Investigation on Inner Diameter Hard Grinding Technology of RN Wind Turbine Bearing

J.X.Xue[1, a], L.N.Wang[1, b], Y.Zhang[1, c] and F.Wang[1, a]

[1]College of Mechatronics Engineering, Henan University of Science & Technology, Luoyang, China

[a]xjx19652000@163.com, [b]wanglinazs@163.com, [c]zhangypds@163.com

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Abstract. The RN wind turbine bearings are difficult to machine as they are large and heavy. Thus the analysis of inner diameter hard grinding process is necessary. In this paper, the parameters related to machining quality were studied based on the grinding principle and experiments, and the optimized machining parameters were obtained, which verifying the reliability, and improve the qualification rate.

Introduction

With the rapid development of wind power, the scale of wind farm and the unit capacity increase in high speed. RN wind turbine bearing is one of the most important parts in wind power equipment [1]. Bearing quality directly determines the performance of the equipment [2]. According to the relevant wind power company, maintenance and replacement costs of the bearing are up to 4489 million CNY [3]. Inner diameter hard grinding is the key process to RN wind turbine bearing machining. Because the inner ring is too thick, the cooling and deformation are difficult to control. It is extremely urgent to research the parameters of manufacturing process.

At present, inner diameter hard grinding of RN wind turbine bearing generally use the traditional grinding method [4]. The Inner diameter of bearing is loaded and clamped by electromagnetic center-less jig. The grinding wheel works in the way of cantilever beam. The work-piece rotation axis changes with the differences of the actual size and geometry shape of the positioning surface.

Process analysis

In order to improve the machining quality of final bearing inside diameter, process parameters and influencing factors in inside diameter hard grinding process were analyzed systematically and comprehensively based on grinding principle and practical experiment as follows.

Selection of Grinding Wheel. The material of RN wind turbine bearing inner raceway was carburization and the most suitable kind of grinding wheel was white corundum abrasive with ceramic bond and 54 to 60 particle sizes. It can save costs and meet the requirements of roughness accuracy by using such a grinding wheel.

Dressing of Grinding Wheel. Diamond roller or diamond pen are the tools to dress the grinding wheel [5]. Fig.1 shows a diamond roller. As the grinding going on, cutting chips may fill the space among the abrasives in the grinding wheel gradually and the abrasives may lose the grinding and cutting ability. So the dressing of grinding wheel is especially important [6]. In the inside diameter hard grinding processing, since large RN wind turbine bearing only have the inner raceway, grinding wheel basically need be dressed once after grinding one work-piece. Dressing amount of the grinding wheel is about 5um every time and the grinding wheel have to feed the compensation size to ensure that the processing size of work-piece does not change.

Influence of Raceway Size. When the inner diameter allowance is 10um, related experiments need to be conducted to determine the values of the specific parameters. If the machining quality of raceway can not meet the requirements in the last procedure, it will directly affect the quality of the inside diameter hard grinding.

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Support Way and Support Angle. The support frame constrains the freedoms of the work-piece. It is very important to choose the appropriate support method to grind internal diameter. At present, the common used diameter grinding support way is "double floating supports" in the actual production. Support way of RN wind turbine bearing with 260mm diameter and 60kg weight should choose "four head floating supports". It will make the work-piece rotates in order to achieve self-positioning by using this floating support way with the friction torque caused by eccentricity. This way just avoids the phenomenon of redundant positioning caused by the positioning error so that the work-piece can be machined more stable and accurate. As is shown in Fig.2, support angles are fixed. The grinding force of work-piece by grinding wheel is in horizontal direction. Work-piece is pressed and grinded in horizontal direction of the support angle. The impact of supporting angle is not significant to the whole processing and it does not need to be adjusted during machining.

