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Fusion Method of Median Estimate and Huber M Estimate on Dynamic Performance Variation of Ball of Rolling Bearing

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Keywords: fusion method of median estimate and Huber M estimate, dynamic performance variation, variation rate, unknown distribution and significance level, dynamic performance degradation

Abstract

Performance degradation of rolling bearing belongs to poor information on unknown distribution test data. It has an important impact for the reliability and safety of the running of mechanical equipment. The paper provides a method to assess dynamic performance variation of rolling bearing, which belongs to the field of performance degradation. Based on robustness theory and fusion theory, fusion method of median estimate and the Huber M estimate is proposed to analyze robust characteristics of the test data of rolling bearing. Attaining to intrinsic interval, variation rate, median and mean on robust data constructs assessment system of dynamic performance variation of rolling bearing on the basis of the method. For the analysis of vibration data of rolling bearings due to effect of different groove raceway damaging diameter of inner ring, results show the change trend of variation rate, median and mean on robust data of vibration is in agreement with change of groove raceway damaging diameter of inner ring. This shows that variation rate, median and mean on robust data of vibration can quantitative characterize dynamic performance degradation of groove raceway damaging diameter of inner ring on rolling bearing. Moreover, variation rate is 89%, in agreement with 0.7112mm on attaining to 89% diameter of failure condition. This shows that variation rate can effectively assess running condition of rolling bearings. This method does not require distribution types and significance level of test data. It provides a valuable solution for problems of test data of the unknown distribution and significance level. At the same time the method solves determination of boundary value of Huber M estimate in modern statistics. Evidence of the judge of dynamic performance degradation of rolling bearing is provided.

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Introduction

Research Status

Performance of rolling bearing mainly includes friction, wear, lubrication and temperature increasing, and mainly reflects index of vibration, friction moment and noise. Vibration index of reflecting dynamic characteristics, life and reliability of rolling bearing, are the results of accumulation of the errors of bearing manufacture, installation, and lubrication, and induces a primary concern of modern engineering and theory (XIA X, et al., 2007), then performance variation of vibration have an important impact for the performance degradation of rolling bearing, so study object of this paper is vibration of rolling bearing.

Vibration of rolling bearing is studied by time domain features (Srividya A, et al., 2009), neural network processing (Castejon C, et al., 2010) and spectral analysis (Antoni J., 2007), research results show that vibration of a rolling bearing is possess complexity, diversity, and do not have unanimous distribution function, how to assess performance degradation of rolling bearing is an important subject of bearings industry.

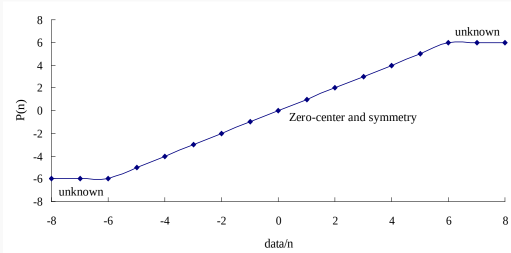
At present, there are many papers proposing various methods for performance degradation of rolling bearing. Electrostatic monitoring method is proposed to resolve performance degradation of oil lubricated rolling bearing (LIU R, etal., 2014); the EEMD and PCA method (XIAO S, et al., 2015), support vector machine and its fusion method with other method (Y Wang, et al., 2012; Z Shen, et al., 2012; H Wang, et al., 2014; B Zhang, et al., 2014) are proposed to analyze performance degradation of rolling bearings; according to the experimental specimen, the extracting characteristics (SU Y, et al., 2015; Zhang L, et al., 2014; ZHANG L, et al., 2015; Wang Y, et al., 2013) may recognize the performance degradation of rolling bearing; wavelet packet correlative band spectrum entropy (PAN Y, et al., 2014; Kang S, et al., 2014; Jiang, et al., 2012; Taha, et al., 2010), hidden Markov model (T Liu, et al., 2014) are proposed to solve the performance degradation assessment of rolling bearing.

