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Research Article

THE ISSUE OF DETERMINING THE GEOMETRIC POSITION DEVIATION OF THE THREADED HOLES

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ABSTRACT

The present article analyzes the specific measurement strategies (techniques) of contact measurement that are used to determine the position deviation of the threaded holes using 3D coordinate measuring system. Furthermore, there are analyzed direct and indirect (location gages) measurement techniques to determine position of the threaded holes and results of the measurements.

Keywords: coordinate measuring system, location gages, position deviation, threaded holes.

INTRODUCTION

All geometric elements of manufactured products are designed with tolerances, which are set for optimal utility, therefore, it is necessary to check threaded holes like all other elements of the component. A threaded hole has to be concentric to another feature, it need to be perpendicular to the another feature and need to be positioned in the relation with other holes or part features [1].

Internal threaded hole centers are not the easiest product feature to quantify. There are actually two axes directly related to in an internal threaded hole:

- the axis of the internal thread pitch diameter cylinder,
- the axis of the internal thread minor diameter cylinder.

The main feature that establishes the threaded hole axis is the thread pitch diameter cylinder. The internal thread pitch diameter cylinder axis may be independent and may differs from all other hole axes, except the internal thread major diameter cylinder axis. The internal thread major diameter cylinder will always be concentric with the thread pitch diameter cylinder because they are both cut with the same tool at the same time, but the internal thread major diameter is very difficult to measure [1].

The internal thread minor diameter cylinder axis is much easier to be located than the internal thread pitch diameter cylinder axis, but the center of the thread pitch diameter cylinder can be different from the axis of the internal thread minor diameter cylinder in any aspect (Fig. 1). This is because the internal thread minor diameter may have been manufactured with a separate cutting tool and even in a separate piece set-up. Typically, before the thread is cut, the internal thread minor diameter is machined along with other diameters located on the same center. Then the threading tool is inserted to cut the thread form. If the threading tool is a single point cutter or a threaded insert being machined in the same set-up as the minor diameter, the chance of the thread pitch diameter cylinder being concentric with the other diameters is high. If the thread was cut with a tap, a thread mill, or in a separate set-up, the thread pitch diameter cylinder may be different from the other diameters [1].

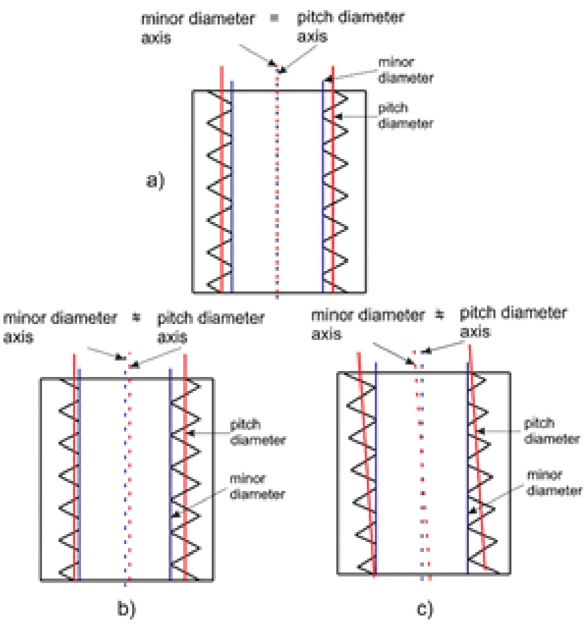

Fig. 1. Position and orientation of the threaded hole diameters axes: a) perfect thread, b, c) actual shape of threads

The use of threaded holes for fastener applications has common place in manufacturing. The location and orientation of the threaded hole is crucial in assuring that the fastener is properly engaged, so that failure of the fastener does not occur. However, measurement of the threaded hole true position is something that is taken for granted by many in industry. Often the techniques used make incorrect assumptions and or take shortcuts to save time and money [2-4].

The location of a theraded hole's axis is often incorrectly checked by putting a unthreaded gage pin into the hole's minor diameter. The gage pin is then probed for location only at the surface of the part. This method gives two-dimensional information about a three-dimensional feature, and it gives that information about the location of a point on the axis of the minor diameter rather than locating the entire axis of the hole's pitch diameter (which is what is required) [5-7].

