# Curve-guided 5-axis CNC flank milling of free-form surfaces using custom-shaped tools

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**Abstract**

A new method for 5-axis flank milling of free-form surfaces is proposed. Existing flank milling path-planning methods typically use on-market milling tools whose shape is cylindrical or conical, and is therefore not well-suited for meeting fine tolerances for manufacturing of benchmark free-form surfaces like turbine blades, gears, or blisks. In contrast, our optimization-based framework incorporates the shape of the tool into the optimization cycle and looks not only for the milling paths, but also for the shape of the tool itself. Given a free-form reference surface and a guiding path that roughly indicates the motion of the milling tool, tangential movability of quadruplets of spheres centered along a straight line is analyzed to indicate possible shapes and their motions. This results in $G^1$ Hermite data in the space of rigid body motions that are interpolated and further optimized, both in terms of the motion and the shape of the milling tool itself. We demonstrate our algorithm on synthetic free-form surfaces and industrial benchmark datasets, showing that the use of custom-shaped tools is capable of meeting fine industrial tolerances and outperforms the use of classical, on-market tools.

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