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Feasible Offset Region Based Tool Path Planning for Face Milling

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Sponsored by CODEF

Abstract— This report describes the optimization of tool path plans to minimize burr formation while face milling powertrain components in the automotive industry. The algorithm controls conditions responsible for burr formation by manipulating tool offsets to generate a feasible region for selection of tool paths.

Keywords: algorithm, burr, edge quality, face milling, offset, tool path.

1. Introduction

Previous tool path planning algorithms developed by Chu [1] and Rangarajan [2] were based on designing contour-parallel tool paths that only avoid exit and assumed that edges with tool entrance do not have significant burr. But recently it has been observed that the burr formation increases as the entrance and exit angles increase. In addition, these algorithms are applicable only when the tool diameter is much smaller compared to the width of the work piece. This offers very high tool maneuverability and the machining is done in a multiple-pass operation. Due to the tight cycle time constraints, sometimes large cutters are used to complete the milling operation in a single pass and this class of operations offers very little maneuverability and hence completely avoiding exits in this case is not possible. The tool path planning scheme described in this report, minimizes burr formation in these single pass operations by controlling the exit and entrance angles by manipulating the tool offsets from the work piece edge.

2. Problem Definition

As mentioned in the Introduction, cycle time is one of the most important constraints to be respected at all times. In general terms, the required tool path must minimize burr size and volume while meeting the cycle time constraint. Based on the knowledge gained regarding the threshold for burr formation, the problem is restated to generate the tool path with minimum length, and with entrance and the exit angles below the threshold for every edge that is being machined. This threshold is a function of the work piece material parameters.

3. Algorithm

The algorithm generates the shortest tool path that minimizes the entrance and the exit burr formation , based on the setting of the machined contour. The tool path planner has been implemented in Visual C++ 6.0 and uses ACIS solid modeling kernel for performing the geometric computations, like finding the intersection between a line and a polygon. Figure 1 shows a flow chart of the tool path planner. In what follows, the steps involved in the algorithm will be explained in detail.

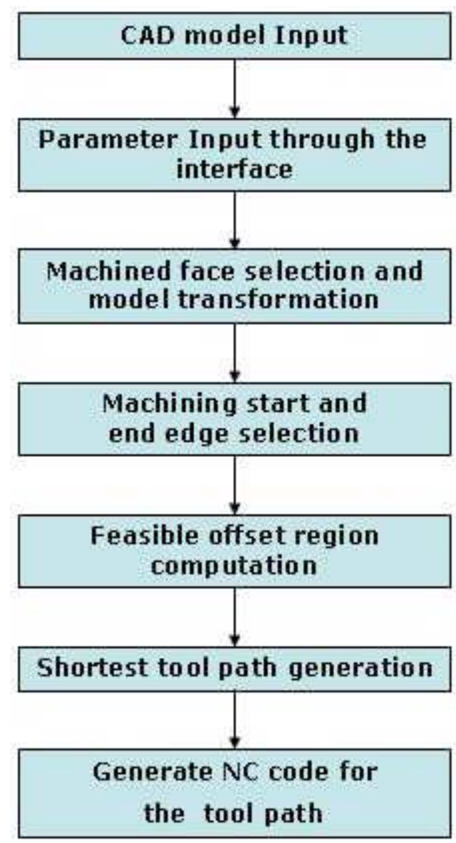

Figure 1. Flow chart for the tool path planning algorithm.

4. Input

The input for the implementation is a solid model of the extruded face that is being machined. As the ACIS API is used for performing geometric computations, it is required to have SAT format as the input format for the solid model. In addition, the diameter of the cutter and the insert geometry parameters are input through a dialog box. After the face selection, the only other information that the software needs is where to start machining and where to end it. This is obtained from the user using an interactive edge picking tool.

5. Feasible Offset region

The edges in the contour defining the face are offset into the work piece. The exit and the entrance angles, which are used as metrics for the entrance and exit conditions, are defined such that they increase as the offsets are increased. The offsets are modified to avoid push exits, which occur when the tool pushes material out of the work piece rather than machining it. The modified offsets are joined to form a region within which both the entrance and the exit angles are below the threshold. This region is called the feasible offset region. Figure 2 shows the feasible offset region for a section of a work piece.

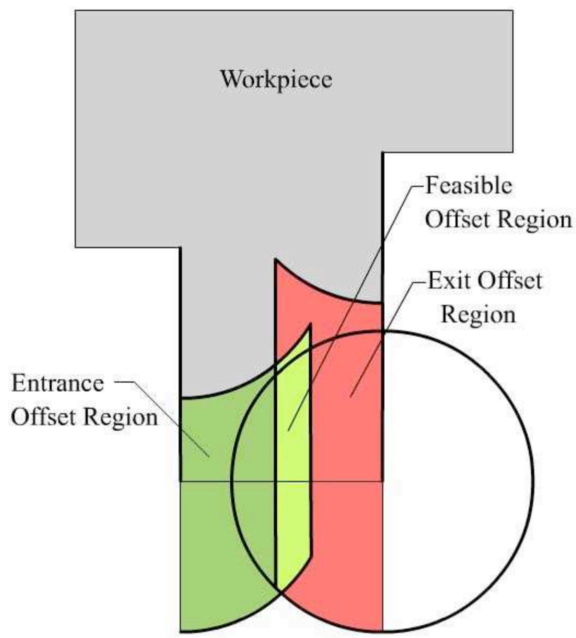

Figure 2. Feasible Offset Region.

6. Shortest Path

Theoretically, the tool can travel anywhere within the feasible offset region and satisfy the entrance and exit angle constraints. But one of the most important practical constraints, the automotive industry respects, is the cycle time constraint. So in order to minimize the cycle time, the shortest path must be chosen among other alternatives. The shortest path is generated by implementing the algorithm detailed in [3] using the triangulation algorithm available in [4].

References

[1] Chu, C.H., *Integrated Edge Precision Machining*, Ph.D. Dissertation, University of California at Berkeley, Department of Mechanical Engineering, 2000.

[2] Rangarajan, A., *Priority Based Tool Path Planning for Face Milling*, Masters Report, University of California at Berkeley, Department of Mechanical Engineering, 2001.

[3] Lee, D.T., Preparata, F.P., *Euclidean shortest paths in the presence of rectilinear barriers*, Networks, Vol. 14, 1984, pp. 393-410.

[4] de Berg, M., van Kreveld, M., Overmars, M. and Schwarzkopf, O., *Computational Geometry - Algorithms and Applications*, Springer, 2nd Ed., New York, 1999, pp. 45-60.