Fig. 2. Drawing - Position tolerance of threaded holes

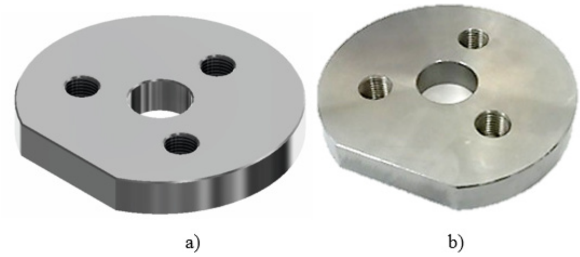

Fig. 3. The sample intended for the experiment: a) CAD model, b) manufactured sample

EXPERIMENT

For experiment was used circular sample (Ø90mm) with three threaded holes (M12x1,25) and one reference hole withe diameter of 20 mm (Figs. 2, 3). Sample material was steel ISO 683-1-87. To determine the position of threaded holes were used two measurment methods:

- direct method
- indirect method (threaded gages of various metrological quality),
- each method was consisted of a various measurment techniques.

For experiment was used spherical contact probe (Fig. 4). Sphere tip with diameter Ø6 mm was made from synthetic ruby, stem and extension from thermostable carbon fibers. As a touch scanning sensor was used VAST XXT (Fig. 5).

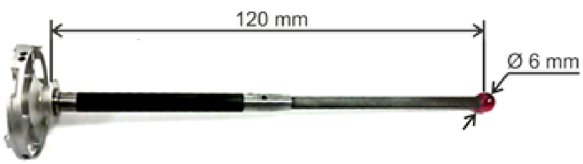

Fig. 4. Contact probe used for measurements

Fig. 5. Sensor VAST XXT by Carl Zeiss [8]

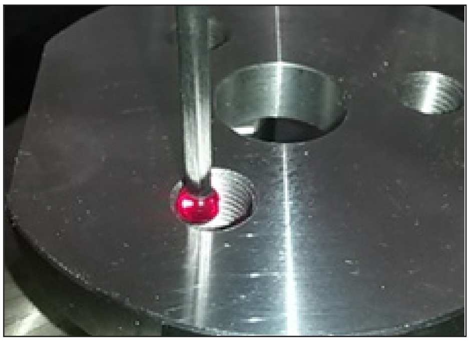

Fig. 6. Leading probe directly to the threaded hole and scanning

Direct measuring of threaded holes position

The basis of the direct method of measuring the position of the threaded holes was that the probe was led directly into the threaded hole (Fig. 6) and then were scanned the certain number of points on the non-functional part of the thread of a certain path. From these points cylinder by least-squares method was created. After that, the position of the axis of the cylinder to a reference hole was determined.

For direct measuring method there were used two measurement techniques:

- Spiral scanning
- Generating lines scanning.

Spiral scanning means that the probe goes into the bottom of the thread from which scanned points on helical path with thread pitch. The thread pitch was 1.25 mm and five turns were executed (Fig. 7).

The second measurement technique consist of scanning generating lines of the thread hole cylinder. For each hole five lines were scanned (Fig. 8). Cylinder was offset through the scanned lines (points) by software and its axis determined.

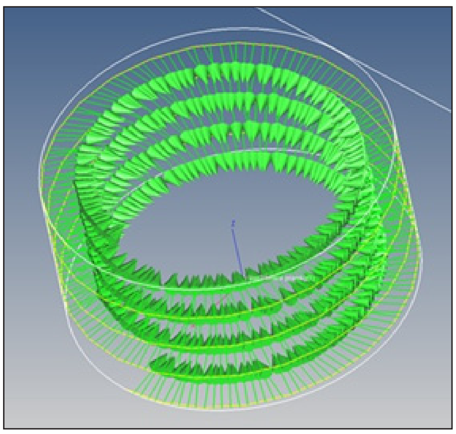

Fig. 7. Visual display of scanned points by spiral scanning

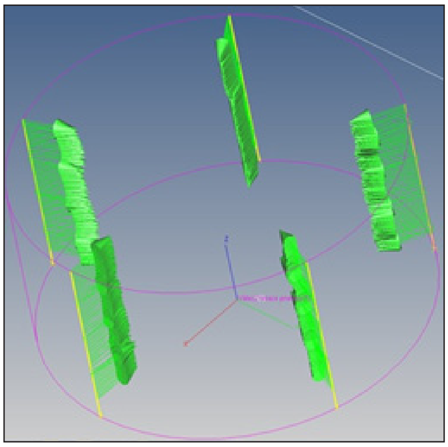

Fig. 8. Visual display of scanned points by generating lines scanning

With such measurment, we should pay attention to cleanness of the threads. Burrs and various other impurities after the production introduce errors in the measurement. These can be removed either by screwing screws into the corresponding threaded hole or by mechanical cleaning.