Fig.1 Diamond roller

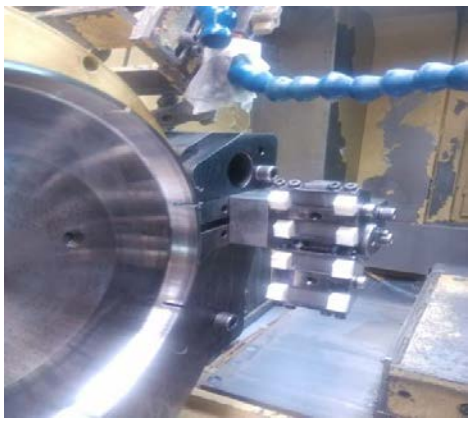

Fig.2 Support angles

Temperature Compensation. In the grinding process, grinding wheel is basically contacted with the ring in line or in surface. The contact area will be bigger when the ring width is large, so a great amount of heat will be produced and cooling will be very difficult. Although a lot of heat can be taken away by cooling fluid washing, for the wall thickness of the inner ring, the processing is completed. A part of heat cannot be dispersed and remains in the work-piece still. As a result, the work-piece dimensions change because of the "thermal expansion and cold shrinkage" physical phenomena. If without considering the heat expansion and cold contraction effects on size of work-piece after processing, the work-piece will have to be scrapped or repaired. Therefore, the forecast of the temperature compensation value is very important for different types of work-pieces before machining.

Grinding Parameters. In the hard grinding of RN wind turbine bearing inner ring diameter, working steps of processing are divided into coarse grinding one SR1, coarse grinding two SR2, coarse grinding three SR3, accurate grinding one SL1, accurate grinding two SL2 and Finishing. In the whole process, the work-piece accuracy influential parameters involved: feed speed, machining allowance of each step, allowance, the time of finishing, the speed of work-piece, the speed of diamond roller, support frame angle eccentricity and other parameters. In these parameters, the eccentricity and the support angle will directly affect the roundness of the work-piece. Diamond wheel speed and feed rate determine the shape of the grinding wheel and control the inner hole taper of the work-piece. Adjustment of diamond roller parameters indirectly controls the grinding surface of the grinding wheel. Together with work-piece speed, the work-piece surface roughness, waviness, twill, etc will be controlled. However, in the actual processing, the vibration pattern of the work-piece is most easily produced and difficult to be eliminated. If the vibration is serious, it needs to be measured again and the support angle has to be adjusted.

Experiment

Influence of the part width on the correction parameters when adjusting the taper of the inner diameter. Work-piece 1: width 85mm, inner diameter tolerance [-30, 0] um. The relationship of taper-adjustment is shown as Fig.3 by the relevant data. Work-piece 2: the width 185mm, inner diameter tolerance [-20, 15] um. The relationship of taper-adjustment is shown as Fig.4 by the relevant data.