However, time and frequency domain assessment of regarding the non-stable signal as the stable signal treatment, do not reflect the signal stability; wavelet of suitable for treating non-stable signal, only studies the low frequency signal; EEMD Method of processing the non-stable and nonlinear signal depend on the mean and the adding noise amplitude; the information entropy of reflecting the working state, do not eliminate the effect of odd point, at the same time these methods lack for the distribution function, or under hypothesis distribution, therefore, these methods do not well resolve the performance degradation problems of rolling bearing which is complexity, diversity, and unknown distribution, thus, based on robustness theory, the fusion method of median estimate and Huber M is proposed to assess dynamic performance variation of rolling bearing, expecting to provide a valuable solution for the problems of unknown distribution and significance level of test data.

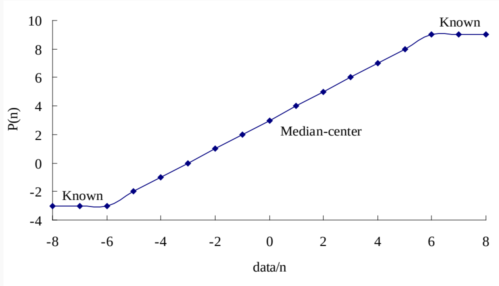
Theory Basis of Fusion Method of Median Estimate and Huber M Estimate

In modern statistical methods, robust data (P Razi, et al., 2011) can reflect intrinsic characteristics of test data, then, unsteady data may show variation characteristics of test data, so performance variation of a rolling bearing can be reflected by unsteady data. Therefore, robust theory is proposed to assess dynamic performance degradation of rolling bearing.

According to robust theory, the Huber M estimate and median estimate are the two optimal estimates under the min-max rule. The Huber M estimate requires that test data meet the linear, zero-center, symmetry, non-reduction and boundary value in fig.1-(a), but test data do not meet the above requirement, so Huber M estimate lack of practicality; median estimate can well reflect location features of actual test data, do not show the whole data characteristics, so fusion method of Huber M and median estimate in fig.1-(b) is proposed to solve robust problems of test data.



(a)



(b)

Fig.1 Comparison of Huber M estimate and fusion method of median estimate and Huber M estimate

Key problems of fusion method of Huber M estimate and median estimate is determination of boundary value, according to robust theory, median is robust, and mean is not robust due to the influence of discrete data, according to Huber M, median should equal to mean of robust data, so data which mean closes to median is thought more robust than data which mean is away from median, therefore the extent of mean closing to the median is regarded as the standard of data robust; when mean deviate median, data exist in unsteady data, and unsteady data is processed by Huber M estimate; based on modern statistics theory, significance level of fusion method of median estimate and Huber M estimate is 0~0.1, according to min value of mean closing to median, boundary value and significance level of data are determined.

Mathematical Model of Fusion Method of Huber M and Median

According to the above theory of fusion method of median estimate and Huber M estimate, the establishment of mathematical model is as follows:

(1). In the real-time monitoring process, suppose the original time series, which can be represented as a vector, outputted X by the measurement system is given by

$$X = \{x(t)\};\ \ t = 1,2\cdots N \tag{1}$$

Where, X is the vector of time series; $x(t)$ is the data vibration at time interval t; t is the time order, N is the total number of time interval.

(2). The drawing data of the i time phase in X constitutes the vector at moment t, X_i is given by

$$X_i = \{x_i(t)\};\quad t = 1,2\cdots N;\quad i = 1,2\cdots m \quad (2)$$

Where X_i is the vector of the i time phase; $x_i(t)$ is the vibration data of time interval t at the i time phase; i is order of time phase, m is the total number of time phase.

(3). In according to the order from small to big of the absolute value of the time series X_i, Y_i is given by

$$Y_i = \{y_i(n)\} \quad i = 1,2,\cdots,m,\quad n = 1,2,\cdots N \quad (3)$$

Where Y_i is the order statistics of X_i, $y_i(n)$ is the n data at the i time phase, n is data order, N is total number of data.

(4). Median β_i of Y_i

$$\beta_i = \begin{cases} y_i\left(\dfrac{N+1}{2}\right), N \text{ is odd} \\ \dfrac{1}{2}\left(y_i\left(\dfrac{N}{2}\right) + y_i\left(\dfrac{N}{2}+1\right)\right), N \text{ is even} \end{cases};$$

$$i = 1,2,\cdots,m \quad (4)$$

Where β_i is the median of i time phase.

