Analysis of Vibration Influencing Factors of High Precision Cylindrical Roller Bearing by Poor Information (PartⅡ: Experiment)

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Abstract. The vibration of high precision cylindrical roller bearings is affected by many factors, which belongs to the problem of poor information. The experimental results show that the main factors influencing the vibration of the experimental bearing are the clearance, the roller convexity and roughness, the inner ring waviness and roughness, and the inner and outer ring flange roughness.

Introduction

High precision cylindrical roller bearings as precision mechanical components, have higher quality requirement than normal ones. As an important connection basic part of mechanical, the rolling bearing's quality is very significant and plays a very important role in the normal operation of the equipment. Many studies have been conducted on their quality [1-7]. Literatures [1-3] studied the bearing quality from the aspects of material, load, life. Literatures [4-7] used different methods to analyze all aspects of the bearing.

According to the poor information system theory [8, 9], a variety of mathematical methods are used, and then those obtained results are compared and analyzed according to the qualitative fusion principle [10] to obtain a common solution. This result is the major factor influencing the vibration velocity of the experimental bearing, namely the final solution of the problem.

Analysis of Influencing Factors

The research object of this experiment is the vibration problem of NJ203 type high precision cylindrical roller bearing. Through the experiment measurement, the parameters of the inner and outer rings and the roller are obtained, and the relationship between the parameters and the bearing vibration is studied by different methods. Qualitative fusion is used to find out the main influencing factors.

The 19 ring parameters, 16 roller parameters and 1 overall parameter of the bearing were selected as the research objects, and the ring parameters included 9 inner ring parameters and 10 outer ring parameters. The relationship between the parameters of the bearing and the vibration velocity of the bearing is studied by experiment.

In order to facilitate the study, the symbols and meanings used in the experimental study are shown in Table 1.

Table 1 Symbols and meanings

Symbol	Meaning	Component	Symbol	Meaning	Component
X_1	S_d	inner race	X_{20}	D_w (A)	roller
X_2	K_i	inner race	X_{21}	ΔLWs (A)	roller
X_3	S_{di}	inner race	X_{22}	bases runout (A)	roller
X_4	S_{if} (flange)	inner race	X_{23}	convexity (A)	roller
X_5	L_i	inner race	X_{24}	roundness (A)	roller
X_6	roundness	inner race	X_{25}	waviness (A)	roller
X_7	waviness	inner race	X_{26}	roughness (A)	roller
X_8	roughness	inner race	X_{27}	bases roughness(A)	roller
X_9	roughness(flange)	inner race	X_{28}	D_w (D)	roller
X_{10}	S_D	outer race	X_{29}	ΔLWs (D)	roller
X_{11}	K_e	outer race	X_{30}	bases runout (D)	roller
X_{12}	S_e	outer race	X_{31}	convexity (D)	roller
X_{13}	S_{ef} (flange)	outer race	X_{32}	roundness (D)	roller
X_{14}	raceway width	outer race	X_{33}	waviness (D)	roller
X_{15}	L_e	outer race	X_{34}	bases roughness(D)	roller
X_{16}	roundness	outer race	X_{35}	bases roughness(D)	roller
X_{17}	waviness	outer race	X_{36}	clearance	overall
X_{18}	roughness	outer race	Y_1	Low frequency vibration velocity	
X_{19}	roughness(flange)	outer race	Y_2	Intermediate frequency vibration velocity	
			Y_3	High frequency vibration velocity	

In Table 1, "A" represents the average of 11 rolling elements in a set of bearings, and "D" represents the difference between the 11 rolling elements in a set of bearings

The bearing vibration velocity of each frequency band is shown in Table 2

Table 2 The bearing vibration velocity of each frequency band [μm/s]

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Y_1	390	150	240	120	320	160	260	150	220	270	120	300	300	300	260
Y_2	400	280	240	170	320	260	220	260	410	180	260	240	320	180	300
Y_3	170	120	180	150	150	140	160	180	240	90	180	190	140	130	140

Continued table 2

Number	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Y_1	200	220	150	240	220	180	330	240	150	270	420	210	270	300	140
Y_2	210	290	170	150	270	180	240	380	170	300	320	240	300	310	230
Y_3	140	130	150	150	140	180	150	120	130	150	140	120	110	140	170

