practical tip

IMAGE PROCESSING SENSOR FOR ANY APPLICATION

Flexible Zoom Optics

An image processing sensor with zoom optics supports different magnifications, thus expanding the potential applications of the coordinate measuring machine. A change in magnification, however, also affects the other parameters of the zoom optics. This must be taken into consideration when using an optical zoom sensor.

Due to the wide variety of applications, coordinate measuring machines with image processing sensors and zoom optics are in widespread use. At a low magnification, a large field of view is available that can be used for setting the workpiece datum. For example, in a measurement program, a workpiece that is imprecisely placed in a fixture can be reliably „found“. The workpiece orientation is found easily and all subsequent measurements will function reliably even at higher magnifications with smaller fields of view. Individual features that are fully inside the field of view, can be measured with sufficient accuracy without moving the machine axes. The advantage of such measurement „in the image“ is the high measurement speed. The disadvantage can be relatively high measurement uncertainty due to resolution restrictions caused by the pixel size (effective pixel size).

For more precise measurement, a high magnification is selected with a correspondingly small field of view and individual features may only be partially visible. To capture a feature completely in this case, the workpiece must be moved relative to the sensor to measure „on the image“. The advantage of a higher magnification is the lower measurement uncertainty, which is

largely determined by the effective pixel size. As the magnification increases, smaller and smaller regions of the workpiece surface are represented by more pixels.

A lower magnification is thus used mainly to navigate to the desired measuring position due to the large field of view which provides a good overview of the workpiece. To optimize efficiency and measurement process capability, an appropriate magnification should be selected with the measurement uncertainty being a factor of about ten times less than the feature tolerance.

Zoom Levels, Telecentricity and Imaging Errors

Zoom lenses consist of several lens packages, a few of which are moveable. The relative position of the lens packages to each other determines the magnification. For conventional zoom lenses, the lens packages are moved by helical control slots in the lens barrels.

Due to friction (stick-slip effects, backlash and hysteresis), the position of the lens packages and thus the corresponding magnification has limited reproducibility. To measure precisely, a time consuming recalibration must be performed after each change of the zoom magnification. Frequent changes in magnification should therefore be avoided and individual features should always be measured at the same zoom level. By using modern zoom optics with motorized linear guides for adjusting the lens packages, these effects become negligible due to the high accuracy of the mechanics (Figure 1).

For lenses that are not sufficiently telecentric, even a slight loss of focus changes the workpiece dimensions. That increases the measuring uncertainty. Therefore the right focus must always be determined prior to each measurement using an autofocus measurement and the sensor must be repositioned accordingly. For telecentric lenses, however, a diaphragm in the optical beam path ensures that the image size remains nearly constant within the telecentric range. This makes the measurement deviations negligible, so no measurement time is lost for additional autofocus measurements.

Imaging errors occur with all optical systems. For zoom optics in particular, the chief issues are distortion in the X and Y directions and image field curvature in the Z direction. Therefore it is recommended to use optics with integrated distortion correction. This is normally done by error mapping inside of the CMM software. As the

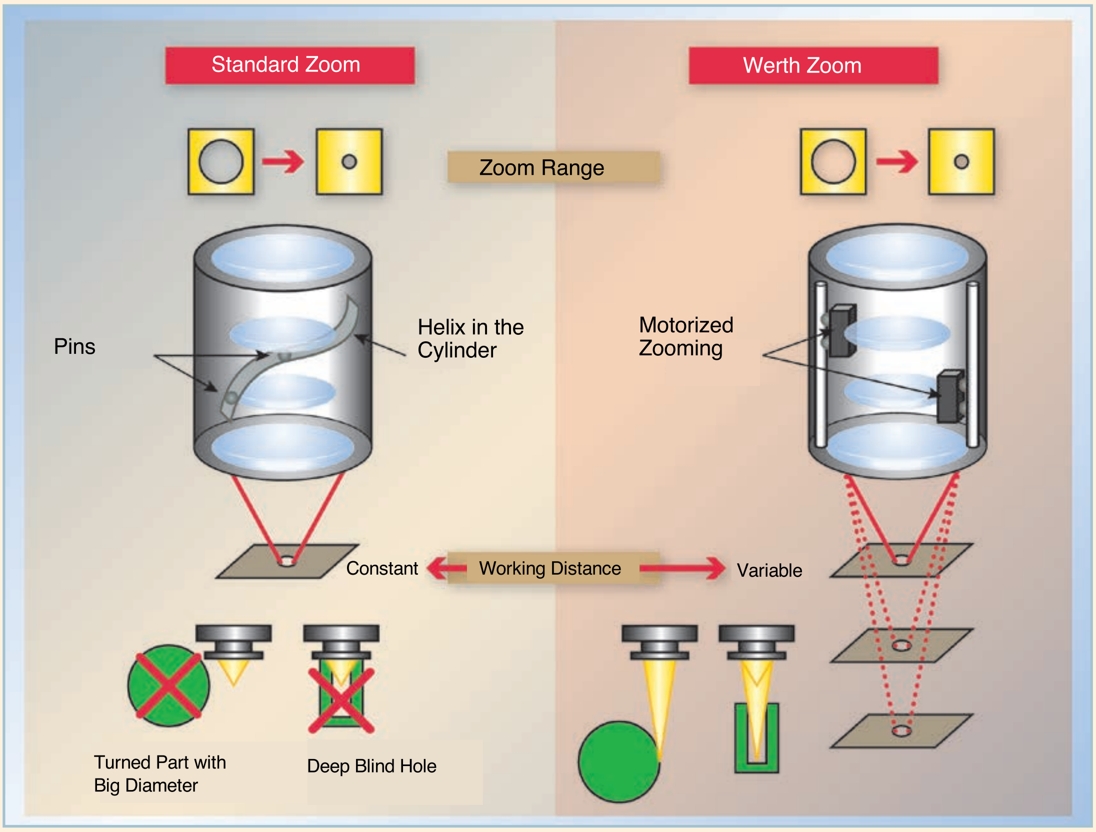

Figure 1. Zoom with helical control slots in the lens barrel (left), Werth Zoom with motorized linear guides and variable working distance (right)