(5). Robustness data series $Z_i(n_1,n_2)$

Suppose data $y_i(b)$ and $y_i(e)$ are two data of Y_i,

$$y_i(b) \le \beta_i;\ i = 1,2,\cdots,m \quad (5)$$

$$\beta_i \le y_i(e);\ i = 1,2,\cdots,m \quad (6)$$

The number of data from $y_i(b)$ to β_i is n_1, the number of data from β_i to $y_i(e)$ is n_2;

If $y_i(n) \le y_i(b)$, then

$$y_i(b) = y_i(n);\ i = 1,2,\cdots,m \quad (7)$$

If $y_i(n) \geqslant y_i(e)$, then

$$y_i(e) = y_i(n);\ i = 1,2,\cdots,m \quad (8)$$

And then, new data series $Z_i(n_1,n_2)$ is constituted by

$$Z_i(n_1,n_2) = \{z_i(n;n_1,n_2)\};\ i = 1,2,\cdots,m$$

$$n = 1,2,\cdots N \quad (9)$$

(6). Mean $\eta(n_1,n_2)$ of robust data series $Z_i(n_1,n_2)$

$$\eta_i(n_1,n_2) = \frac{1}{N}\sum_{n=1}^{N} z_i(n;n_1,n_2);$$

$$i = 1,2,\cdots,m \quad n = 1,2,\cdots N \quad (10)$$

(7). Difference absolute value $D_i(n_1,n_2)$ of median β_i and mean $\eta(n_1,n_2)$

$$D_i(n_1,n_2) = |\beta_i - \eta_i(n_1,n_2)|;\ i = 1,2,\cdots,m \quad (11)$$

n_1, $n_2$can choose in according to the specific requirements, in the paper

$$n_1 = n_2 = 1,2,\cdots,\frac{N}{2} \text{ or } \frac{N+1}{2}, n \text{ is even or odd} \quad (12)$$

(8). Boundary value $K_{i,1}$, $K_{i,2}$

$K_{i,1}$, $K_{i,2}$ are the boundary value, the series absolute difference $D_i(n_1,n_2)$ are attained in according to difference absolute between median β_i and mean $\eta(n_1,n_2)$ of equation (11), the $D_{i,min}(n_1,n_2)$ is the min value of $D_i(n_1,n_2)$, the corresponding $y_i(b)$, $y_i(e)$ are respectively $K_{i,1}$, $K_{i,2}$, namely

$$K_{i,1} = y_i(b);\ i = 1,2,\cdots,m \quad (13)$$

$$K_{i,2} = y_i(e);\ i = 1,2,\cdots,m \quad (14)$$

Therefore, n_1, n_2 are determined in according to $D_{i,min}(n_1,n_2)$.

(9). Intrinsic interval $[K_1,K_2]$

$$K_1 = K_{i,1};\ i = 1,2,\cdots,m \quad (15)$$

$$K_2 = K_{i,2};\ i = 1,2,\cdots,m \quad (16)$$

Thus $[K_1, K_2]$ and n_1, n_2 are determined in according to the above $D_{i,min}(n_1,n_2)$.

$$\alpha_i = (1 - \frac{n_1+n_2}{N})\%;\ i = 1,2,\cdots,m \quad (17)$$

α_i is the [0,0.1], α_i is the significance level of Y_i.

(10). Intrinsic interval $[\mu_1,\mu_2]$of the whole data

In according to $[K_1, K_2]$, $[\mu_1,\mu_2]$ are determined as following:

$$\mu_1 = \min K_1 = \min K_{i,1};\ i = 1,2,\cdots,m \quad (18)$$

$$\mu_2 = \min K_2 = \min K_{i,2};\ i = 1,2,\cdots,m \quad (19)$$

Thus, Intrinsic interval $[\mu_1,\mu_2]$of the whole data are determined according to μ_1,μ_2, the data out of the intrinsic interval $[\mu_1,\mu_2]$.

(11). Distribution function $P_i(t)$

$$P_i(t) = \begin{cases} y_i(t) & \mu_1 \le y_i(t) \le \mu_2 \\ \mu_2 & y_i(t) > \mu_2 \\ \mu_1 & y_i(t) < \mu_1 \end{cases};\ i = 1,2,\cdots,m \quad (20)$$

$P_i(t)$ is the distribution function, the corresponding interval $[\mu_1,\mu_2]$ is the intrinsic interval of the whole data, the data out of the intrinsic interval $[\mu_1,\mu_2]$ is named the variation data, these data mean data variation extent of Y_i.

