Research on Roundness Error Evaluation Algorithm and Software Design

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Abstract: The roundness error refers to the variation of the ideal circle on the section perpendicular to the axis of the rotary body. The magnitude of the error value is directly related to the rotation precision of the hole shaft fit, the centering accuracy, and the reliability of the fastening connection. Roundness error is one of the important indexes for evaluating the shape accuracy of rotary parts. It is usually measured by a roundness meter. The national standard (GB/T 7235) specifies four roundness error assessment methods, namely least squares (LSC), minimum circumscribed circle (MCC) and maximum inscribed circle (MIC), and minimum area method (MZC). In the recently published standard of the International Organization for Standardization (ISO), the Geometric Product Specification (GPS), a new roundness error assessment method, the Chebyshev fitting method, has been added. Studying various roundness error evaluation algorithms and developing corresponding software is the primary task of automatic measurement of roundness error, which is very important for the design and modification of roundness instrument.

1. Introduction

Instruments are tools for understanding the world, and machines are tools for transforming the world. Transforming the world is based on the understanding of the world. The instrument is the tool and source for obtaining information. The quality and quality of the instrument directly determines the quantity and quality of the information. Large precision and precious instruments are important tools for the development, manufacture and quality control of mechanical products. The development of science and technology, first of all, the development of measuring instruments, the quality of the instrument will directly affect the quality of the product. The roundness meter is a high-precision instrument for measuring the roundness of the workpiece. The roundness meter plays a very important role in mechanical manufacturing and scientific research, and its application is also very extensive. In the 1970s and 1980s, Chinese universities and some enterprises imported a number of high-precision roundness meters from the United Kingdom, Germany and other countries. These devices have always played an important role. However, with the passage of time, the related circuits and supporting computers of these high-precision roundness meters are seriously aging, the faults are increasing, and the technical backwardness is becoming increasingly prominent. The key components of the roundness meter are the spindle and sensor of the instrument, but both parts are durable precision parts and still maintain high precision. If the entire instrument is idle because of the failure and damage of the electrical part, it will be a great waste.

2. Roundness measurement method

With the deepening of the industrial revolution, machines are becoming more and more widely used in people's production and life. The widespread and extensive use of machines has led to an increasing demand for parts, especially for the most common rotary body parts, the shaft. At the same time as the quantity demand increases, more and more requirements are put forward for its quality. Therefore, quality evaluation parameters such as roundness error are proposed. The roundness error refers to the amount of variation of the contour on the section perpendicular to the axis of the rotor to its ideal circle. Commonly used roundness error measurement methods are: two-point measurement method, three-point measurement method and radius change measurement method (central rotation method).

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The two-point measurement method and the three-point measurement method are abbreviated as two-point and three-point methods, and belong to the characteristic parameter measurement method. The characteristic parameter value measured at two or three points is used as the roundness error value, but there is a certain difference between it and the actual roundness error. Despite this, the method is still applicable in the actual production process because of its simple equipment and convenient measurement. The three-point measurement method is a measurement method performed between two fixed measurement supports and an indicator probe that can move in the measurement direction. In the measurement, point or line contact is often used for positioning support. If the outer surface is measured, a smaller radius ball support or short cylindrical support is preferred; if the inner surface is measured, a smaller radius ball support is used. When measuring by the three-point method, the part to be tested can be placed on the V-shaped block or other measuring device. The axis of the part should be perpendicular to the measuring surface, and the axial position of the part should be fixed. During the measurement, the measured part can be rotated, or the measuring device can be rotated, and the roundness error is reflected by the displacement change of the pointing probe relative to the measured contour during the one-time rotation of the measured part in the measuring device. During the measurement, the part to be tested does not rotate around the fixed axis, and its center of rotation changes at all times, so the indication value of the indicator is not the amount of change in the radius of the measured contour, and the difference between the maximum and minimum indication values of the indicator is not necessarily Equal to the roundness error value. The relationship between the measured value Δ and the roundness error value f is determined by the reflection coefficient F. This coefficient is theoretically the ratio of the measured value to the actual roundness error, which reflects the degree to which the measured value is enlarged or reduced for the actual roundness error value.

The path change measurement method refers to comparing the actual measured contour with the ideal circle to measure the change amount of the actual measured contour radius, and then processing the data to obtain the roundness error value. When measuring, the ideal circle is formed by a trajectory of a moving point about an axis of equidistant slewing motion, which can be embodied by an indexing device or a roundness meter. The roundness error of a general precision part can be measured in polar coordinates on an indexing device such as an indexing head and an indexing table. When measuring, the rotary axis of the indexing device is used as the measurement reference, so the axis of the measuring part should be adjusted as much as possible to the position coaxial with the rotary axis. Measuring the roundness error of the hole on the indexing table, using the end face of the tested part to locate; measuring the roundness error of the axis on the indexing head, the common axis of the two top points of the indexing head is parallel to the flat plate, for the axis class The measuring part is positioned with the center hole at both ends thereof, and for the tested part with the hole, it is positioned with the center hole at both ends of the mandrel which has no clearance fit with the hole. Then, the probe of the indicator is brought into contact with the measured profile, and the indexing device drives the component to be tested to rotate; when the indicator value is adjusted so that the indexing device has a value of 0°, the indicator value is zero. Then, according to the specified layout method (usually using even-numbered uniform points), the indexing device is rotated, and each measuring point is measured in turn, and the measured part is measured at a certain angle on the indexing device, and the corresponding radius change is measured. .

