practical tip

HOW TO USE CONTOUR COMPARISON TO REDUCE SCRAP

Functionally appropriate inspection with a virtual gage

Fig. 1. Measuring machines with image processing capture the measured object in one image

Functional workpieces are often rejected even though they could work perfectly. One reason for this is that individual numerical measurements or geometric dimensioning and tolerancing (GD&T) features without material conditions do not provide a complete picture of the part. Evaluation based on the minimum or maximum material principle and contour comparison, with tolerance-zone dependent alignment, provides possibilities to inspect parts under functional aspects. This approach can reduce scrap and makes manufacturing more efficient.

The discrete measurement of individual features to judge the quality of a particular workpiece is a fundamental part of metrology. However individually measured values often do not provide a conclusive statement about the functionality of a workpiece. For example, to measure angles on a very short length could cause a large variation in the results due to the mathematics involved, even if the measurement uncertainty for individual points is very low.

Other common examples include the measurement of radii with a very small angular segment and in the end zones (fillets) where poorly selected measurement areas can falsify the result. If the number of points used for the analysis is too low, the results will vary significantly. The analysis in these cases is strongly dependent on the user, who must define the position of the measurement points. Measurements that are derived in this manner will generally result in an unstable measurement process. This will increase scrap, as mechanically functional workpieces are flagged as defective.

Contour comparison

While traditional numerical measurement often yields only unreliable values for radii or dimensions of short contour segments, a contour comparison can even give insight to the cause of the deviation. Through this approach the production process can be easily optimized. The links between several features, such as a radius, radius end zones, and position, can also be analyzed using contour comparison. This greatly simplifies the interpretation of measurement results and allows for both a qualitative evaluation and dimensional analysis of the workpiece.

Contour comparison has been used in metrology for decades. Profile projectors (comparators) provide a scaled image of the contours of the measured object that can be compared to a drawing or template.

This allows workpieces to be inspected comprehensively in a few simple steps, and provides easily understood results that are highly reliable.

This method has significant drawbacks however, since the alignment and evaluation must be done manually, making them highly operator dependent and difficult to document. A solution that is independent of the operator and has extensive documentation potential, however, is software-supported alignment of a captured contour.

Software for fast alignment

A contour can be captured using a variety of sensors today. The closest thing to a profile projector is a measuring machine with image processing, such as the Werth QuickInspect, which captures the measured object in a single image (Figure 1, left).

In order to measure larger objects with the same structural resolution—which is critical in order to be able to accurately evaluate small elements—contours can be captured using the patented method of raster scanning. The contour of the measured object is captured in several images, which are then merged. This is made possible by the high precision of the coordinate measuring machine and the knowledge of the exact positions at which the images were captured (Figure 1, right). This creates an overall image of the measured object that can be used both for contour and for dimensional analysis. Operation is just as simple as measuring „in the image."

The results from other scanning sensors can also be used for contour comparison. Sensors, such as conventional probes, the Werth Laser Probe, the Werth Fiber Probe and others thus considerably expand the range of applications for contour comparison. The captured contours can be aligned to a nominal contour automatically using Werth BestFit software. This guarantees fast and automatic alignment, even if the nominal and measured contours have very different coordinate systems. If the drawing and workpiece coordinate system are very far apart from each other, as is often the case, automatic alignment is still possible. More precise mathematical alignment methods can also be used if needed.

After optimal alignment, residual part deviations can be visualized using a color coded vector plot. This makes it easy to see both the magnitude and direction of deviations on the measured objects. Thus it is possible to determine what measures must be taken to correct the workpiece. In addition, these vectors can also be used to automatically correct the tooling.

Simulation of a mechanical gage

The patented ToleranceFit software, in contrast to BestFit, does not align the contour points to a nominal contour. Instead, it considers the tolerance band surrounding the nominal contour (Figure 2). This simulates a mechanical gage measurement, making it a functional inspection. According to Werth Messtechnik, this is the only correct way to check the function of the workpiece, because the prescribed tolerance bands are not considered in a BestFit alignment to a nominal contour.

By using all available measurement points in the selected elements, ToleranceFit provides a linked analysis of all inspected dimensions. This means that the software also provides optimal results with respect to tolerances based on the maximum material principle.

One example is the position tolerance for a pin. If the pin's diameter is smaller than the nominal value but within the tolerance, then it can hit the intended hole in a subsequent function, even if its position tolerance has been exceeded. In other words, the position tolerance can effectively be increased by the deviation of the pin to the nominal diameter without affecting the function of the pin.

Multiple geometric elements can be linked to each other in the same way. Using functional inspection, a significant reduction in scrap and expansion of production tolerances are possible, reducing costs. When ToleranceFit is used for the alignment, the complex interactions of the maximum material principle can be easily applied, visualized and understood by anyone. □

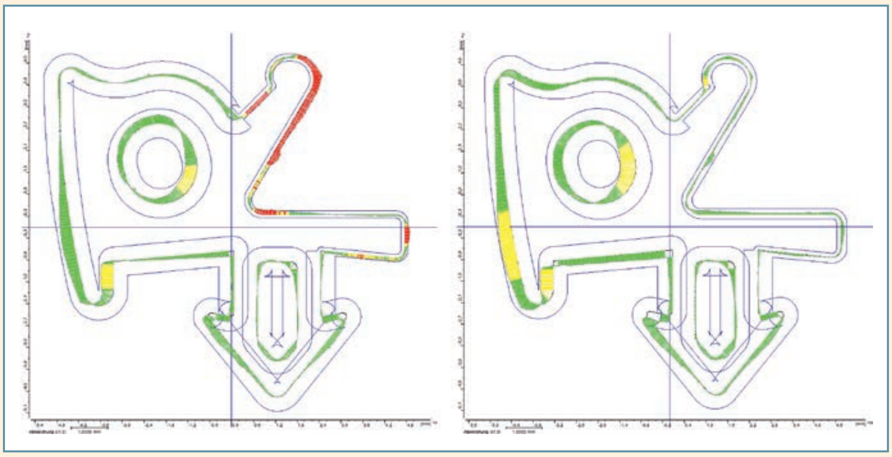

Fig. 2. When adapting the measured contour to the target contour using BestFit, the workpiece appears to be non-functional (left)—adapting using ToleranceFit, in contrast, considers the interactions between the tolerances (right)

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