(12). Variation rate v_i

$$v_i = \frac{n_{vi}}{N}\%;\ i = 1,2,\cdots,m \quad (21)$$

n_{vi} is the number of variation data, and N is the total number of test data, bigger v_i show more severe extent on variation property.

Experiment

Experiment design

Purpose of experiment is to test assessment results of fusion method of median estimate and Huber M estimate for dynamic performance degradation of a rolling bearing. According to the GB/T24607-2009 on life and reliability experiment rules of rolling bearings, when the peeling area is not less than 0.5mm^2, the rolling bearing should be regarded as failure condition. Assume that peeling area is circular, and then the diameter of peeling area on failure condition can attain to 0.798mm. Due to study performance degradation of rolling bearing, 0mm groove raceway damaging diameter of inner ring vibration data is chosen to be normal running condition. Meanwhile, 0.7112mm (attaining to 89% diameter of failure condition)is chosen to to be failure condition. Given the transition process from normal condition to failure condition, 0.1778mm and 0.5344mm are chosen to be transition condition. The 0mm, 0.1778mm, 0.5344mm, 0.7112mm groove raceway damaging diameter of inner ring can reflect performance degradation process of rolling bearings.

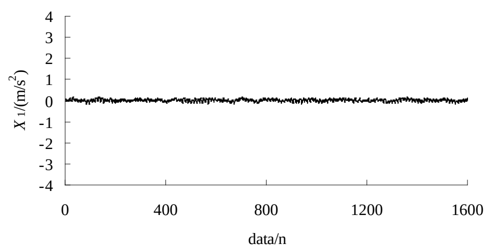
Test equipment and instruments

Test data come from website of data center of rolling bearing of Case Western Reserve University in American. The test center possesses a special experiment rig of simulating fault of rolling bearing, which include electric motor, sensor of twisting moment, decoder and testing meter of power.

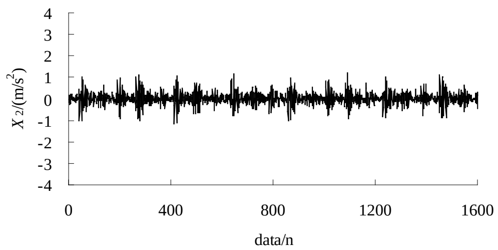
SKF6205 of pending detection support rotating shaft of electric motor, driving bearing is SKF6205, fan bearing is SKF6203, using acceleration sensor measure acceleration of SKF6205 of pending detection, driving speed is 1797r/min, the vibration data of different groove raceway damaging diameter of inner ring is obtained by 12 kHz sampling frequency, diameter of groove raceway damaging diameter of inner ring are 0mm, 0.1778mm, 0.5344mm, 0.7112mm. 0.03s is time interval of test data, 1600 vibration data were collected according to test requirement.

Data Analysis

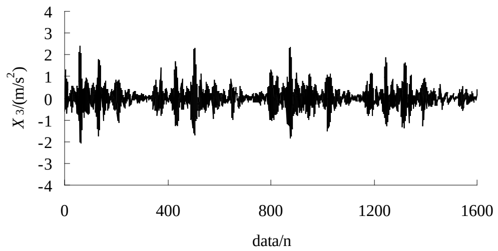
Vibration data of the different groove raceway damaging diameter of inner ring are simulated the vibration of the different time phase of rolling bearing, namely 1, 2, 3, 4 time phase, namely m=4, N=1600. The data see as follows fig.3, the vertical axis indicates the vibration data (unit: m/s^2); the horizontal axis indicates the number of unit time (unit: n).