The remaining parameters affecting the measurement data are shown in Fig. 1

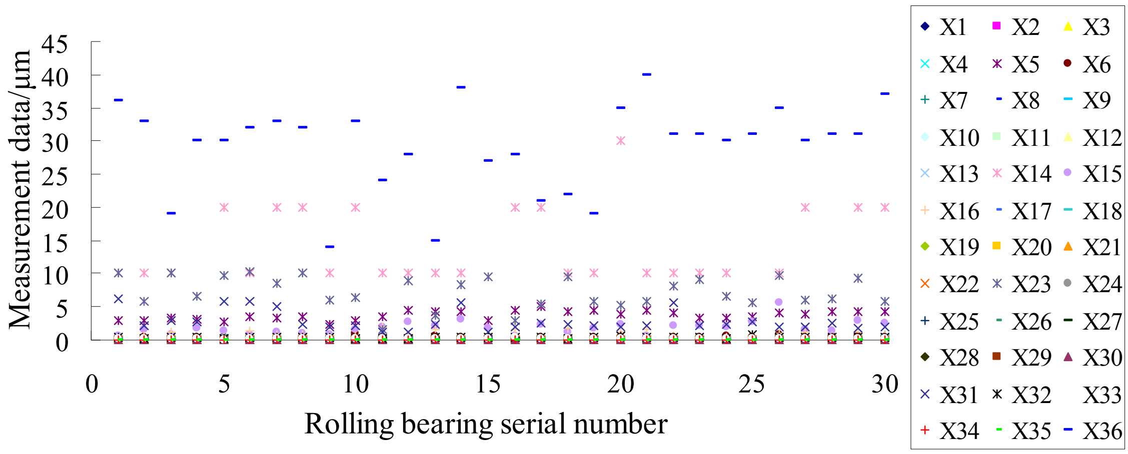

Figure 1. Finite The parameter data of each parameter

Calculation Result

The correlation degree of each method is sorted to obtain the correlation sequence, and the first ten parameters are taken as the research objects. The results of the correlation sequence of different frequency bands are shown in Table 3, 4 and 5.

Table 3 Influencing factors affecting low frequency vibration velocity

Method	Top 10 factors
Gray correlation degree	$X_{23}, X_7, X_{26}, X_{31}, X_9, X_{36}, X_{34}, X_{19}, X_8, X_1$
Absolute correlation degree	$X_{36}, X_{31}, X_{23}, X_9, X_7, X_{19}, X_8, X_{26}, X_{33}, X_{25}$
Relative correlation degree	$X_{12}, X_{23}, X_{31}, X_{34}, X_{19}, X_7, X_9, X_{36}, X_{26}, X_8$

Table 4 Influencing factors affecting intermediate frequency vibration velocity

Method	Top 10 factors
Gray correlation degree	$X_{26}, X_7, X_9, X_{23}, X_8, X_{36}, X_{19}, X_{34}, X_{31}, X_{25}$
Absolute correlation degree	$X_{36}, X_{31}, X_{23}, X_9, X_7, X_{19}, X_8, X_{26}, X_{33}, X_{25}$
Relative correlation degree	$X_{12}, X_{23}, X_{34}, X_{31}, X_{19}, X_7, X_9, X_{36}, X_{26}, X_8$

Table 5 Influencing factors affecting high frequency vibration velocity

Method	Top 10 factors
Gray correlation degree	$X_{26}, X_8, X_9, X_{25}, X_{36}, X_3, X_7, X_{33}, X_{23}, X_{24}$
Absolute correlation degree	$X_{36}, X_{31}, X_{23}, X_9, X_7, X_{19}, X_8, X_{26}, X_{33}, X_{25}$
Relative correlation degree	$X_1, X_8, X_{26}, X_{36}, X_9, X_7, X_{19}, X_{34}, X_{23}, X_{12}$

Result analysis

According to the qualitative fusion theory, the main factors affecting the vibration value of three frequency bands can be obtained by fusing the results of the different methods.

Table 6 qualitative fusion results

Vibration velocity frequency	Influencing factors
low frequency	$X_7, X_8, X_9, X_{19}, X_{23}, X_{26}, X_{31}, X_{36}$
intermediate frequency	$X_7, X_8, X_9, X_{19}, X_{23}, X_{26}, X_{31}, X_{36}$
high frequency	$X_7, X_8, X_9, X_{23}, X_{26}, X_{36}$

The main influencing factors of different frequency bands are compared and analyzed. The frequency bands and influence degree of the influence factors are shown in Table 7 and 8.

Table 7 Factors affecting the number of frequency bands

Number	Influencing factors	The number of frequency bands
1	$X_7, X_8, X_9, X_{23}, X_{26}, X_{36}$	3
2	X_{19}, X_{31}	2

Table 8 The influence degree of main influencing factors on vibration velocity

Number	Influencing factors	Degree
1	inner raceway waviness, inner raceway roughness, roughness (inner flange), convexity (A), roughness (A), clearance	Most
2	roughness (outer flange), convexity (D)	Secondary

From the table, it can be known that there are 8 main influencing factors, including 3 roller parameters, 3 inner ring parameters, 1 outer ring parameters, and 1 overall parameter. Considering only the quality of the parts, the weight ratio of the influence factors of the roller / inner ring / outer ring on the vibration velocity is 3/3/1.It can be seen that the influence of outer ring parameters is less than that of the inner ring parameters

There are 6 most important factors affecting the three frequency bands, including 2 roller parameters, 3 inner ring parameters and 1 overall parameter. Considering only the quality of the parts, the weight ratio of the influence factors of the roller / inner ring on the vibration velocity is =2/3.

In summary, under the measurement conditions, the biggest influencing factor of the bearing vibration velocity is the inner ring, followed by the roller, and finally the outer ring. This is because in the vibration velocity measurement process, the outer ring of cylindrical roller bearing is fixed, and the rotating shaft is connected to the inner ring. Both the flange of inner and outer rings have an influence on the vibration velocity of the bearing. This is because the main force of the cylindrical roller bearing during the vibration velocity measurement is the axial force, which is mainly conducted by the flange.

Summary

The results show that for the roller, the roller convexity and roughness average are the weak links of the bearing quality, which shows that the shape, size, quality and roughness of the convexity and the size of roughness have an important influence on the bearing vibration velocity. For rings, the inner ring waviness, roughness and roughness of the inner and outer ring flange are the weak links of the bearing quality. For the overall, the bearing clearance is the weak link of the bearing quality. Because these parameters can be controlled in the production and processing process of bearing, the control of bearing quality during the process of machining and assembly is achievable.

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