Application and comparative analysis on three dimensional camera measurement system in full size inspection of batch production parts

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Abstract. Box-type parts are the basic parts of general machines, they assemble the shaft, sleeve, gear and other related parts of the machine into a whole, so as to maintain the correct mutual position accuracy between the parts. Their complex forming structure, large matching dimensions and high precision requirements directly affect the accuracy, performance and life of the machine. Aiming at the problems of large size and low efficiency of single piece inspection for box parts, this paper takes the spindle box of horizontal lathe as the research object, simulates through virtual testing platform, puts several parts of the same box parts in a certain order, determines the appropriate angle and shoots batch parts placement model in many directions, and adopts three-dimensional method. The camera measurement system detects the full size of the same batch of products and obtains the test results. On this basis, the traditional laser tracking measurement method is used to detect and compare the randomly selected single spindle box. The comparison results show that the three-dimensional camera measurement method can detect the forming accuracy of batch box parts well under the appropriate position and photographic angle, and the full-scale measurement error can be effectively controlled within the technical allowable range. This study provides a preliminary basis for the three-dimensional camera measurement technology in improving the efficiency and accuracy of full-scale measurement of batch box parts.

1. Introduction
Digital precision measurement is an important part of mechanical manufacturing system and the basis of manufacturing quality evaluation. With the improvement of product design level and performance evaluation requirements, the application of integrated manufacturing of complex box parts in various products is becoming more and more common, and the evaluation method is also developing from static to dynamic evaluation. The inspection methods and efficiency of manufacturing qualification rate for complex box parts also put forward new requirements for the efficient operation of manufacturing enterprises.

Box parts are the basic parts of general machines. They assemble the shaft, sleeve, gear and other related parts of the machine into a whole, so as to maintain the correct mutual position accuracy between the parts. Their complex forming structure, large matching dimensions and high precision requirements directly affect the accuracy, performance and life of the machine. Therefore, the detection accuracy and efficiency of the forming dimension of complex box parts are also required. The traditional typical measuring tools have a high accuracy in measuring the forming dimension[1]. However, with the increase of the structure size, it is difficult for the traditional measuring tools to complete the measurement at one time, and they all need multiple overlapping detection [2], However,
this method increases the error of repeated measurement process of measuring tools, and it is difficult to accurately reflect the actual forming size of parts, so it is seldom used in the measurement of large-scale parts [3]. With the improvement of manufacturing efficiency of manufacturing enterprises, the requirement of high efficiency measurement is put forward accordingly for the detection efficiency of products [4]. New measurement techniques and means, such as laser tracker measurement method [5], laser scanning measurement method [6], have emerged, and the measurement accuracy and efficiency of large box parts have been improved. To a great extent. Aiming at the characteristics of complex structure, low processing and testing efficiency and high testing accuracy of box parts, Tian Peng studied in-depth on-machine testing technology of box parts based on features on the platform of precision boring and milling processing center developed by the project. By comparing the layout of testing points for typical features of box parts on-machine testing, he put forward a scheme for on-machine testing of box parts. A new method of locating points effectively improves the detection efficiency and accuracy of large box parts [7], it provides a good foundation for the research of other CNC machine tools. Hao Yonggang et al. realized the measurement of the space dimension of box parts [8,9] by using self-made special checking tools and mathematical geometry method without the aid of coordinate measuring instrument. With the rapid development of high-end manufacturing industries such as aerospace and military industry, in order to ensure the performance and installation accuracy of the whole machine, a large number of key components are manufactured by integrated manufacturing process, and all of them are produced in batches. The above-mentioned detection methods are mostly applied to the detection of single product, which is undoubtedly a high-speed and efficient production enterprise. Restrictive factors, therefore, on the premise of ensuring the detection accuracy, the detection of full-size accuracy of batch parts is undoubtedly the key problem to be solved to further improve the detection efficiency.

In view of this, this research takes typical box parts as the research object, applies the three-dimensional camera measurement system, carries out the research on the full-scale batch detection method of complex structure products, and further improves the efficiency of product forming dimension detection.

2. The measured parts and measuring principles
In this study, a rough processing product box (as shown in Figure 1) of a body is taken as the research object. The box parts have the characteristics of complex structure, hollow cavity inside, partition wall in the middle and uneven wall thickness. Because the dimension of the product after rough processing should be measured, the roughing allowance of the part is mainly as follows: wall thickness (+3 mm), aperture (+3 mm). The forming dimension of parts involves a large number of measurement characteristics of shape and position tolerance, which are mainly embodied in coaxiality measurement of two end holes, parallel hole system measurement, vertical hole system measurement, hole system position measurement, and many spatial dimensions are formed between hole system and hole system. Because there is no direct measuring instrument for space dimension, it is impossible to measure dimension with conventional measuring instruments, and even more it is impossible to read dimension data directly, which makes the measurement of space dimension accuracy and geometric tolerance of parts more difficult.