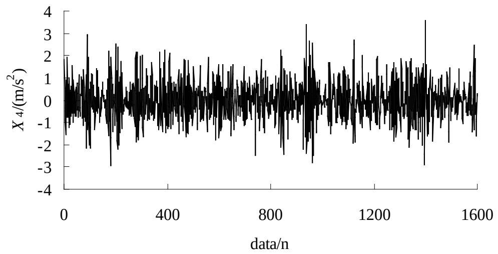
(a) First time phase



(b) Second time phase



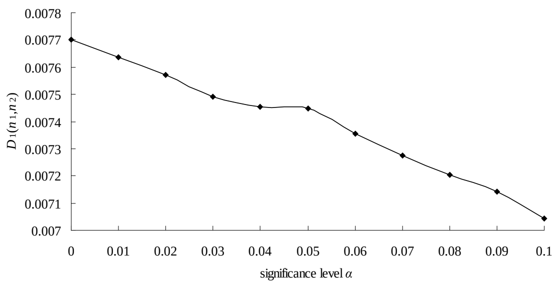
(c) Third time phase



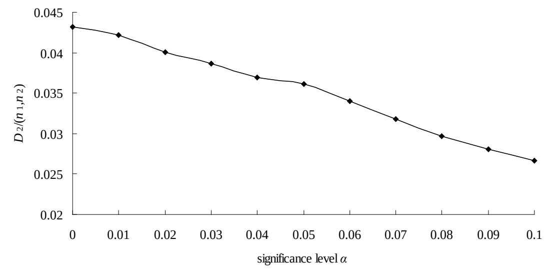
(d) Fourth time phase

Fig.2 Vibration data of rolling bearing of the different time phase

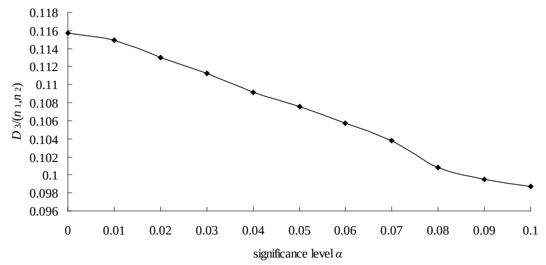
Fig. 2 shows the results of vibration of the different time phase, vibration range of time phase 1-4 have obvious difference that range of vibration increase with increasing of time phase, show performance of rolling bearing appear variation, at the same time, vibration of every time phase appear discrete vale(no robust data) which are bigger and smaller(piercing line), show performance of every time phase appear variation data, moreover with the increasing of the time phase, variation property of rolling bearing is more hard, in order to assess variation property of a rolling bearing, the data characteristics $D_i(n_1,n_2)$ of reflecting discrete data for every time phase in significance level within 0~0.1 are analyzed as follows fig. 3, vertical axis indicates absolute difference $D_i(n_1,n_2)$ of median and the mean based on fusion method. The horizontal indicates significance level within 0-0.1.



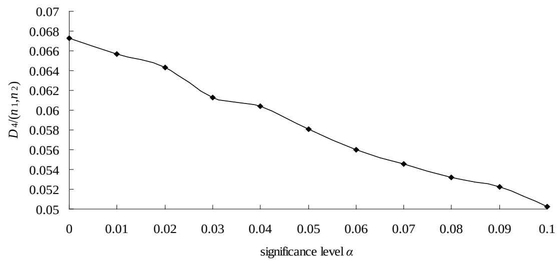
(a) First time phase



(b) Second time phase



(c) Third time phase



(d) Fourth time phase

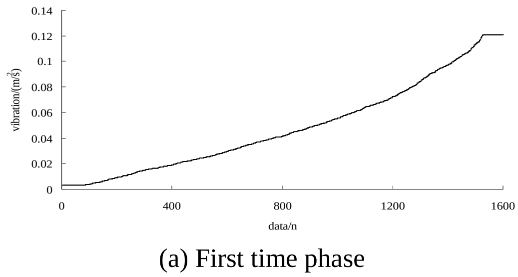
Fig.3. $D_i(n_1,n_2)$ of different time phase in 0~0.1 significance level

Fig. 3 shows the contrast results of $D_i(n_1,n_2)$ of different time phase (the absolute difference of median and mean) in 0~0.1 significance level. The absolute difference $D_i(n_1,n_2)$ of median and the mean of different time phase can reflect the effect degree of the part data for the whole data, the smaller $D_i(n_1,n_2)$ value show the corresponding data series have more robust, namely the data series can show the intrinsic characteristics. The similar characteristics of $D_i(n_1,n_2)$ of time phase 1-4 appear, namely $D_i(n_1,n_2)$ decreases with the increasing of significance level within 0~0.1, at the same time, order of the small to big of robust of vibration data of 1-4 time phase is 1, 2,4,3. According to minimum $D_i(n_1,n_2)$ theory, then significance level of the vibration data of rolling bearing of time phase 1-4 is 0.1, so range of robust data of vibration of time phase 1-4 can be attained according to $k_{i,1}$ and $k_{i,2}$ of corresponding data series of min $D_i(n_1,n_2)$, boundary value of time phase 1-4 and intrinsic interval of a rolling bearing are calculated according to equation (18-19) as follows table.1.