Indirect measuring of the threaded holes position – measuring with threaded hole location gages

Tapered threaded hole location gages were screwed into the hreaded holes (M12 x 1.25mm) and then we determined the position of the axes of these gages to the reference hole's axis.

There were two sets of solid tapered threaded hole location gages used (Fig. 9), each type from different manufacturer. The gages have a threaded part and a part designed to scanning. These parts are highly accurate and have guaranteed alignment.

There were two circles scanned on the location gages (Fig. 10). The cylinder was offset by these circles by last-square method. The axis of

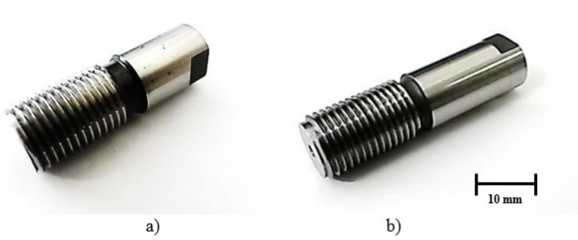

Fig. 9. Tapered threaded hole location gages: a) short, b) long

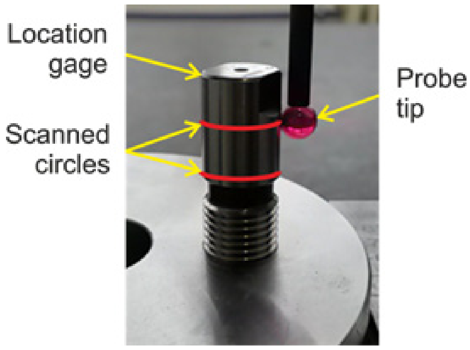

Fig. 10. Scanning of the two circles on the location gage

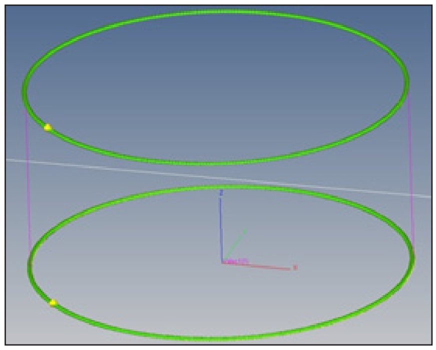

Fig. 11. View of the scanned points in Calypso 5.0 program

the cylinder represents the axis of the gage, and thus the threaded hole's axis.

These circles consist of exact number of points (Fig. 11), from which required position deviation of location gages was calculated to the reference hole by the software.

Two measurement techniques with set of short gages were used, the case of the scanned cylinder had height 3 and 6 mm.

With a set of long gages we used three measurement techniques, the case of the height of scanned cylinders was 3, 6 and 13.5 mm.

Each measurement technique was repeated 30 times and after each measurement the location gages were screwed/unscrewed in to the threads. Also, the gages changed the position in holes after each measurement.

Experiment evaluation

Mutual comparison of all used measurement techniques for threaded hole number 1 in terms of measured position deviation are graphically displayed in Figure 12.

The smallest position deviation is reached by the location gage with dislocation of the scanned cylinder and direct measurement techniques (0.1153 mm to 0.1249 mm). The position deviation is about 0,12 mm. Measuring without dislocation of the scanned cylinder had position deviation more than three times higher (0.3621 mm and 0.4304 mm).

A comparison of the measured position deviations of the threaded hole number 2 is graphically presented in Figure 13. The value of the position deviation obtained during the measurement technique on a long location gage without dislocation of the scanned cylinder was outside of the tolerance zone, more than one tenth of a millimeter (0.6167 mm). Values of other measurement techniques were in the desired position tolerance of 0.5 mm.

Mutual comparison of all used measurment techniques for threaded hole number 3 in terms of measured position deviation are graphically displayed in Figure14.

Outside the tolerance zone was the value of the position deviation for long location gage without dislocation of the scanned cylinder (0.6549

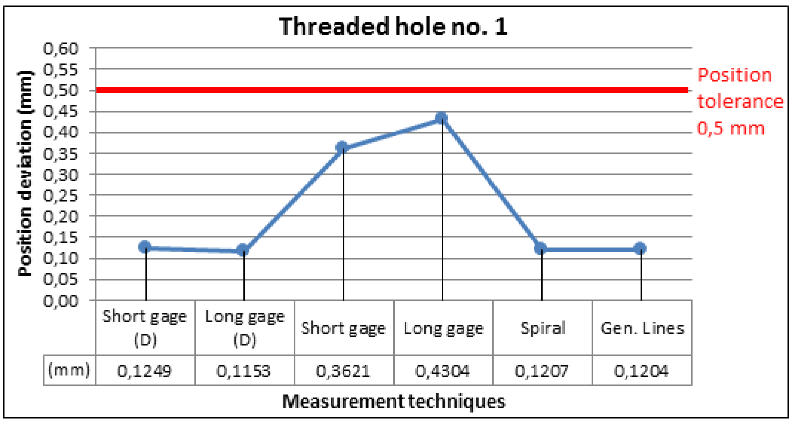

Fig. 12. Comparison of measured position deviatons by all measurement techniques for threaded hole number 1

