Practical Tip

MEASURING WORKPIECES IN TWO OR THREE DIMENSIONS

Avoiding Projection Errors

Workpiece inspection drawings contain mostly two-dimensional definitions for dimensions, which often leads to the conclusion that the measurement task can be handled using 2D coordinate measuring technology. However, this requires precise mechanical alignment of the, generally, three-dimensional workpiece. Otherwise it is nearly impossible to avoid significant measurement deviations. One alternative is to use 3D coordinate measuring technology.

There are many possible ways to capture the dimensions of a workpiece using coordinate measuring technology. The measurement task and coordinate measuring machine must be well matched to each other (Figure 1). The simplest type of measurement follows the 2D views of the drawings. All dimensions are provided in projected form or in cross section planes. Length dimensions are often one-dimensional, while diameters and angles are defined in two dimensions. It therefore appears at first glance that a simple measurement on a 2D coordinate measuring machine would be sufficient.

For very flat measured objects, such as printed circuit boards, extruded profile sections, and 2D punched parts, this is indeed true. For more complex three-dimensional shapes, such as stamped bent parts, only those dimensions that are actually physically in a single plane can be measured in this manner. All dimensions at different heights are automatically projected into the plane of the support surface.

In order to be able to measure the workpiece precisely according to the view or section, the user must ensure that the workpiece is precisely aligned to this plane by hand on the measuring machine, as otherwise significant project errors will occur (Figure 2). The advantage of simple measurement can come at a cost of erroneous measurement results.

If 2D dimensions are to be determined in different section views, then the measurement is really a 3D measurement task. Changing setups is also not a good solution, since moving the workpiece during the measurement destroys the established reference coordinate system, dimensions that are based on a reference from the other setup position may also be measured incorrectly.

It is important to recognize that a drawing view is always based on a workpiece coordinate system that is constructed from the references indicated on the drawing. Unfortunately, a complete three-dimensional mathematical alignment is not possible on a 2D coordinate measuring machine.

2D Measurement Tasks

For measurement tasks that use 2D measurement technology, the workpiece is placed flat on the stage of the instrument and provides an opportunity for rapid optical measurement. With printed circuit boards, for example, the inspection dimensions such as diameter and position of holes can be taken directly from the hole pattern.

For 2D measuring machines such as the QuickInspect MT or the FlatScope from Werth Messtechnik, Giessen, the workpiece geometry is captured completely and precisely, then displayed and analyzed in an image, using the patented “raster scanning” operating mode. The dimensions for sections of plastic or aluminum profiles, such as window frames or automotive com-

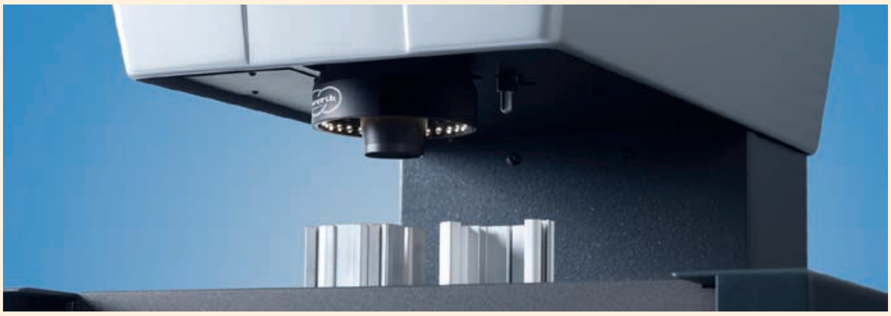

Figure 1: This 2D measuring machine is also used to measure large workpieces “in the image.”

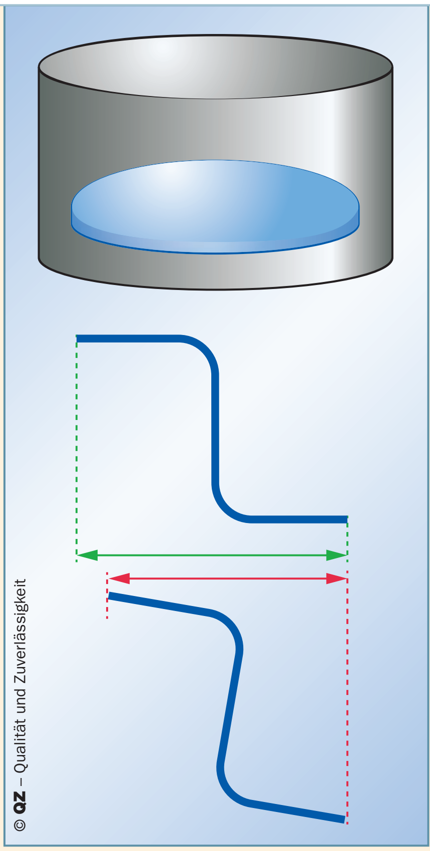

Figure 2. Tilting of the measured object leads to falsified measurement results.

ponents, are also measured in two dimensions on the cross section. If the user selects appropriate boundary conditions, such as a perpendicular cut, deburring, telecentric optics of sufficient magnification, and good telecentric lighting, then good measurement results can be achieved in this way. For punched parts, a purely two-dimensional measurement may also make sense. Clamping problems of bent sheet metal parts that are not purely two-dimensional can, however, easily lead to projection errors and thus to incorrect measurement results.

Round workpieces such as shafts can also be measured simply and quickly on a 2D measuring machine such as the Werth ShaftScope. This allows 2D dimensions such as diameters, lengths, and angles to be taken very quickly at high point density. Measurement of 3D dimensions such as radial and axial runout, however, requires 3D measuring machines.

3D Measurement Tasks

As production methods are increasingly developed, workpiece geometries are becoming more and more complex and three-dimensional. The limits of 2D measuring machines are soon reached, as they cannot be used for complete 3D alignment. Measurements in the plane also become measurements in space. Using a 3D coordinate measuring machine, however, standard geometric elements can be captured precisely on the workpiece and can be used to mathematically align the workpiece. All dimensions are then automatically evaluated in the correct drawing view.

This is illustrated by the example of stamped bent parts; these parts generally cannot be measured in two dimensions after the bending process. The workpieces would have to be aligned with great mechanical precision on a 2D coordinate measuring machine, which can be achieved only with very precisely manufactured fixtures for each workpiece. Aside from the time and effort this would require, even a slight tilt of the workpiece would cause a significant deviation in the derived dimensions from their actual values due to projection errors. Length dimensions are shortened and angles and radii are distorted. This can be avoided with 3D measuring machines. These machines can also capture height dimensions of the workpiece in the correct 3D alignment.

The measurement of more complex printed circuit boards populated with LEDs is another example where three-dimensional measurement of an apparently two-dimensional workpiece makes sense. Quickly checking the position and tilt of the base LED bodies on the board and calculating the heights of the individual LEDs relative to each other require 3D measurements.

By adding tactile sensors to a shaft measuring machine, the scope of application can be expanded from rapid measurement of 2D dimensions to include capture of flat surfaces for determining axial runout and more precise length measurements. Multisensor machines such as the Werth ScopeCheck retain their reference system even when a sensor is changed out, so the dimensions can be linked to each other in all three dimensions. □

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