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Inverse problems of measurement with application on specification of surface profile

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Introduction:

A contradiction of the specification of free-form surface profile is pointed out. The inverse problem of measurement (IPM) is defined based on the representational measurement theory. By using the concept of IPM, a desired property of specification limit is derived and a correction for solving the contradiction is proposed.

Specification and measurement of surface profile

The upper and lower specification limits (LSL and LSL) of a free-form surface profile defined in ISO 1101 are two curves enclosing circles of certain diameter r, the centres of which are situated on the nominal surface profile (see figure 2a). For an actual surface profile l, if all the points on l are within the tolerance zone, i.e. LSL ≤ l ≤ LSL, l is within the spec.

The empirical method of measuring surface profile is contact measurement by moving a tactile stylus along the surface to be measured to obtain the locus of the centre point of the stylus tip.

A correction of the specification of free-form surface profile

The contradiction

Due to the extensive property of closing filters, the estimated profile is always above the actual profile (see figure 1). Hence when an actual surface profile coincides with the LSL (flat within spec.), the measurement result (without errors) would, however, be out of spec., which contradicts with the real situation.

The correction of the tolerance zone of surface profile

Figure 2. Accuracy of the tolerance zone of surface profile

A proposed solution

The inverse of pseudo-inverse of h, denoted as g: D → X, can be used to find the inverse solution, g, it is expected to satisfy the following equation:

\[ X = \text{Estimated values of measured} \]

For any IPM, X and D are always determined by an measurable ERS.

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