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Tolerance-Maps for line-profiles constructed from Boolean intersection of T-Map primitives for arc-segments

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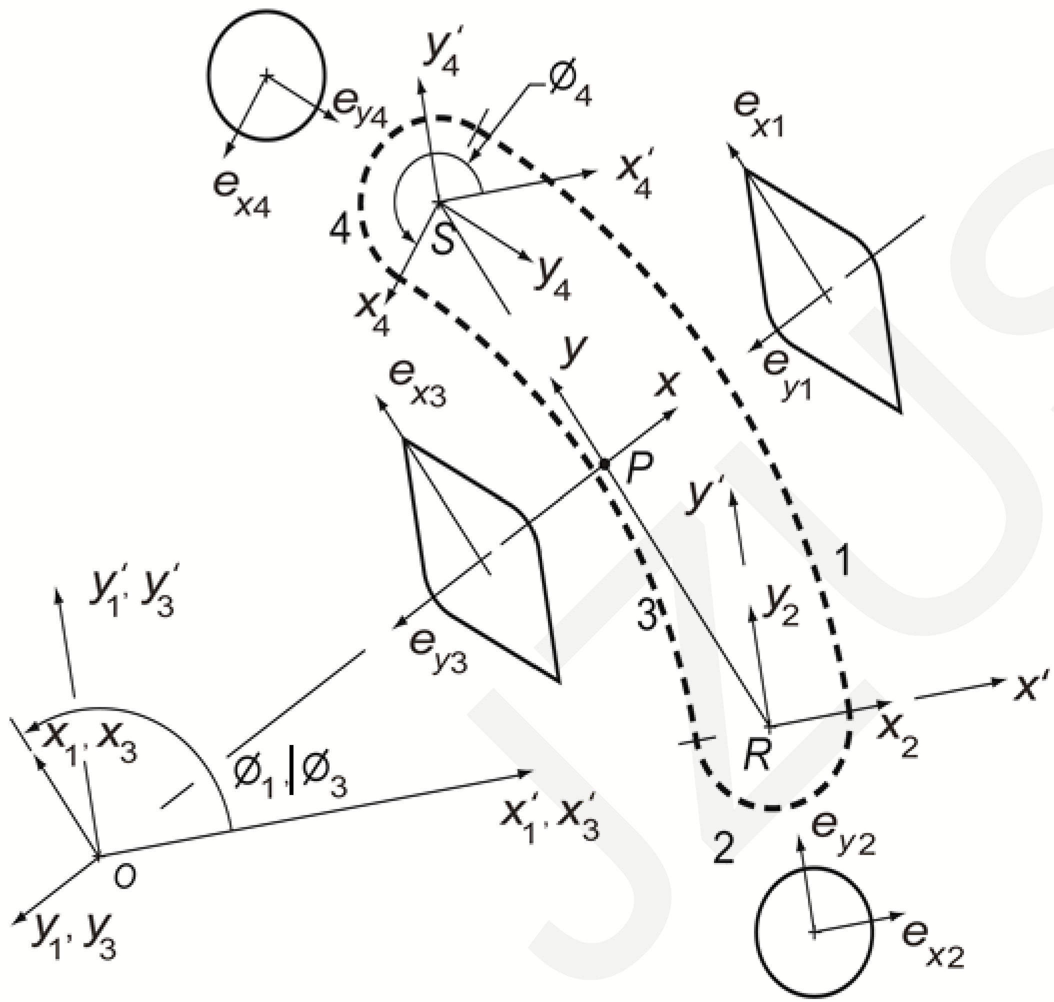
Abstract

For purposes of automating the assignment of tolerances during design, a math model, called the Tolerance-Map (T-Map), has been produced for most of the tolerance classes that are used by designers. Each T-Map is a hypothetical point-space that represents the geometric variations of a feature in its tolerance-zone. Of the six tolerance classes defined in the ASME/ANSI/ISO Standards, profile tolerances have received the least attention for representation in computer models. The objective of this paper is to describe a new method of construction, using computer-aided geometric design, which can produce the T-Map for any line-profile. The new method requires decomposing a profile into segments, creating a solid-model T-Map primitive for each, and then combining these by Boolean intersection to generate the T-Map for a complete line profile of any shape. To economize on length, the scope of this paper is limited to line-profiles formed from circular arc-segments. The parts containing the line-profile features are considered to be rigid.

