Application of the precision industrial measurement technology in geometric measurement

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Abstract. In recent years, for expanding the productivity and improving the market competitiveness, some methods are carried out, which include new technology, new process, new materials and so on, to constantly improve the precision of geometric measurement in the manufacturing field. In addition to this, a large number of the advanced manufacturing equipment has also been used. In the case of rich field experience, this paper mainly introduces the application of laser tracker, laser interferometer, joint arm type coordinate measuring machine, three-dimensional contour optical scanning measuring instrument in robot, automobile fixture, ground penetrating radar, special-shaped parts scanning and so on.

1. Introduction

Precision industrial measuring equipment has been widely used in aviation, aerospace, shipbuilding, automobile, machinery manufacturing, hydropower and other fields. Based on the use of laser laser tracker, laser interferometer, joint arm type coordinate measuring machine and three-dimensional contour optical scanning measuring instrument, this paper introduces the application of the above precision industrial measuring equipment in robot, automobile fixture, ground penetrating radar, special-shaped parts scanning and so on.

1.1. Laser interferometer

Laser interferometer is a high-precision, multifunctional measuring instrument with laser wavelength as the measurement standard, which is used to measure geometric quantities such as displacement, straightness and Angle[1]. It is the use of two single-frequency laser beam, or two with a small fixed frequency difference of dual-frequency laser beam, dry measurement instrument. The laser interferometer includes a laser head, an electric box (including a data transmission card), an optical component, a computer, an environmental parameter sensor, a measuring software, etc. The laser interferometer mainly used for machine tools, machining centers, coordinate measuring machines and other equipment detection.

1.2. Laser tracker

The measuring system of the laser tracker consists of a host machine and a reflecting target[2]. The host is composed of two mutually perpendicular Angle measuring systems through an interferometer or rangefinder to establish a spherical coordinate system. By controlling the movement of the reflection target of the ray tracker through the biaxial rotating driving mechanism, measuring the distance between the main engine and the reflection target at the same time, as well as the angular coordinates of these
rotating axes, determining the position of the target in the coordinate system, can measure the stationary
target, track and measure the moving target. The laser tracker measures distance using a built-in
interferometer or rangefinder. Some laser trackers have only one range measurement power, while others
have both. Different configurations make the laser tracker more sensitive to different error sources.

1.3. Articulated Arm Coordinate Measuring Machine
Articulated arm type coordinate measuring machine is also called portable three dimensional measuring
arm[3]. It is a coordinate measurement system based on rotary joint and rotary arm. The coordinate of
probe in the instrument coordinate system is obtained through coordinate transformation through the
Angle information measured by the Angle encoder at each joint. The measuring arm generally consists
of three joints, namely the shoulder, elbow and wrist. The probe is mounted on the last shaft, and the
measurement is achieved by manual operation.

1.4. Three-dimensional contour optical scanning measuring instrument
There are many kinds of 3D contour optical scanners. There are two kinds of projection grating and
hand-held laser line scanning[4]. Type optical scanner is the projection grating projection and grating
measurement methods, using sinusoidal grating projection and phase shift technique, the grating
projected onto a surface to be tested, due to the contour modulation of the measured surface, grating
shadow line will change, through the camera measurement and demodulation of the grating shadow line,
get full stripe space information and a striped cycle timing parameters of phase shift stripe get three-
dimensional coordinates of the measured surface discrete points. Based on the optical triangulation
method, the hand-held laser scanner projects the laser line to the object and forms the characteristic light
strip on the object surface. The characteristic light strip is collected by the camera, and the three-
dimensional coordinates of the discrete points on the light strip are obtained by using the principle of
the optical triangulation method.

2. Application Cases
Precision industrial measuring equipment has many uses. At present, it mainly carries out the testing of
robots, conventional fixtures and other non-standard length equipment. In precision industrial
production, manufacturing and other industries such as aerospace, railway industry, automobile
manufacturing and other industries, it has become an essential measuring tool.

2.1. Surgical robot
At present, there are various types of robots, including industrial robots used in industrial assembly,
pipeline robots that can replace manual inspection, as well as common sweeping robots and catering
robots, etc., as shown in Figure 1, the surgical robots we see.

