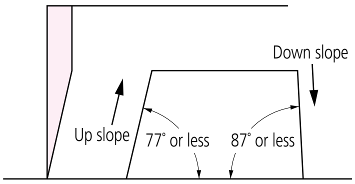
Contracer (Contour Measuring Instruments)

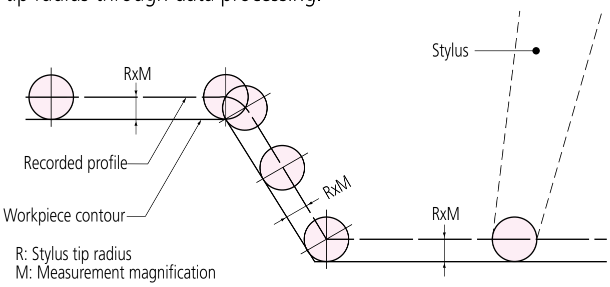
Traceable Angle



The maximum angle at which a stylus can trace upwards or downwards along the contour of a workpiece, in the stylus travel direction, is referred to as a traceable angle. A one-sided sharpened stylus with a tip angle of 12° (as in the above figure) can trace a maximum 77° of up slope and a maximum 87° of down slope. For a conical stylus (30° cone), the traceable angle is smaller. An up slope with an angle of 77° or less just by measurement may actually include an angle of more than 77° due to the effect of surface roughness. Surface roughness also affects the measuring force.

Compensating for Stylus Tip Radius

A recorded profile represents the locus of the center of the ball tip rolling on a workpiece surface. (A typical radius is 0.025mm.) Obviously this is not the same as the true surface profile so, in order to obtain an accurate profile record, it is necessary to compensate for the effect of the tip radius through data processing.

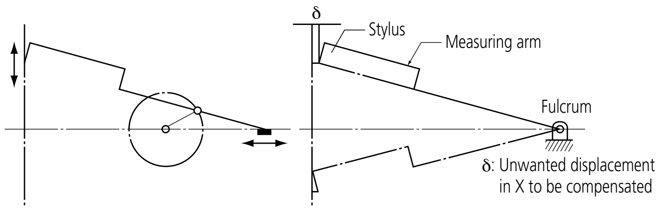


If a profile is read from the recorder through a template or scale, it is necessary to compensate for the stylus tip radius beforehand according to the applied measurement magnification.

Compensating for Arm Rotation

The stylus is carried on a pivoted arm so it rotates as the surface is traced and the contact tip does not track purely in the Z direction. Therefore it is necessary to apply compensation in the X direction to ensure accuracy. There are three methods of compensating for arm rotation.

1: Mechanical compensation
2: Electrical compensation



3: Software processing. To measure a workpiece contour that involves a large displacement in the vertical direction with high accuracy, one of these compensation methods needs to be implemented.

Overload Safety Cutout

If an excessive force (overload) is exerted on the stylus tip due, perhaps, to the tip encountering a too-steep slope on a workpiece feature, or a burr, etc., a safety device automatically stops operation and sounds an alarm buzzer. This type of instrument is commonly equipped with separate safety devices for the tracing direction (X axis) load and vertical direction (Y axis) load.

Simple or Complex Arm Guidance

In the case of a simple pivoted arm, the locus the stylus tip traces during vertical movement (Z direction) is a circular arc that results in an unwanted offset in X, for which compensation has to be made. The larger the arc movement, the larger is the unwanted X displacement (δ) that has to be compensated. (See figure, lower left.) The alternative is to use a complex mechanical linkage arrangement to obtain a linear translation locus in Z, and therefore avoid the need to compensate in X.

Z-axis Measurement Methods

Though the X-axis measurement method commonly adopted is by means of a digital scale, the Z-axis measurement divides into analog methods (using a differential transformer, etc.) and digital scale methods.
Analog methods vary in Z-axis resolution depending on the measurement magnification and measuring range. Digital scale methods have fixed resolution.
Generally, a digital scale method provides higher accuracy than an analog method.

