and axial directions, the motor is 0.35 ㎜ higher than the water pumps, and a 0.1mm-lower-opening lies between the two couplings, which indicates the assembly concentricity between the motor and pumps is largely beyond specific standard.

**3.2.2 Axial movement value of the pump bearings measured with dial gauge**

While the manual barring rotates the water pumps, the axial movement value of the pump shaft, measured with dial gauge,is 0.2mm which is not the maximum during pump running. As the pumps operates at high speeds, the value increases.

**3.2.3 Table 4 shows the fit between the inner ring of Bearing No.2 and the shaft.**

**3.2.4 Table 5 shows the fit between the outer ring of Bearing No.2 and its inner bearing housing**.

| Items to be measured | Bearing No.2 |
|---|---|
| the journal’s diameter | ¢ 50 +0.02 |
| Bearing’s inner diameter | ¢ 50 -0.02 |

Table 4: fit between the inner ring of Bearing No.2 and the shaft

| Items to be measured | | Bearing No.2 |
|---|---|---|
| To measure the top clearance between the outer ring and inner bearing housing prior to disassembly for overhauling or maintenance | | The structure of the bearing housing was not accessible for the measuring |
| The aperture of the inner bearing housing in vertical direction | | ¢ 110 +0.08 |
| The outer diameter of the bearing | D max | ¢ 110 +0.02 |
| | D min | ¢ 110 -0.02 |

Table 5: fit between the outer ring of Bearing No.2 and its outer bearing housing

The measurements shows that, the fit between the outer ring and inner bearing housing was clearance fit and the clearance was a little bit large. The maximum clearance Gmax = 0.08+0.02 = 0.10mm. The minimum clearance Gmin = 0.08-0.02 = 0.06mm. Also, it was found the outer ring had slight deformation of 0.02mm and the inner bearing housing had wear of over 0.03mm.

**3.2.5 the fit between the outer and inner bearing housings of Bearing No.2 checked**

The fit between the outer and inner housings, measured with lead, was a interference fit of 0.95mm.

**3.2.6 the clearance of Bearing No.2 checked**

The radial windage of Bearing No.2, measured with a feeler, is 0.08mm. Measured with a depth vernier caliper, the axial assembly dimension are depth of the inner bearing housing of 36.68 mm, bearing width of 27mm and the depth of the bearing cap rabbet of 9.92mm. Since the 0.5mm-thick adjusting pad already put on the cap, the axial clearance of Bearing No.2 can be calculated as follows.

$$36.38 + 0.5 - 27 - 9.92 = 0.26\text{mm}$$

**3.2.7 assessments of bearing damage and lubrication**

Paragragh 3.2.4 shows slight deformation of 0.02mm in the outer ring, wear of over 0.03mm in the inner bearing housing, slight pitting and wearing on the surface of raceway of the outer ring, deteriorating of grease in the bearing due to high temperatures which ruined the lubricating performance of the grease.

**3.3 Reasons behind the heating of Bearing No.2**

Three reasons behind the heating are as below, based on the above results of check.

**3.3.1 Excessively tight fitting between outer and inner bearing housings is the main culprit.**

Due to the excessively tight fit between the outer and inner bearing housings, the inner one underwent compressive deformation, pressing the outer ring and reducing the axial clearance, which, on one hand, increased friction among running rolling body, outer and inner rings, esp. at start-up and braking, resulted in skidding of the rolling body which changed relative moving situation, even the outer and inner rings locking the rolling body sometimes which made the outer ring run abnormally under interference fit condition which increased friction drag among the rolling body and outer and inner rings, resulting in heating of the bearing; on the other hand, resulted in grease being squeezed out, deteriorating lubricating condition of the bearing, which increased the friction coefficient and friction heat.

**3.3.2 The outer ring had big axial clearance and wasn't positoned bothway, which also resulted in heating of the bearing.**

Bearing No.2 is end-fixed and its outer ring was not axially positioned, which increased the axial movement frequency of the outer ring and the friction between the rolling body and the outer ring, leading to the bearing heating.

**3.3.3 Big concentricity deviation between the motor and the running pump also caused the bearing to heat.**

The big concentricity deviation gave additional load to the water pump, even changed the way the bearing was forced, which resulted in vibration of the bearing and the heating due to increased friction of the bearing.

## 3.4 measures taking

According to the above reasons, following measures should be taken.

**3.4.1** Due to the slight deformation of the outer ring, a new bearing was used. And, technical parameters of the new one was checked and required to conform to specific standard. The inner and outer rings of the new Bearing No.2 were all two-point positioned in axial direction, and the surfaces of the outer ring and inner bearing housing were checked and required to be evenly interfacing with contact area of up to 70%.