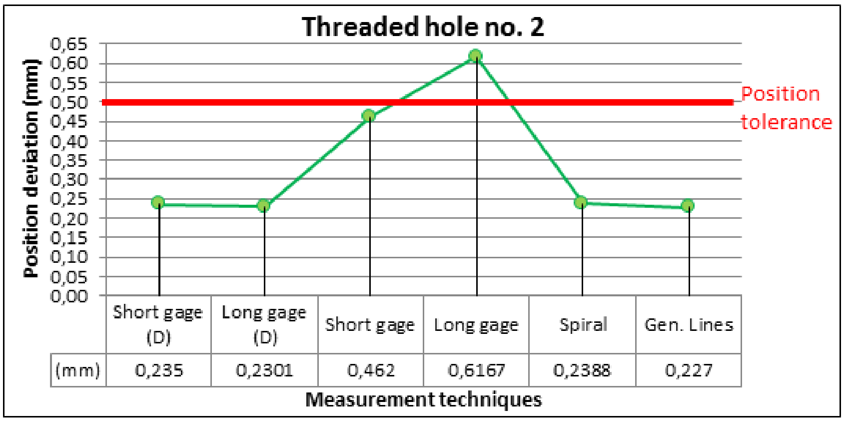

Fig. 13. Comparison of measured position deviatons by all measurement techniques for threaded hole number 2

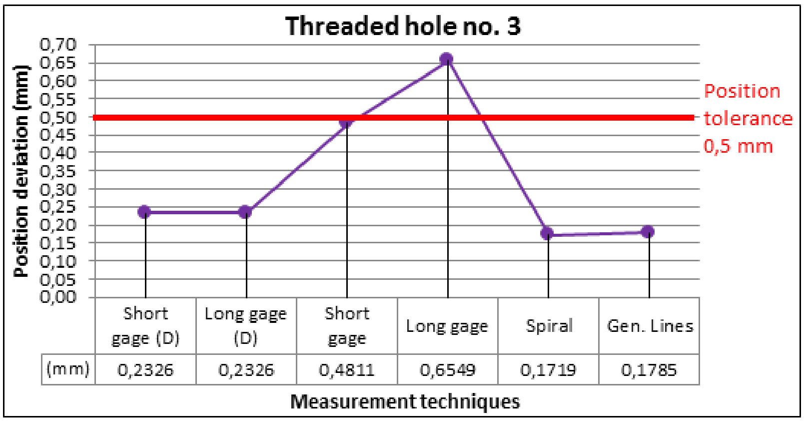

Fig. 14. Comparison of measured position deviatons by all measurement techniques for threaded hole number 3

mm). Short location gage has deviaton just below the position tolerance. The smallest position deviation has a direct measurement technique by a spiral scanning (0.1719 mm) and generating lines scanning (0.1785 mm). Measurement techniques using short and long location gages with dislocation had position deviation 0.2326 mm.

CONCLUSIONS

To determine position deviation of the threaded holes two methods of measurement were used – direct and indirect. Each method consisted of a certain measurement techniques and procedures. For indirect methods two different sets of tapered threaded hole location gages were used, which are screwed into the holes and their location was identified on a 3D coordinate measuring machine. Gage position represented the position of threaded holes.

The results of measurements with gages were not very differnt. The main difference occurred when using various position evaluation methods (with and without dislocation of the scanned cylinder).

There was a notable difference – more than three times (position deviation between the different sets of gages). In practice, it is recommended to use the dislocation of scanned cylinder. Also direct measurement techniques give similar results by scanning spiral and generating lines. In the third threaded hole we even got the slightest deviation position measurement techniques by a spiral scanning.

It appears from the experiments we can conclude that in terms of accuracy of measurement methods the results are very similar and it is not possible to clearly identify better method or technique of measurement of threaded holes. However, to verify the accuracy of direct measurement it is appropriate to execute further experiments, in that nonfunctional part of the thread hole is scanned.

Acknowledgements

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