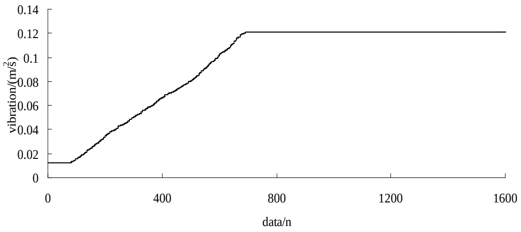
Table.1. Characteristics parameter of performance of rolling bearing

Time phase/i	Significance level	$K_{i,1}$/(m/s^2)	$K_{i,2}$/(m/s^2)	Intrinsic interval[μ_1, μ_2]
1	0.1	0.002921	0.120788	[0.002921, 0.120789]
2	0.1	0.012345	0.63106	
3	0.1	0.017056	1.106589	
4	0.1	0.037842	1.765539	

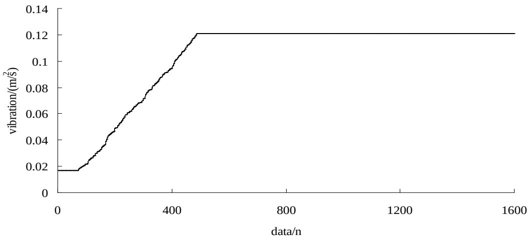
Table.1 presents the contrast results of the parameters of vibration data of rolling bearing, with the increasing of different time phase, $K_{i,1}$ and $K_{i,2}$ of boundary value increase show performance variation of a rolling bearing begin to appear and gradual deterioration. In according to $K_{i,1}$ and $K_{i,2}$, intrinsic interval of rolling bearing is [0.002921, 0.120789], the vibration data out of the intrinsic interval named the variation value, these data are instead by near intrinsic interval boundary value, the distribution function are obtained according to equation (20) as follows in fig. 4 according to equation(20). The vertical axis indicates vibration data. The horizontal axis indicates the number of different time phase.



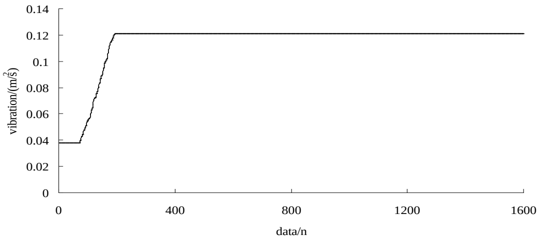
(a) First time phase



(b) Second time phase



(c) Third time phase



(d) Fourth time phase

Fig.4. Distribution function of different time phase of rolling bearing

Fig. 4 shows the distribution function of different time phase of rolling bearing, according to the distribution function, with the increasing of time phase, number of the minimum value is same, however, minimum value of different time phase increase with increasing of time phase; the number of the maximum value (which can be indicted by the directly line) increase; these show performance variation of rolling bearing is more hard with the increasing of time phase (service time). In order to further analyze dynamic performance variation of a rolling bearing, median and mean of different time phase of a rolling bearing are calculated as follows in fig.5.

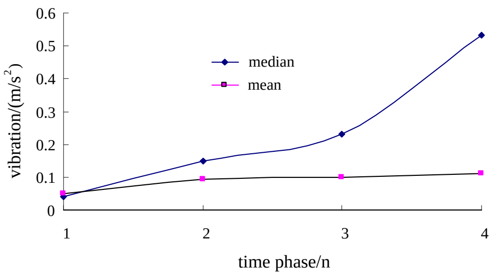
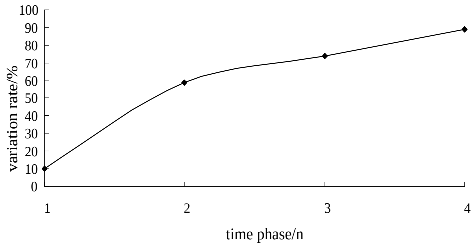
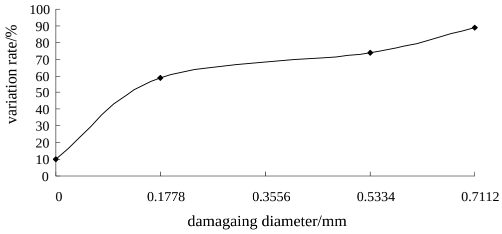