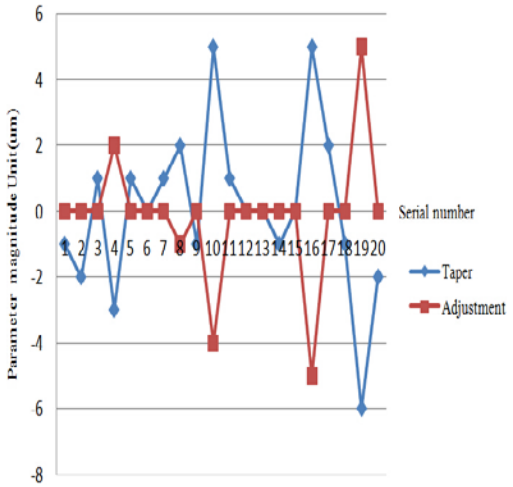

Fig.3 Taper-adjustment for work-piece 1

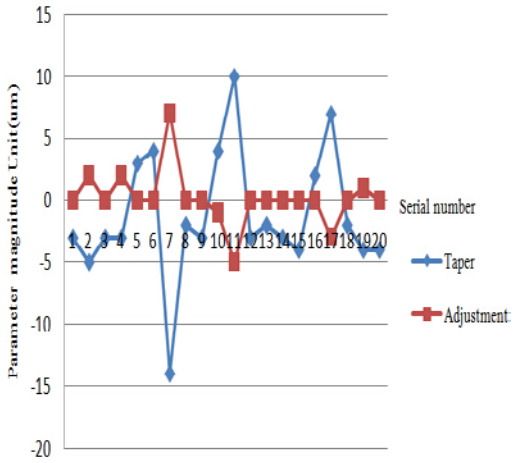

Fig.4 Taper-adjustment for work-piece 2

It can be seen from Fig.3 that the proportion is 1:1 between the taper values with the corresponding adjustment. It means that if there is 1 taper, the machine parameters of taper need to be adjusted with 1um.

It can be seen from Fig.4 that the proportion is 1:1 between the taper values with the corresponding adjustment. It means that if there are 2 taper, the machine parameters of taper need to be adjusted with 2um.

There are differences in the machine tools used in different companies. The numerical values of the corresponding taper adjustment are also different. But through the experiments, it can be proved that with the different width of the work-piece, taper need to be adjusted and the corresponding parameters should be different. When the work-piece width is larger, the corresponding taper-adjustment ratio is greater.

Feeding parameters determination of grinding wheel. This experiment object is RN wind turbine bearing with 260mm inner ring diameter. The experiment recorded 10 sets of adjustment data shown in Tab.1. The tolerance of the work piece is [-30, 0] um.

Tab.1 Parts processing parameters (um)

Test number	Raceway	Margin	Finished size	Correction
1	22	260	-15	-13
2	11	220	-18	13
3	21	270	-9	5
4	18	210	-15	-15
5	20	240	-18	-1
6	16	240	-19	3
7	10	270	-21	8
8	5	220	-20	-6
9	18	240	-18	-5
10	18	260	-10	10

From above ten sets of data, it can be seen that the tolerance of the next work-piece can be controlled in the range through the method introduced in the last chapter.

Experiment results. Through the production experience and a large number of processing parameters, the optimal grinding parameters of the RN wind turbine bearing with 260mm inner diameter can be obtained as shown in Tab. 2.

Tab.2 Grinding parameters

	Idle running			SR1			SR2		
	Min	Value	Max	Min	Value	Max	Min	Value	Max
Feedrate [um/s]	15	30	54	3.7	4.6	6.9	2.8	3.5	4.2
Margin [um]	64	80	96	182	227	272	108	135	162
Finishing time[s]	0	0	0	0	0	0	0	0	0
Rotating speed[rpm]	56	94	121	56	94	112	56	94	112
Magnetic	3	7	11	3	7	11	3	7	11
Dressing speed[um/s]				3000	6000	9000			

Tab.2 (Continued)

	SR3			SL1			SL2		
	Min	Value	Max	Min	Value	Max	Min	Value	Max
Feedrate [um/s]	3.2	2.9	3.5	1.4	1.8	2.1	0.7	0.9	1.1
Margin [um]	64	80	160	26	32	38			
Finishing time[s]	3	3	4	0	0	0	8	10	50
Rotating speed[rpm]	56	94	121	56	94	112	56	90	108
Magnetic	3	7	11	3	7	11	3	7	11
Dressing speed[um/s]				3000	5000	9000			

Combined with the actual production, the corresponding parameters affected by the yield of the work-piece are obtained and presented in the form of table. Because there are differences in machine tools used at each company, the data have only reference values for other bearings. But the corresponding principle and the law are the same. It has guiding significance for the actual production.

Conclusion

Through the analysis of the RN wind turbine bearing inner diameter hard grinding process, it shows that when the bearing inner ring diameter width is larger, the corresponding taper-adjustment ratio is greater. At the same time, the optimized grinding parameter values are obtained which can improve the product qualification rate. And longer life of bearings under the lower manufacturing costs will be achieved also.

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