ASIATRIB 2002International Conference
JEJU ISLAND, KOREA

Rotational Accuracy Measurement of Scroll Compressor with D-type Sectional Shaft

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This paper presents the measurement process of the rotational accuracy and the comparison with the theoretical results in the main bearing of scroll compressor. The main bearing is cylindrical oil journal bearing, but there are straightly cut used for oil supply. Therefore the roundness error is not a negligible quantity compared with the rotational accuracy. For this reason, three-point method is used in the experiment. The result of three-point method coincides with the theoretical value. So if the theory in this paper is used to the bearing design of scroll compressor, the efforts for testing and designing can be reduced.

Keywords : Rotational accuracy, Roundness error, Scroll compressor, Three-point method

1. INTRODUCTION

Recently, a bearing and shaft system supporting the compressor for refrigeration is required the miniaturization in structure, high performance and high reliability. To support the rotation of the compressor, journal bearing having high performance for rotational accuracy is used. The shaft supported in the journal bearing have straight cutting used for oil supply. So the section seems like the alphabet character D. But there is almost no information of rotational accuracy about this shaft. This paper presents rotational accuracy of scroll compressor shaft in journal bearing.

2. MEASUREMENT OF ROTATIONAL ACCURACY

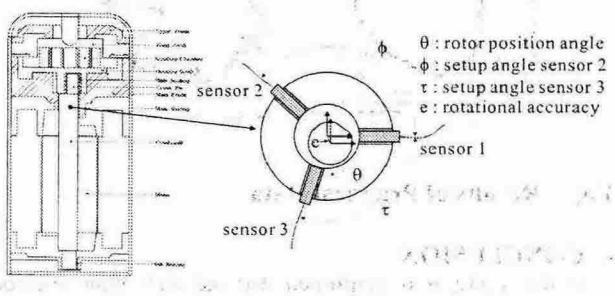

Fig. 1 Location of Sensors in Scroll Compressor

In the scroll compressor used in the test, a hydrodynamic thrust bearing and two hydrodynamic journal bearing are used. High pressure is generated in the scroll, therefore the reaction of high pressure is applied to these bearings. Among three bearings, the tested bearing is the main bearing under the thrust bearing. Fig.1 shows the locations of the main bearing and sensors in the scroll compressor. Two sorts of sensors can be used in this kind of test: eddy current sensors and capacitance sensors. A mix of lubricating oil, refrigerant flows in the gap of the shaft and sensors. The ratio of oil to refrigerant varies in the mix, so the capacitance sensor cannot be used in this case because its permissivity varies. The eddy current sensor was used in this experiment.

2.1 Constitution Elements of Measurement System

- Eddy Current Sensors(3EA) and Amplifier (Micro-Epsilon)
- PC with A/D Converter(PCL-818)
- Calibration tools and Digital Dial Gage
- Oscilloscope(Tektronix TDS-3012)

2.2 Calibration of Sensors

To measure a gap between the main bearing and the shaft more accurately, we made calibration tools same shapes with the main bearing and the shaft. Sensors were calibrated using the method seen Fig.2.

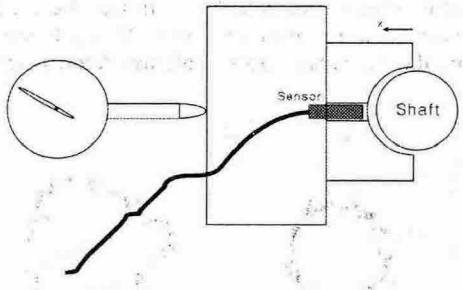

Fig. 2 Calibration of Sensors

The round area of the shaft limited a range of measurement voltage to the extend from 5V to 8V. The result of calibration is presented in Fig. 2. All sensors have the resolution of 0.026V/μm

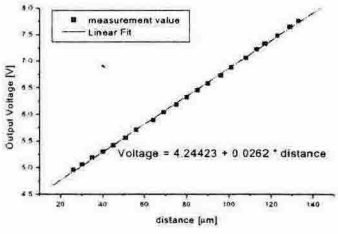

Fig. 3 Calibration Data

2.3 Measurement of Rotational Accuracy

We assumed that the shaft would be driven by a 3-Phase motor working at 60Hz. The number of data for a period is 256 for the FFT process. Then a sampling frequency was determined by the following term:

3(No. of sensors)×256(No. per period) ×60Hz = 46080Hz

After installation, exhaust pressure and a temperature of the compressor arrived at steady state, the data was read into A/D converter.