The three-dimensional photogrammetric system takes multiple photographs of the same workpiece from two or more positions of the same camera to obtain images from different angles of view. The three-dimensional coordinates of the measured points are obtained by calculating the position deviation between image pixels based on the principle of triangulation. The system can control the global measurement error within 0.02 mm/10, except that The key points can be used for coordinate measurement of large objects, and can also be used for the detection of holes, edges and corners. It mainly consists of professional digital camera, high-performance computer, system measurement software, non-coding reference point, high-precision calibration ruler and other basic components. The system measurement software is installed on a high-performance desktop or notebook computer. The coding reference point consists of a central point and a surrounding ring code, each point has its own.
The numbered non-coding reference point is a circular reference point, which is used to obtain the three-dimensional coordinates of the relevant parts of the measurement object. The high-resolution digital camera with fixed focal length interchangeable lens of professional digital camera has a scale as the proportion of the measurement results. It has a very precise reference point which has been measured to determine their length.

### 3. Measuring method

The measurement plan of this study is shown in Figure 3. The specific measurement steps are as follows:

**3.1. Prepare array of measured objects**

In this study, the batch products shown in Figure 1 were placed in the form of fee measurement facing down. Each time, 20 pieces were measured and placed in four rows, with five columns in each row. In order to ensure the accuracy of measurement data, it is necessary to place the measured batch box products on the array measurement tooling neatly, to locate each tested box parts on non-coding standard points, to place the coding points around the measured objects, and to ensure that all coding points are evenly distributed, to set the benchmark, to be measured.
3.2. Capture photos
Using the special fixed camera tooling specially designed for this batch product in this study, the high-precision camera in this instrument is fixed in the position above a certain distance from the measured object, and multi-camera stations are taken to take photos. In order to ensure the accuracy of the measurement results and facilitate system identification, the shooting angle should be ensured when taking photos. Because the angle between measurement and measured object is larger than a certain measurement angle, the fixed camera tooling has designed a tilt angle of 30 degrees. At the same time, more than five coding points are required in each photograph taken.

3.3. Point cloud computing and output
After collecting enough photographs for analysis and importing them into the system, the operation software of the three-dimensional photogrammetry system can calculate the whole picture taken, and finally get the measurement point cloud of batch image as shown in Figure 4.

3.4. Single component point cloud extraction
According to the navigation of the software interface of the measuring system, the point clouds of the fragrant parts of the batch parts calculated by the above three-dimensional photogrammetric system are segmented, and the point clouds of the individual parts are output one by one according to the segmented results. Then the three-dimensional digital module and the single point clouds of the box parts are simulated by the third-party data simulation software. Through the comparison simulation, we can get the full size test report of each foam module.
4. Comparative verification of measurement results

In order to verify the accuracy of the above batch measurement results, this study randomly selected one of the above 20 pieces, and manually inspected the whole size of the product one by one. Under the same equipment, the same person and the same measurement method, the box parts were tested one by one, and the results of the two tests were compared. The measured values of 15 key dimensions obtained from a random sample are compared with those obtained from batch samples as shown in Fig. 5. The deviation between the two measurements is shown in Fig. 6.

As can be seen from the above figure, the deviation between the key dimensions measured by the three-dimensional camera measurement technology and those obtained by the single-piece traditional measurement method is not large. With the increase of the basic size, the detection error of the batch detection method increases, but the maximum measurement error of the product is within (+0.2mm), which is acceptable. Within the design tolerance.
5. Conclusion

Aiming at the problems of large size and low efficiency of single piece inspection for box parts, this paper takes the spindle box of horizontal lathe as the research object, simulates through virtual testing platform, puts several parts of the same box parts in a certain order, determines the appropriate angle and shoots batch parts placement model in many directions, and adopts three-dimensional method. The whole size of the same batch of products is detected by the camera measurement system. The test results show that the three-dimensional photogrammetry system can be used for full-scale measurement of small-scale batch products. On the premise of ensuring the measurement accuracy, the method greatly improves the measurement efficiency and provides a practical basis for batch detection of the same series of products.

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