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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 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 limits is derived and a correction for solving the contradiction is proposed.

Specification and measurement of surface profile
The upper and lower specification limits (LSU and LSL) of a free-form surface profile defined in ISO 1101 are two curves enclosing circles of certain diameter 1, the centres of which are situated on the nominal surface profile (see figure 2a). For an actual surface profile S, if all the points of S are within the tolerance zone, i.e., LSL ≤ S ≤ LSU, S is within the spec.
The canonical 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 Contradiction of the Specification of Free-form Surface
The contradiction
Due to the extensive property of closing filter, the estimated profile is always above the actual profile (see figure 1). Hence when an actual surface profile coincides with the LSU (lies within spec.), the measurement result (without errors) would, however, be out of spec., which contradicts with the real situation.

Figure 1. working principle of measuring surface profile with a tactile stylus

Figure 2. Accuracy limits of the tolerance zone of surface profile

Representational model of measurement
Representational measurement theory allows measurement to be defined as the assignment of numbers to attributes of objects in such a way as to describe them (Feldkamp, 1992). Hence measurement can be considered as a mapping from the measured objects to the measured properties.

For the measurement of a physical and/or more empirical attributes would be defined between the measured objects. E.g. provider ≤ is a very general empirical relation.
The set of the measured objects with the empirical relations, R0,R1,...,Rn, can be taken as a mathematical object M=(M0,M1,...,Mn), called an empirical relational system (ERS). E.g. the NRS representing the length is (R0,Sn). The numbers in the NRS are the values of the measured quantity to be measured.

Principle of correcting the contradiction

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