Surface Profile Analysis Method

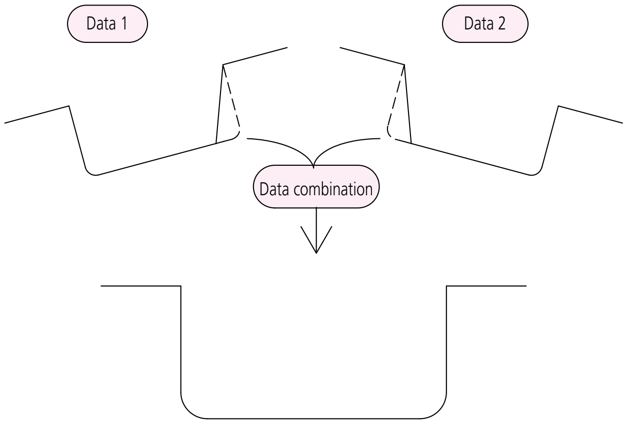
The following two methods are available as a means of analyzing a surface profile after the measurement operation has been completed.

1: Recorder
There are two methods by which the dimensions of a measured surface profile can be obtained from a recorded profile. The first is by reading a dimension with a scale applied to the recorded profile and dividing the result by the measurement magnification. The second method is by performing comparative measurement with a template [(actual dimension ± tolerance) x measurement magnification] that has been created with a CAD package, etc., applied to the recorded profile. In both methods stylus tip radius compensation must be considered at the time of measurement, and template creation, and the fact that reading error or human error may be significant.

2: Data processing unit and analysis program
In this method, the measured surface profile is fed to a data processing unit in real-time and analysis of the profile is performed by a dedicated analysis program controlled from a mouse and/or keyboard. The data processing unit displays angle, radius, step height, pitch, etc., directly in numeric values and also allows straightforward analysis in combination with a coordinate system. The recorded profile is subjected to stylus tip radius compensation and then output to a plotter or a laser printer.

Data Combination

Conventionally, if tracing a complete contour is prevented by stylus traceable-angle restrictions then it has to be divided into several sections that are then measured and evaluated separately. This function avoids this undesirable situation by combining the separate sections into one contour by overlaying common elements (lines, points) onto each other. With this function the complete contour can be displayed and various analyses performed in the usual way.

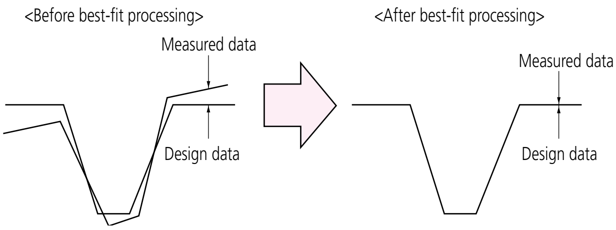


Tolerancing with Design Data

Measured workpiece contour data can be compared with design data in terms of actual and designed shapes rather than just analysis of individual dimensions. In this technique each deviation of the measured contour from the intended contour is displayed and recorded. Also, data from one workpiece example can be processed so as to become the master design data to which other workpieces are compared. This function is particularly useful when the shape of a section greatly affects product performance, or when its shape has an influence on the relationship between mating or assembled parts.

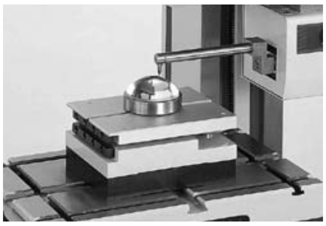
Best-fitting

If there is a standard for measured surface profile data, tolerancing with design data is performed according to the standard. If there is no standard, or if tolerancing only with shape is desired, best-fitting between design data and measured data can be performed.

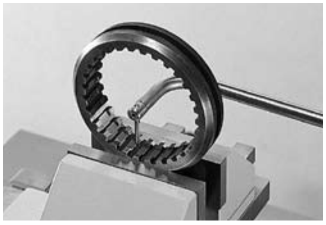


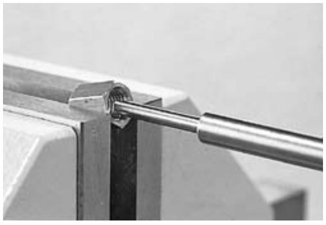
The best-fit processing algorithm searches for deviations between both sets of data and derives a coordinate system in which the sum of squares of the deviations is a minimum when the measured data is overlaid on the design data.

Measurement Examples

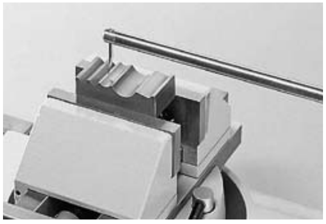

Aspheric lens contour


Inner/outer ring contour of a bearing


Internal gear teeth


Female thread form


Male thread form


Gage contour