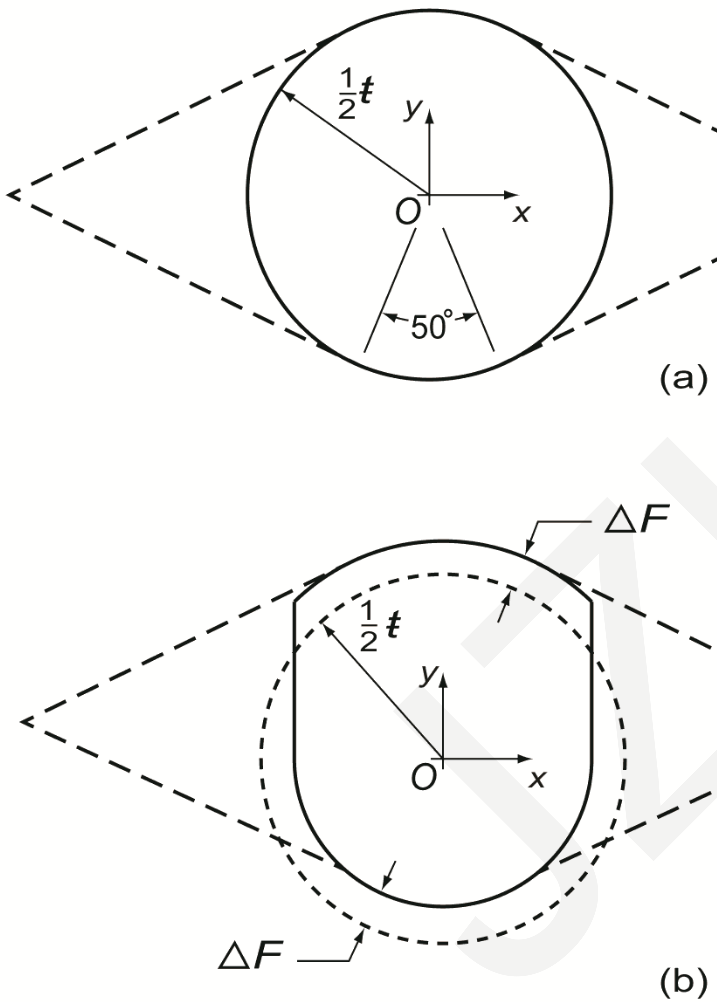
Key words: Geometric tolerance, Line-profile, Tolerance modelling, Tolerance-zone, Boolean intersection

Method



Global $Rx'y'$- and Pxy-frames for the arc-slot in Fig. 1a which has been decomposed into four arc-segments, each with its local reference frames x_iy_i and $x'_iy'_i$ and its 2D T-Map primitive. The angles ϕ_i shown are for global frame $Rx'y'$