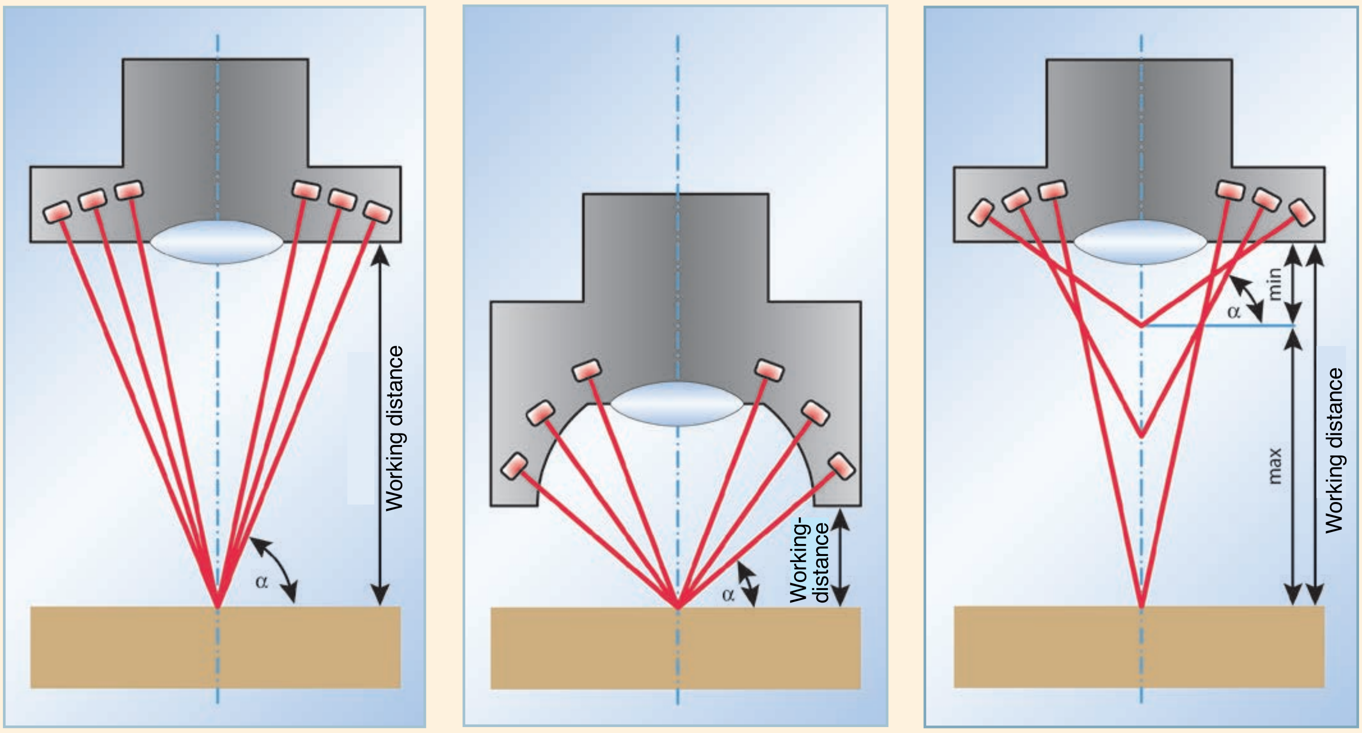

Figure 2. Darkfield incident light with adjustable angle: Constant working distance with a small angular range (left) or short working distance with a medium angular range (center) and MultiRing with a variable working distance and large angular range (right)

distortion increases from the center to the edge of the field of view, the measurement window should be placed as close to the center of the image as possible to reduce these effects.

Working Distance and Lighting

Using zoom lenses with motorized linear guides allows any number of zoom steps (magnifications) to be calibrated because the lens packages can be moved independently of each other. This means that not only different magnification levels can be set, the working distance can also be varied. Each zoom system is optimized for a particular working distance where the most accurate measurements can be made. A larger working distance with somewhat lower precision, however, allows non contact measurements of round workpieces with large diameters or measurements in deep holes that would otherwise not be possible due to collisions (Figure 1).

There are also various lighting options. For standard lenses with constant magnification, transmitted light and brightfield incident light are available. Darkfield incident light is of particular interest, such as the patented MultiRing, consisting of several LED rings that can be switched on independently of each other. Each ring also consists of independent ring segments of diodes that allow lighting from different directions. This can vary the angle of incidence of the light. For zoom optics with a constant working distance, however, only a small range of angles is possible (Figure 2, left). It is only possible to increase the angular range by sacrificing working distance, that is, by having a constant, very short working distance (Figure 2, center). In this case, however, measurements at all zoom levels are limited to flat objects.

If the zoom optics has a variable working distance, then the angle of incidence of the darkfield incident light relative to the optical axis can be varied over a large range (Figure 2, right). For some measurements, a very shallow incidence angle at a short working distance can be advantageous. A shallow angle of incidence can both increase contrast and the cast shadow. Particularly for edges with a slight difference in height, edge detection consistency can be significantly increased.

The greatest flexibility is provided by a CNC adjustable working distance in combination with a MultiRing, as the lighting and working distance can be adapted to the particular measurement task.

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