Video measurement enables high accuracy

Video measurement lets manufacturers ensure that processes are under control and that parts are within specification. Video measurement systems use specialized software to measure an image of the part, so the process is non-contact. The image is usually magnified many times, so the system is like a microscope with the eyepiece replaced by a camera.

The key advantage of video measurement is that it can be CNC-controlled for fully automatic operation. What constitutes a video measurement system? Good quality optics must faithfully present the image to a camera since aberrations in the optics might be interpreted as a measurement error in the part. A zoom lens allows video measuring systems to change magnification in order to maximize detail for features of various sizes. Each change in magnification must be calibrated in order to achieve measurement accuracy - the best systems do this automatically.

Converting an image to electrical signals is done by reading the signal levels from each of the pixels in a digital sensor (camera). The image is magnified until the feature of interest covers many pixels so individual details can be determined unambiguously. Good video measurement systems use sub-pixel algorithms to extend measurement resolution.

In the case of a three dimensional part, it is necessary to know the position of the image and the part throughout the measurement volume of the system, requiring position sensing on macro and micro scales. Taking Z motion alone, it is necessary to move the camera/optical assembly so the feature of interest is within the optical depth of focus at the particular magnification being used (depth of focus typically decreases as the magnification increases). The entire camera/optical assembly must retain its critical alignment as it moves. In CNC systems, Z-motion is by motorized linear slides, with scales to keep track of position. On a micro-scale, auto-focus takes over to maximize the sharpness of the image. System software notes the final position of the focused image relative to the original datum.

To maximize image quality at the camera, proper illumination is important. Since measured features can be straight, curved, or be on the perimeter or the surface of the part, different methods of illumination are necessary. Back lighting (profile illumination) is best for through-holes and the perimeter of the part. Oblique angle top lighting is helpful for highlighting subtle surface features. For example, a ring-light made up of concentric rings of LEDs allows illumination at selectable angles of incidence as the different rings are illuminated. Segmenting the rings allows the light to be directional. This is especially helpful for features that lie in a particular orientation. It is rare for an entire part to fit within the optical field of view. This means the part must be moved under the lens until every feature to be measured is brought into the field. Since this is a measuring machine, any motion in the X-Y plane must be quantified. X-Y stage travels of video machines extend to as much as one meter or more. Parameters of importance include straightness of travel, stage speed, and positional resolution. Open loop motion uses counts of a known increment and assumes a position is reached based on the accumulation of a given number of counts. Closed loop motion adds a feedback device such as a linear scale to actually measure the stage position.

Measurement accuracy depends on the structural integrity of the system. The three axes must be orthogonal (true 908 apart). This requires a precision design and exacting assembly. No part of the machine must move independently of any other or that offset will affect measurements.

This requires a stable, damped mechanical structure, so video measuring systems are made of materials such as steel and granite for their structural stability.

Video measurement consists of the choreographed motion of XYZ stages, magnification changes, setting illumination type, intensity, and angle, and the acquisition and processing of camera data, that ultimately lead to a digitized model which contains dimensional and angular relationships of the part under test. There is a lot going on, but user interaction with the machine need not be complex.

Over the past 20 years, video measurement technology has advanced dramatically. Computers are faster. Cameras have higher resolution and better signal-to-noise ratios.

Image processing software is better capable of ignoring background noise and artifacts. Stages are servo driven. Surface mounted components offer increased speed, lower noise and less energy consumption.

Other sensor technologies are being added to video systems to expand their functionality. These multi-sensor measurement systems might use touch probes, allowing access to features that are beyond the range of the optics; laser sensors for auto-focus and surface scanning; micro-probes for miniature or fragile parts. Metrology software has evolved to accommodate multi-sensor measurement.

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