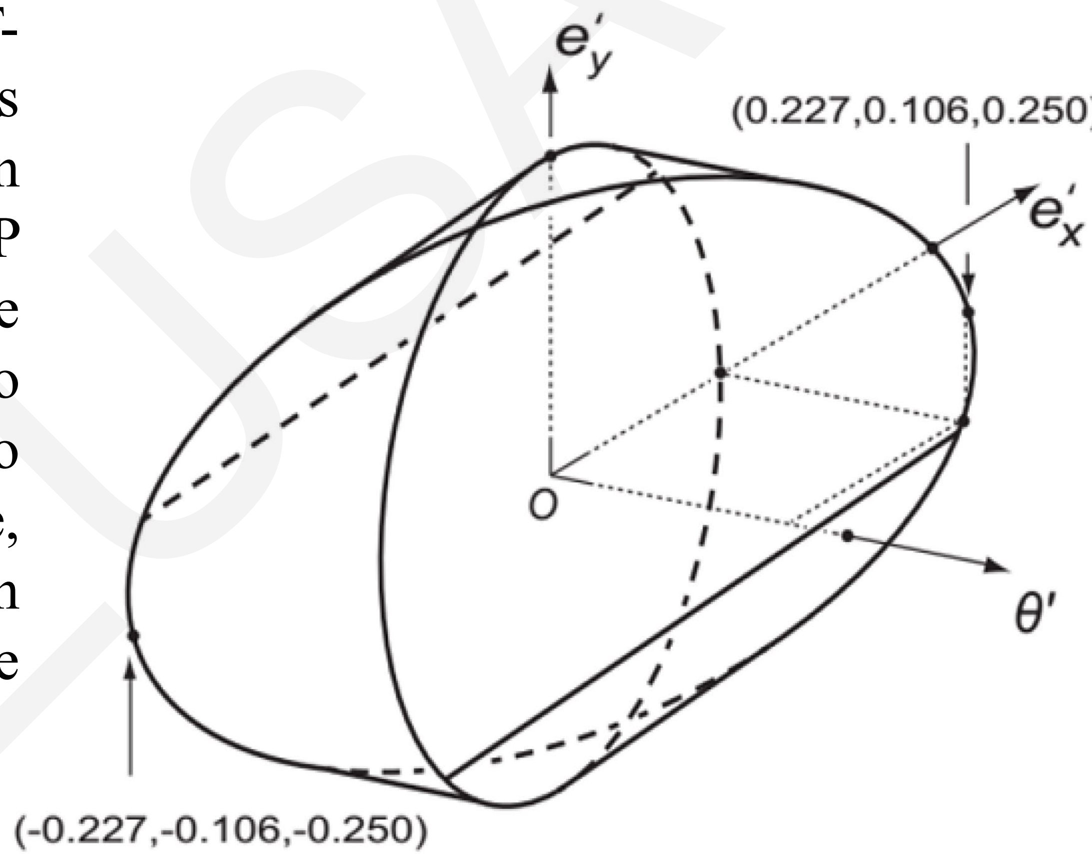
Method



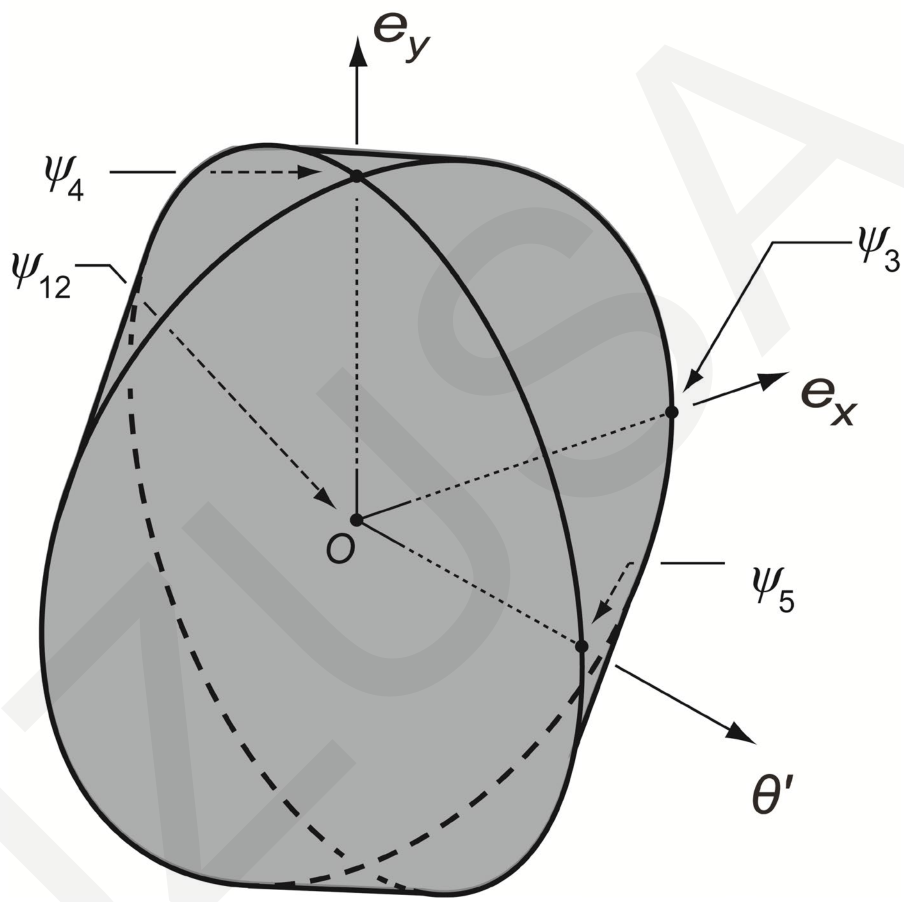
2D T-Map primitives for the arc-segments of the curved slot in Figs. 1a and 2, the dashed lines (rounded rhombus) for both arcs centered at O and the solid lines for the two arcs at R and S; (a) For the MSP; (b) For arcs 1, 2, and 4 of an arc-slot larger than the MSP by ΔF