Fig.5 Median and mean of rolling bearing vibration on different time phase in fusion method

Fig.5 shows results of median and mean of robust vibration of rolling bearing of different time phase, trend of the median and mean of robust vibration data nonlinear increase with the increasing of time phase, the trend agree with the test results in fig. 3 show the median and mean value of robust processing of vibration data can reflect dynamic variation property of rolling bearing, in order to further analyze dynamic performance variation, variation rate of different time phase is calculated in according to equation (21), the result see as follows fig.6. The vertical axis indicates variation rate. The horizontal axis indicates time phase.



(a)



(b)

Fig.6. Variation property of the different time phases and groove raceway damaging diameter of inner ring of rolling bearings

Fig. 6(a) shows the results of variation rate of different time phase of rolling bearing, with the increasing of the time phase, the variation rate increase show that the variation rate agreement with vibration range of results of fig.3. At the first time phase, variation rate is only 10% show the running performance of rolling bearing is normal, rolling bearing do not easy appear fault; At the second time phase, variation rate increase 59% show the performance degradation condition begin to appear and the running performance is gradually worse; At the third time phase, variation rate is 74% show the performance degradation begin to deteriorate and the running performance is severe; At the fourth time phase, variation rate is 89% show the performance degradation condition continue to deteriorate and the running performance is failure. Fig.6(b) show the variation rate of different groove raceway damaging diameter of inner ring; agreements results of fig.6(a) and fig.6(b) can prove the assessing results agree with the actual working condition, illustrated that fusion method of median and Huber M can well assess dynamic performance variation of rolling bearing.

According to the classical statistics, the median and mean of different time phase are as follows fig.7.

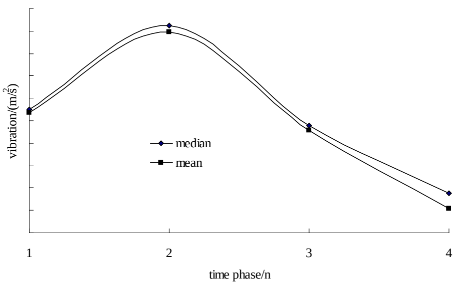


Fig. 7 Effect of median and mean of rolling bearing vibration on different time phase in classical statistics

Fig.7 shows results of median and mean of a rolling bearing vibration of different time phase in classical statistics, trend of median and mean of vibration data do not have the law with the increasing of time phase; obviously do not agree with fig.2. While fusion method of median estimate and Huber M estimate regard robust data of absolute value of test data as research objective, and reflect true working state of rolling bearing, contrasting with the results of fusion method in fig.8, results of fusion method of median estimate and Huber M estimate are better than the classical statistics.

Results and discussion

Results

According to the experiment, table.1, fig.6-8, the results of dynamic performance variation of rolling bearing show as follow table. 2.

Table.2 Characteristics parameter of dynamic performance degradation of rolling bearing

Working state	Intrinsic interval (m/s^2)	Characteristics parameter			groove raceway damaging diameter /mm
		Variation rate (%)	Median (m/s^2)	Mean (m/s^2)	
Normal running	[0.002921, 0.120789]	10	0.041515	0.048468	0
Initial fault		59	0.14798	0.092323	0.1778
Moderate fault		74	0.23147	0.10038	0.5344
Severe failure		89	0.532836	0.111156	0.7112

Table.2 present the results of characteristics parameter of dynamic performance degradation of rolling bearing in different working state, characteristics parameter of dynamic performance degradation of rolling bearing are composed to intrinsic interval, characteristics parameter (variation rate, median and mean) and groove raceway damaging diameter of inner ring, characteristics parameter (variation rate, median and mean) which are calculated by obtained experiment data and intrinsic interval based on fusion method may judge the working state and prognosis of groove raceway damaging diameter of inner ring according to table. 2.