The roundness meter has two types of sensor rotation and table rotation. The structure is shown in Figure 1.4 and Figure 1.5, respectively. When measuring with a sensor rotary roundness meter, the part 4 to be tested is placed on the table 5 and fixed. The spindle 1 of the instrument drives the sensor 2 and the probe 3 to rotate. The instrument spindle is rotated around an ideal axis. When the instrument probe is in contact with the actual measured contour, the probe makes a corresponding radial motion as the actual measured contour radius changes, reflecting the actual measured contour radius variation. Since the workpiece is fixed on the worktable during measurement, it not only makes it have strong bearing capacity, but also is suitable for measuring heavier parts. Moreover, the rotation precision and service life of the spindle are not affected by the workpiece load, so high rotation precision and comparison can be guaranteed. Long service life. When measuring other related geometrical errors with a roundness meter, since the sensor is fixed on the main shaft, the position of the sensor relative to the workpiece is not easily changed arbitrarily, and several sensors cannot be used for measurement at the same time. These measurement bands for perpendicularity and coaxiality are used. It is difficult. Therefore, the sensor rotary roundness meter has a single measurement function and is difficult to expand its function.

3. Roundness assessment procedure test

The accuracy of the calculation results is an important indicator of the evaluation process. The following is a test of the accuracy of the roundness assessment procedure to verify that the program calculations are reliable. The center of the least squares is (1.32735, 1.05502) in μm. The center of the least squares given in is (1.327, 1.055) and the unit is also μm. Comparing the two results, the deviation of the two results is due to the difference in the number of significant digits taken from the calculation. Therefore, the results can be considered to be consistent. The evaluation center coordinates, the roundness error value obtained by the least square method, the maximum inscribed circle method, the minimum circumscribed circle method and the minimum area method for evaluating the roundness are shown above, and the enrollment of the enlarged concentric ring to the measurement point is shown. . The graphic display can judge that the maximum inscribed circle and the minimum circumscribed circle program evaluation result meet the triangle criterion of the tangent circle discrimination, and the obtained roundness error value satisfies the evaluation requirement graphic display. It can be seen that the minimum area ring satisfies the cross criterion; The roundness error value is the smallest among the four evaluation methods.

In, the application of AutoCAD software to evaluate the data of a set of 12 measuring points is presented, and the results are compared with the results of the programmed program. The results of the least squares method and the minimum area method for referring to this set of data in the literature are 3.973 μm, 3.5 μm, and the least squares program and the minimum area method are evaluated as 3.938 μm, 3.5 μm. Example 1 inrefers to a set of data in, which is 25 points of measurement data measured by a coordinate measuring machine, and the result is 29.28175 μm. The data compiled by the minimum area method is used to evaluate the data. The result is 0.02928017478mm; the small difference between the two results is due to the difference in the accuracy of the data types used in the program. Example 4 evaluates a set of 24 points of three-coordinate measurement data with a rating of 38.231 μm; the program is evaluated by the minimum area method and the result is 0.038230945 mm. It can be seen from the comparison of the above evaluation results that the results obtained by the various algorithms for evaluating the roundness error are accurate. Robustness is also called robustness (Robust). It is the key to program survival in exceptional and dangerous situations. For example, if the program enters an error or special input, can it not crash, not crash, this is the robustness of the program. Here, it refers to whether the programmed algorithm can process arbitrary roundness measurement data. In order to verify the robustness of the program, a set of analog measurement data with a center coordinate of (x0, y0) and a radius length of R+r is randomly generated; wherein x0, y0 and r are random numbers greater than -1 and less than 1. If a roundness evaluation program is added to the program loop, the roundness of the simulated data is evaluated, and the general data is used to evaluate the normal result and enter the next cycle; if the evaluation program cannot process the simulation data generated by the current cycle, an infinite loop occurs. Can't enter the new loop. You can add a data saver before the assessment process and save the data before the assessment process is performed. In this way, you can use the single-step execution to verify the vulnerability of the assessment program and modify the program. After testing, the least squares method, the maximum inscribed circle method, the minimum circumscribed circle method and the minimum area method can be continuously cycled for 30 minutes without an infinite loop; this proves that the program is robust.

4. Conclusion

This paper introduces the minimum circumscribed circle method and the maximum inscribed circle method in the roundness error evaluation method. Firstly, the evaluation principle and applicable occasions of the minimum circumscribed circle method and the maximum inscribed circle method are introduced. Then the criteria for the minimum circumscribed circle and the largest inscribed circle are given. The minimum circumscribed circle algorithm and steps are introduced in detail. The maximum inscribed circle method is the heart-shifting algorithm. Finally, the differences between the two methods of the centering algorithm are compared, the program flow chart is drawn, and the tangential circle evaluation procedure for roundness error is designed.

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