Research and Application of Laser Ranging Method in Form and Position Tolerance of Precision Machining Products

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Abstract. Precision measurement of shape and position tolerance plays an important role and significance in manufacturing industry. It is an important link to measure and guarantee the quality of manufacturing. Especially for large-scale precision parts, the repeated use of measuring tools easily leads to measurement errors. Aiming at the problems of low detection efficiency, complex process and high cost of high precision three-coordinate measuring instrument for large-size parts, the characteristics of contact measurement and non-contact measurement for large-size parts are studied based on the characteristics of large-size parts. A measurement method combining laser ranging with reflective target is proposed, and a rotating shaft for fixing laser launcher is designed. A complete spherical coordinate measuring system is constructed, which is applied to the measurement of straightness, flatness, parallelism, verticality and height difference of large-scale precision machined parts. Measurement results are obtained in a constant greenhouse. On this basis, under the same temperature conditions, the same shape and position tolerance dimensions of the same part are measured by a three-coordinate measuring instrument. Comparing the results of measurement, it can be seen that the measurement results obtained by the two methods are the same in the range of 0.001 mm, and the measurement efficiency and cost of the laser ranging method have obvious advantages. This paper also gives the method of measuring the shape and position tolerance of large-scale precision parts.

1. Introduction
Optical rangefinders are widely used in topographic surveys, battlefield surveys, ranging of targets by tanks, aircraft, ships and artillery, and measuring the altitude of clouds, aircraft, missiles and satellites. It is an important technical equipment to improve the accuracy of high tanks, aircraft, ships and artillery[1]. As the price of laser rangefinder is decreasing, laser rangefinder is gradually used in industry, which can be widely used in industrial measurement and control, mine, port and other fields[2].

There are some errors between the results of any kind of detection and the real value, which is the accuracy of the detection.[3]. Laser range finder is an instrument that can measure the distance of target by modulating some parameters of laser. The measuring range of laser rangefinder is 3.5-5000 meters. According to the method of ranging, it is divided into phase ranging instrument and pulse ranging instrument. Pulse laser ranging instrument is to shoot a beam or a sequence of short pulsed laser beams to the target at work. The laser beams reflected by the target are received by photodetector elements. The time of laser beams from launching to receiving is measured by a timer, and the distance from the observer to the target is calculated[4]. The phase method laser rangefinder detects the distance by detecting the phase difference between the transmitted light and the reflected light.
when they propagate in space. Laser rangefinder is light in weight, small in volume, simple in operation, fast and accurate, and its error is only one fifth to one hundred of other optical rangefinders. With the improvement of manufacturing efficiency in manufacturing enterprises, the requirement of high efficiency measurement for product detection efficiency has been put forward accordingly. Accordingly, new measurement techniques and means have emerged, such as laser tracker measurement method[5], Laser Scanning Measurement Method [6]. The measurement accuracy and efficiency of large-size parts have been greatly improved by such technologies. In the past research, engineers and technicians converted the space dimension into plane dimension without the aid of coordinate measuring instrument, and realized the measurement of the space dimension of box parts by mathematical geometry method [7, 8]. In order to ensure the performance and installation accuracy of the whole machine, the key parts in the manufacturing industry are mostly manufactured in batches, while the traditional detection methods are mostly applied to the detection of single-piece products. Therefore, on the premise of ensuring the detection accuracy, the detection of the full-size accuracy of batches is undoubtedly the key problem to further improve the detection efficiency.

In view of this, this study takes the typical box parts as the research object, starting from the characteristics of large-size parts, studies the characteristics of contact measurement and non-contact measurement of large-size parts, and further improves the efficiency of product forming dimension detection.

2. Brief Introduction to Basic Theory

Laser tracker is an instrument which uses laser as ranging means and reflector target to form a complete spherical coordinate measuring system. It is also equipped with angular measuring mechanism rotating around two axes. Therefore, it can be used to measure stationary targets, track and measure moving targets or their combination in engineering. Its measuring principle is shown in Figure 1.