Compared with the traditional spine surgery, minimally invasive spine surgery has the characteristics
of smaller wound, shorter postoperative recovery period, better postoperative results and higher quality
of life, which is the main development direction in the field of spine surgery. However, because the spine
is adjacent to the important nerves and blood vessels of the human body, the millimeter error will bring
disastrous consequences. Therefore, in the minimally invasive operation with small incisions, the
technology is required to be more precise and precise, and the movement is more stable, so as to prevent
the damage to the healthy tissues around the lesions. In addition, because minimally invasive spinal
surgery requires repeated positioning through intraoperative X-ray or intraoperative CT, doctors are
vulnerable to radiation injury, which affects their health, which also hinders the promotion and
application of minimally invasive spinal surgery.

The birth of minimally invasive spinal intelligent surgery robot can replace doctors’ surgical
operations under the radiation line, reduce the risk of surgery and the incidence of postoperative
complications, and also reduce the radiation damage to doctors, which plays a positive role in the further
promotion and application of minimally invasive spinal technology in clinical practice. In Figure 1,
 intraoperative navigation accuracy and surgical channel implantation accuracy were tested for the
minimally invasive spinal intelligent surgery robot developed by a company in Chengdu, which is of
great significance to improve the accuracy of surgery and further promote the minimally invasive spinal
technology in clinical practice.

![Test diagram of surgical robot](image1)

2.2. **CNC machine tool**
The fifth axis of CNC machine tools is known as the swing axis or cradle axis[5], ordinary machine
tools only X, Y, Z three straight axis and the fourth axis of rotation, equipped with the fifth swing axis
of high-precision machine tools are rare. In recent years, with the ascension of the domestic mechanical
processing technology and the demand of the market, the whole SiChuan province have many company
bought the five axis machine tool, the number increased year by year, to better serve customers, my unit
is equipped with detection of nc machine tool's fifth axis turntable and special tooling, on-site testing
services for users, and the successful completion of the testing task. Fig. 2 shows an illustration of a
machine tool tested with a laser interferometer.

![Testing diagram of CNC machine tool](image2)

2.3. **Vehicle welding fixture**
The welding fixture is the platform of all parts assembly of the body in white, and it is an important tool
to ensure the geometric dimension precision of the welding assembly of the car body, whose precision
has a great influence on the geometric precision of the body shell welded on it. In order to maintain the
precision of fixture and improve the geometric precision of car body, the measurement of fixture
precision is an important guarantee to ensure the precision of fixture. In daily work, if there is a fixture
locating element location deviation, positioning element wear and clamp the phenomenon such as clamping force is not enough, will cause the parts deformation, cause orientation deviation, parts clearance position due to the change, will eventually lead to increased stress and components assembly size error of deterioration, directly affect the precision of the white body, quality and safety. It can be seen that ensuring the precision of welding fixture is an important premise to reduce the deviation of the shape and size of the body in white and improve the manufacturing precision of the body.

Articulated arm coordinate measurement has a huge application space in the measurement of tooling and fixture. Fig. 3 shows the rolling mill measuring site schematic diagram.

![Fig.3 Schematic diagram of welding fixture test site](image1)

2.4. GPR
Ground Penetrating Radar (GPR) is a geophysical method which uses antenna to transmit and receive high frequency electromagnetic waves to detect the material characteristics and distribution in the medium. GPR was called a variety of things in its early days. Such as ground detection radar, underground radar, geological radar, pulse radar, surface penetrating radar, etc., all refers to the geological exploration target, the use of high frequency pulse electromagnetic detection of the internal structure of the geological target of an electromagnetic wave method. Because of the high precision, high efficiency and non-destructive characteristics of GPR detection, it is mainly used in archaeology, mineral exploration, disaster geology survey, geotechnical engineering investigation, engineering quality detection, building structure detection and military target detection and many other fields. Fig. 4 is a GPR detection schematic diagram, in which a laser tracker is used as the main standard to provide an accurate coordinate system for GPR.

![Fig.4 Schematic diagram of GPR detection](image2)
2.5. Workpiece scanning
Laser scanner plays an important role in quality control. Three-dimensional digital technology uses lasers to easily and precisely capture surface shapes. Originally used by the industry for quality control of geometric quantities and surfaces, it is now also used in reverse engineering, fitting and assembly processes. Figure 5 shows the scanning image of the on-site workpiece by the hand-held 3D laser scanner, and Figure 6 shows the scanning of the fabric texture by a projection raster optical scanner.

![Fig.5 Scanning measurement of special-shaped parts](image1)

![Fig.6 fabric texture scanning](image2)

3. Conclusions
The development of precision industrial measurement technology continues to promote the progress of the manufacturing industry, laser tracker, laser interferometer, three coordinate measurement system, scanner measurement system and other high-precision measuring equipment almost covers the needs of field geometric measurement, but also plays a more and more important role.

References
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