Method

Boolean intersection of the T-Map primitives which forms the 3D hypersection T-Map in global frame $Rx'y'$ for the MSP of the arc-slot in Fig. 1a. The coordinate values correspond to the MSP rotated to its two limits in the tolerance-zone, e.g., the CCW limit shown in Fig. 2. The diameter of the circular edge is t

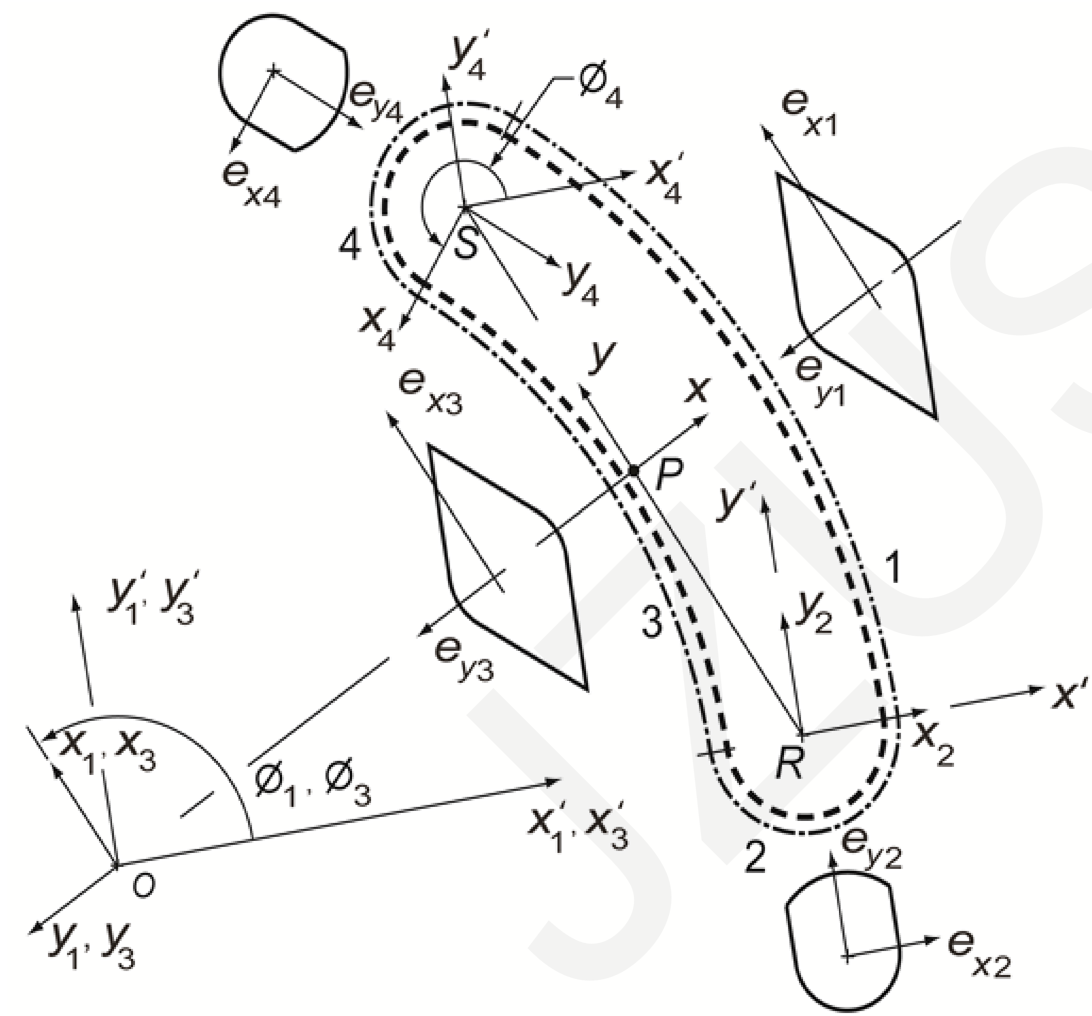


Method



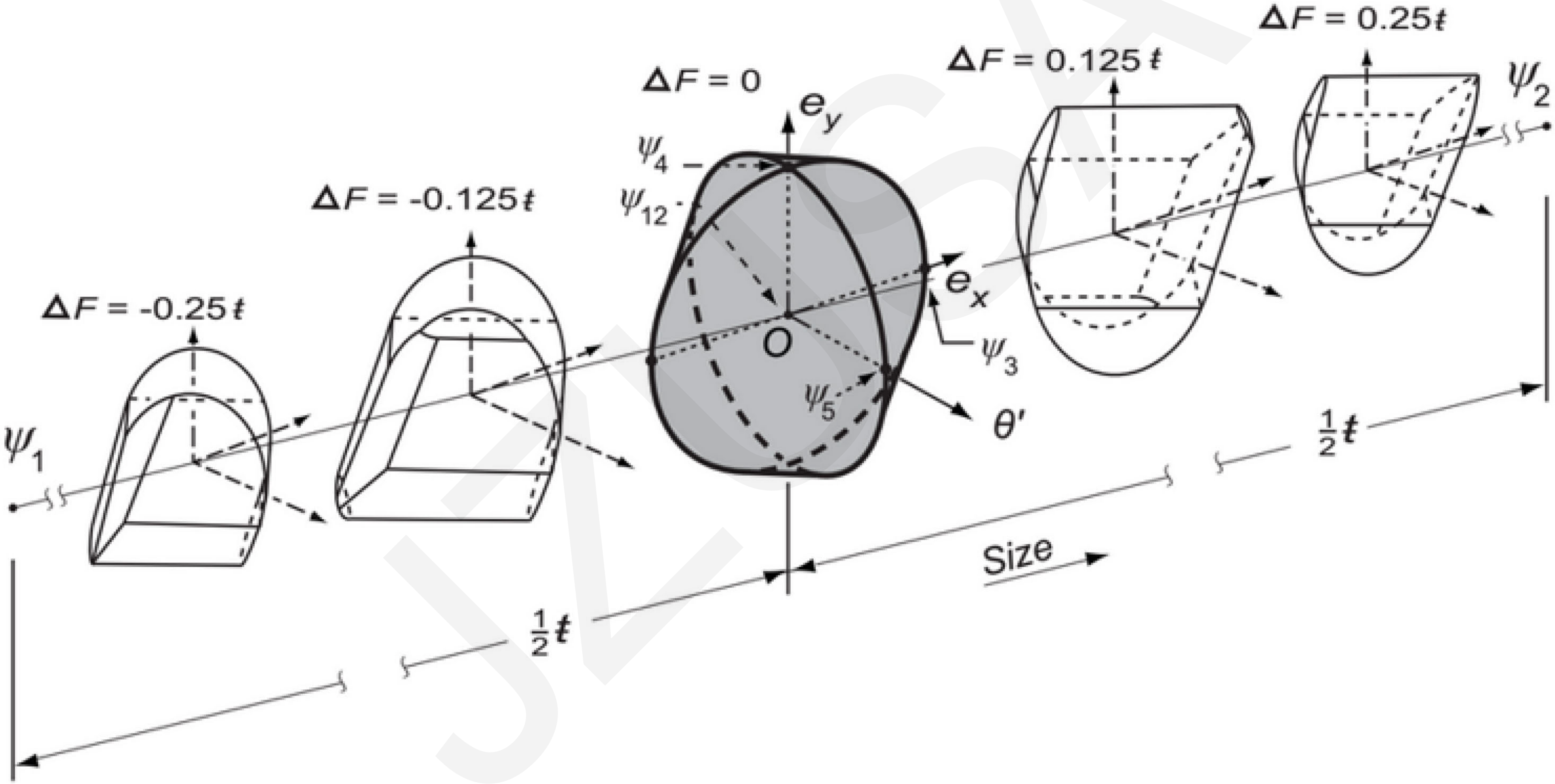
T-Map of Fig. 8 for the MSP of the arc-slot in Fig. 1a, now transformed to the canonical global *Pxy*-frame. Both circular edges have diameter t

Method



The same geometry as in Fig. 6, but now the deployed 2D T-Map primitives are for a profile size ΔF larger (long-and-short dashed curve) than the MSP (Fig. 7b)

An example of a 4D T-Map



Conclusions

- This paper introduces a new method for con-structing T-Maps for line-profiles that are to be manufactured on rigid parts.
- The new method constitutes a decomposition of the profile into joined segments, the formation of a T-Map primitive (a 3D solid) for each one in a local coordinate system, the transformation of all of these to different orientations and shapes in a common reference frame, and the Boolean intersection of these transformed T-Map primitives to obtain the T-Map for the entire profile.
- We have used a kinematic equivalent to represent the allowable displacements of the perfect-form profile within its tolerance-zone.