![Types of Laser Ranging](image)

Laser tracker is based on laser ranging, so it has certain ranging accuracy, but the position error of angle encoder with the increase of distance is also very large, so the tracker itself is mainly angular error. In the application of laser tracker, the influence of target on measurement accuracy can not be ignored. Usually the target is spherical in shape and has three vertical reflectors (CCRs) inside. If the corners of the three mirrors do not coincide with the center of the outer sphere or the three mirrors are not perpendicular to each other, errors will be caused. Therefore, the same mirror is recommended in the same measurement, and the mirror should not rotate around its own optical axis. Laser itself is affected by atmospheric temperature, pressure, humidity and airflow, so the compensation of atmospheric parameters is very important for the normal use of the instrument[9].

When measuring, it is necessary to select the measuring and projection datum, in which the measuring and evaluation datum or the projection datum of the mining point are as consistent as possible with the processing datum of the project under test, and the mining point covers all the areas under test as far as possible, and the distribution is symmetrical and symmetrical, so that the mining point which truly reflects the shape and position characteristics of the project under test should be determined according to the measuring position and measuring range. Point position. When the
processing datum can not be measured or the deviation caused by measurement reasons is large, the position equivalent to the processing datum can be selected as the measurement datum. The side head is always perpendicular to the measuring surface when the mining point is taken. In the construction and evaluation of tolerances of size and shape and position, the evaluation elements should be constructed with as many points as possible. The selected points should be distinguished and corrected, and the abnormal points should be deleted to avoid affecting the accuracy of measurement results. Target picking points should be used as far as possible in high precision measurement. When the target ball can not achieve part of the hidden position picking points, auxiliary tools can be used for picking points.

3. Requirements for workpiece placement in measurement process
The measuring surface of the workpiece should be clean, free of debris and oil pollution, and the position of the production point should be free of burrs and bumps. Under the condition of ensuring the laser coverage, the laser tracker should be as close to the workpiece as possible. When measuring in vertical direction, the accuracy loss of the tracker in distance should be reduced. The laser tracker should be placed as far as possible in the middle of the measured dimension of the workpiece, and the height of the turning center of the workpiece should be as close as possible to the laser. The laser emission point of the tracker is the same height. For workpieces with high measurement accuracy, they should be placed at constant temperature in the greenhouse after machining, and then begin to measure. The symmetry and uniformity of each measuring point relative to the laser emission point are ensured. When measuring the revolving workpiece, the revolving center line is as parallel or vertical as possible to the height direction of the laser tracker.

4. Measurement experiment process
In the process of height difference form and position tolerance measurement, height difference is the difference of elevation between two points, that is, the end elevation reduces the starting elevation. Research drawings clearly need to measure the height requirements, determine the datum level, in the software interface command, select the response elements and complete the naming. When measuring the unknown elevation points with the elevation measurement method, first measure the difference between the two points from the known elevation points, and then calculate the elevation of the unknown elevation points. The unknown point is higher than the known point, the difference between the two points is positive, and vice versa.

Verticality measurement: Verticality is position tolerance, verticality tolerance is the actual direction of the measured elements, and the maximum allowable variation between the ideal direction of the vertical reference phase. The elements of verticality are generally straight line and plane. The reference elements are generally planar, that is, given in the drawings, to limit the maximum allowable range of variation of the measured actual elements from the vertical direction.

Cylindricity measurement: Cylindricity measurement is the measurement of cylindricity error in length measurement technology. When measuring, the probe of the length sensor can measure some cross sections of the cylinder along the precise linear guideway, and can also make spiral motion sampling along the measured cylinder.

5. Conclusion
Precision measurement of shape and position tolerance plays an important role and significance in manufacturing industry. It is an important link to measure and guarantee the quality of manufacturing. Especially for large-scale precision parts, the repeated use of measuring tools easily leads to measurement errors. In this study, by studying the technical indicators and measurement methods of laser tracker, aiming at the problems of low efficiency, complex process and high cost of traditional measuring instruments for large-size parts, starting from the characteristics of large-size parts, the contact measurement and non-contact measurement methods for large-size parts are studied, and the measurement accuracy obtained by changing the measurement methods of courseware can be achieved.
In the range of 0.001 mm, the measurement method of shape and position tolerance of large-scale precision parts is given.

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