Also, the clearance between the outer ring and inner bearing housing was checked and adjusted; its min. value shall be calculated as the following formula.

$$\delta \min = D(\Delta t_1 a_1 - \Delta t_2 a_2)$$

where

D refers to external diameter of the bearing,and equials 110mm;

$\triangle t_1$ refers to the difference between the highest operating temperature of the bearing and room temperature during assembly of the bearing. With the room temperature of 20℃, the highest room temperature of 40℃ and the operating temperature of bearing being 30℃ higher than the room temperature, $\triangle t_1 = 40+30-20 = 50$℃;

$\triangle t_2$ refers to the difference between the highest operating temperature of the bearing and room temperature during assembly of the bearing housing. Considering the most disadvantageous situation that the bearing is 10℃ higher than the bearing housing in temperature, $\triangle t_2 = \triangle t_1 - 10 = 40$℃;

$a_1$ refers to the linear expansivity of the bearing material, and $a_1 = 14\times10^{-6}$ (1/℃);

$a_2$ refers to the linear expansivity of the bearing housing material, and $a_2 = 12\times10^{-6}$ (1/℃).

So, $\delta min = D(\triangle t_1 a_1 - \triangle t_2 a_2) = 110\times(50\times14-40\times12)\times10^{-6} = 0.024$mm. Considering the actual lubricating condition and the dimensional tolerance of the new bearing, the actual clearance shall be (0.04 - 0.06)mm. The radial windage of the new bearing shall not be less than min. windage λmin, and λmin is calculated as **$\lambda min = \Delta t_3\times[d+(D-d)/4]\times a_1+0.65Hmax$**, where

$\triangle t_3$ refers to the allowed temperature tolerance of the outer and inner rings of the bearing during operating, and is set as 10℃;

d, D refer respectively to the inner and outer diameter of the bearing, and d＝50mm, D＝110mm;

$a_1$ refers to linear expansivity of bearing material, and $a_1 = 14\times10^{-6}$ (1/℃);

Hmax refers to max. shrink range of the fit between the inner ring of the bearing and the journal; through checking, the inner diameter of the bearing $d=50_{-0.02}$, the diameter of the journal $d = 50_{+0.02}$; then $Hmax = 0.02+0.02 = 0.04$mm.

So, λmin shall be calculated as $\lambda min = \Delta t_3\times[d+(D-d)/4]\times a_1+0.65Hmax = 10\times[50+(110-50)/4]\times14\times10^{-6}+0.65\times0.04 = 0.035$mm, which denotes the minimum radial windage of the new bearing shall be over 0.035mm.

**3.4.2** The fit between the outer and the inner bearing housings of the new bearing was adjusted, and shrink range was controlled within 0.05mm. The two housings were required to be evenly interfacing and the contact area was required up to 70%.

**3.4.3** Additional assembly and alignment were made to the motor and the running pump. The radial deviation was required within 0.1mm, the axial deviation 0.2mm.

**3.4.4** The axial clearance of Bearing No.1 was checked and adjusted. The clearance value A shall be calculated as

**$A = La\Delta t + 0.15$** $= 750\times14\times10^{-6}\times30 + 0.15 = 0.465$mm, where

A refers to the axial clearance of Bearing No.1;

L refers to the span between the two bearings No.1 and No.2, and L＝750mm;

a refers to the linear expansivity of the bearing material, and $a = 14\times10^{-6}$ (1/℃);

□t refers to the difference between the highest operating temperature of the new bearing and room temperature,and □t＝30□.

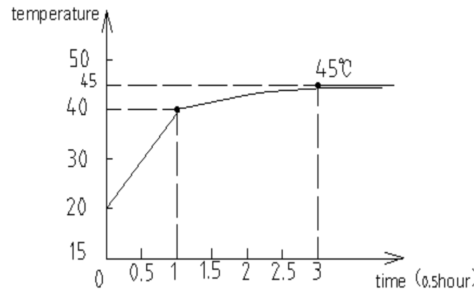


Fig.2: Curve of the temperature rise of the new bearing and time

## 4 Results of measures taking

Through no-load commissioning and continuous operation, the max. temperature rise measured conforms to specific standard. Figure 2 shows the temperature rise curve of the new Bearing No.2 during its continuous operation. The figure shows that, the highest stable temperature of the new bearing was 45□,which is 25□ higher than the room temperature and well in line with specific standard.

Since the measures taking, the new bearing has been in good operation, which justifies the analyses on the heating of the No.2 bearing and measures taking.

## References:

[1] GU Shi-qiang, "*Installation and Maintenance of Metallurgical Machinery*", Design & Research Institute of Wuhan Iron & Steel;

[2] GAO Zhe-yuan, "*Machinery Engineering"*, Northeast Technical College;

[3] XU Hao, "*Machinery Engineering Manua*l", China Machine Press;

[4] ZHANG Shu-chi, "*Machinery Maintenance Engineering"*, Shenyang Institute of Gold Technology;

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