Discussion

The aim of the research is to propose the assessing method of performance variation of rolling bearing. Fig.3 show results of closing extent of median and mean in significance level within 0-0.1, difference of $D_i(n_1,n_2)$ illustrate unsteady data indeed exists in test data, results of the fig. 3 and table.1 show fusion method of median estimate and Huber M estimate may help to improve the robustness and isolate the variation value of a rolling bearing, and attain the intrinsic interval of a rolling bearing; the results of the fig. 4, fig. 6(a) and fig. 6(b) show the variation rate may evaluate the performance variation and prove the validity and correctness of the evaluation; the results of the fig. 5 and fig. 6(a) show change trend of the variation rate, median and mean of robust processing may regard as characteristics parameter of performance variation of rolling bearing, because their trend are consistent with actual working condition of the fig. 2 and fig. 6(b); variation rate and mean of robust processing can reflect characteristics of the whole data, but trend of variation rate is obvious than mean of robust processing show evaluation results of variation rate are better than mean of robustness processing, median only reflect location features of data, so the result of variation rate is best than median and mean according to fig. 5 and fig. 6(a); dynamic performance degradation assessment are judged according to table. 2.

The method need not know distribution function, density function, significance level of test data, test data is directly processed by fusion method, and the distribution function and significance level are determined according to the closing extent of median and mean value. Therefore, boundary value is determined in according significance level.

In contrast to classical statistics and fusion method of Huber M and median, counteracting of positive and negative and continuous of test data make median and mean of 3, 4 time phase is smaller than 1, 2 time phase, results is paradox with test results in fig2 and fig7, show symmetrical characteristic of positive and negative of data of 3,4 time phase is better than one of 1,2 time phase, assessing method of classical statistics do not well solve problems of positive and negative of test data. While, fusion method of median and Huber M regard robust data of absolute value of test data as research objective, avoiding effect of positive and negative and continuous of test data, and reflect true working state of rolling bearing.

In addition, the method of this paper only present the results analysis of dynamic performance degradation condition and measure of the groove raceway damaging diameter of inner ring for vibration of rolling bearing, not involve to the noise, friction moment of a rolling bearing, and so on, the method possible cover the full range property research; the discussing significant level of the paper mainly are limit 0~0.1, the results of the other significance level are not be discussed, these problems is focus on objective for the author.

Conclusion

On the basis of robust process of the modern statistical methods, under the min-max rule, fusion method of median estimate and Huber M estimate are proposed to extract unsteady data from test data, and attain the intrinsic interval in according to the results of the fig. 4 and table. 1; the method provides a valuable solution to the robust problems of the unknown distribution and significance level of test data, and give determination method of boundary value which regard closing extent of median and mean of robust data as the standard of robust data; Variation rate of rolling bearing on fusion method can effectively assess the dynamic performance variation condition of rolling bearing in running according to table.2, which show that fusion method analyze the running condition and give a reasonable judge according to the results of the fig. 4, and fig. 6; Change trend of variation rate, median and mean of robust processing of rolling bearing vibration data based on fusion method is in agreement with the experimental result of the fig. 2, which can be regarded as characteristics parameters of dynamic performance degradation of rolling bearing; according to the results of fig. 5 and fig. 6. At the same time, variation rate of rolling bearing can assess service condition of rolling bearings.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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滾動軸承動態性能變異的中位數估計與 Huber M 估計融合方法

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摘要

滾動軸承性能退化屬於分佈未知的乏資訊系統，對設備運行的可靠性、安全性有重要的影響，本文提供一種屬於性能退化領域的滾動軸承動態性能變異評估方法。基於穩健理論和融合理論，中位數估計與 Huber M 估計融合方法被提出分析滾動軸承實驗資料的穩健特徵，獲取的本征區間、變異率以及穩健資料的平均值和中位數構建滾動軸承動態性能變異的評估系統。通過對滾動軸承內圈溝道損傷直徑對振動性能影響的資料分析，結果顯示變異率、穩健資料的中位數及平均值有與內圈溝道損傷直徑一致的變化，可以表明變異率、穩健資料的中位數、平均值可以定量的表徵滾動軸承內圈溝道損傷直徑的變化。而且，內圈溝道損傷直徑 0.7112mm 對應的變異率 89%和 0.7112mm 為失效條件的 89%一致，說明變異率能夠有效的評估滾動軸承的運行狀態。這種方法不要求實驗資料的分佈類型和顯著性水準，同事這種方法可以解決近代統計學中 Huber M 估計邊界值確定的問題，為滾動軸承性能動態退化的判斷提供證據。