2.4 Processing of the measurement data

There is a cut part in the shaft. Owing to this shape, a pulse appears in the measurement data and generates errors in the three-point method. Nonlinear regression was carried out to decrease these errors. A theoretical data was generated to test an influence of the pulse. The theoretical data is the data of a sensor when a shaft with shape error 10μm, surface roughness 2μm and cutting width 14mm is rotating with rotational error 20μm. Fig. 4 shows the theoretical rotation data and the data produced by nonlinear regression.

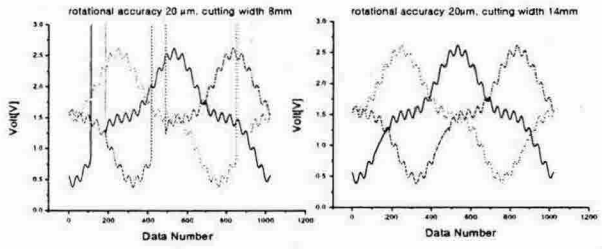

Fig. 4 Raw and Regression Theoretical Data

Rotational accuracy and roundness error of theoretical data without regression is given by Fig.5. If regression is not carried out, there are many errors with high frequencies in two graphs.

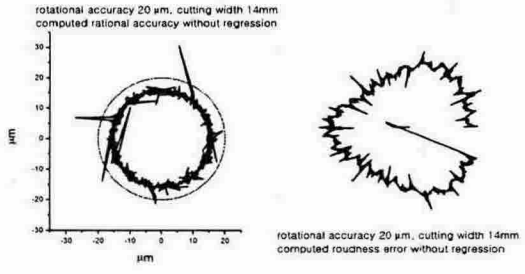

Fig. 5 Results of Theoretical Data without Regression

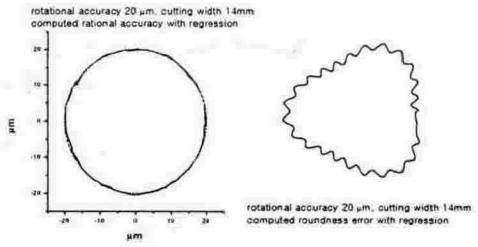

Fig. 6 Results of Theoretical Data with Regression

In Fig. 6, the errors for the results of data with regression is less than those of data without regression.

3. RESULTS

Fig. 7 shows the steady state data.

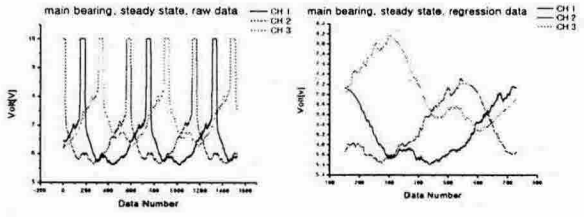

Fig. 7 Raw and Regression Practical Data

Fig. 8 shows rotational accuracy and roundness error in the steady state. In this diagram, clearance means the difference between the bearing radius and the shaft radius.

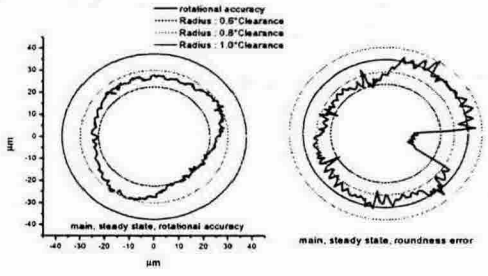

Fig. 8 Results of Practical Data

4. CONCLUSION

In this study, it is confirmed that the three-point method separates rotational accuracy and roundness error that the two-probe method has together. In the case, that the shaft has a cut part or a groove, a pulse breaks out and the sensor loses the information of rotational accuracy and roundness error when the sensor passes a groove. Because of this reason, regression was carried out in a pulse of the data to decrease a error produced by groove.

5. REFERENCES

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