Material left cleaning operation

In TOPSOLID CAM for 3D Machining

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MISSLER SOFTWARE

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Outline

• Introduction of MISSLER Software and short demonstration of TOPSOLID.
• Clean up Machining Description
• Tools used in Machining.
• Approaches for Cutter Location points calculation.
• Material left removal operation steps and sample results.
Missler Software is an Industrial Partner participating in the SAGA Initial Training Network.

Missler Software is a leading global supplier of CAD, CAM and ERP solutions. The company has been in operation for more than 20 years and is classified as one of the leading CAD/CAM developers worldwide.

Missler Software offers an integrated solution for the mechanical industry (general mechanical design, special machinery, tool and die, subcontracting industries…) with its product lines TopSolid and GOelan.
TOPSOLID: An Introduction

TopSolid is an integrated CAD/CAM/ERP solution for the design and manufacture of products in diverse domains of activity: machines, plastic parts, tools, sheet metal, general mechanical engineering, wood working, etc. TopSolid is a single-source software solution that can be used to effectively meet all design, production and company-specific manufacturing control requirements.

- Mechanical Engineering
  TopSolid'Design, TopSolid'Cam

- Product Design
  TopSolid'Design, TopSolid'Draft

- Machining
  TopSolid'Cam, TopSolid'Wire, TopSolid'PunchCut

- Tool making
  TopSolid'Mold, TopSolid'Progress, TopSolid'Electrode

- Sheet metal
  TopSolid'Fold, TopSolid'PunchCut

- Wood working
  TopSolid'Wood, TopSolid'WoodCam

- Management
  TopSolid'Pdm

- ERP
  TopSolid'Erp

TopSolid'Erp is a fully integrated ERP system which responds to all supply chain requirements from commercial to production management. TopSolid'Erp offers a complete solution for the following areas: Commercial administration, management of technical data, shop floor management, client support and PDM (Product Data Management). TopSolid'Erp is fully integrated with the TopSolid CAD/CAM range of products, thus allowing full integration between all company departments.
Clean-up Machining or Material left Removal Operation

The clean-up machining discussed is pencil-cut and fillet-cut for a polyhedral model of the STL form with a ball-endmill. The Pencil points are obtained from the Parallel cutting planes on the xz, yz, and xy planes.

The purpose is to generate Pencil-point curve and then to generate the fillet-cut path in order to remove uncut volumes, which are left at concave regions after finish Machining, by employing ball end-mills of the same or smaller sizes.
Fig: Tool path generation for clean-up machining.
  a) Uncut Volumes (Material left)
  b) Pencil-cut
  c) Fillet-cut
The name comes from the way that a pencil could naturally be drawn along these corners. It's sometimes called a rolling ball toolpath
Tools used in Machining

- Cone End Mill
- Rounded End Mill
- Inverted Cone End Mill
- Cylindrical End Mill
- Ball End Mill
- Bull Nose End Mill
- Taper End Mill
- Taper Ball End Mill
- General End Mill

REAL CUTTER
KENNAMETAL End Mill with Insert Tool Number: KIRP125-RP3 Insert Number: RPGB-325
The machining operation is commonly performed by 3-axis milling using ball-end mills because they are more easily positioned with respect to design surface and therefore results in Simpler NC code to machine the surface. Though 5-axis flat end milling offers many advantages, including faster material removal rates and improved surface finish, it has a number of drawbacks, such as motion specification and collision avoidance. 3-axis milling is relatively cheap, commonly available and suitable for surfaces with high curvature variations.
Gouge points

Fig: Problem of Detecting Gouge points in Point to Point based tool path generation.
Offsets

Offset curves are defined as the locus of the points which are at a constant distance \( d \) along the normal from the generator curve. Let \( C(t) = (C_x(t), C_y(t)) \) be the curve for parameter \( t \). Then \( C_{\text{offset}}(t) = C(t) + dN(t) \).

The unit Normal \( N(t) = \frac{(C_y'(t), -C_x'(t))}{\sqrt{C_x'(t)^2 + C_y'(t)^2}} \).

However facets are used to generate offsets in our case.
Offsets of vertices in Polyhedral Models

Offsets when ball-end mill is used.
Example

Fig: An example of the parallel-cutting planes method for a polyhedral model
(a) A polyhedral model.
(b) The local offset model.
(c) Untrimmed CL-curves (Cutter Location)
(d) CL-paths (Cutter Location paths)
Steps for Material Left Removal Operation

1. Polyhedral model
2. Machining conditions
   - Generate scanning tool paths (yz planes)
   - Generate scanning tool paths (zx planes)
   - Generate contouring tool paths (xy planes)
   - Detect pencil point candidates
   - Trace pencil-cut paths
   - CL-data for pencil-cut
   - Bi-contact vectors
   - Calculate cutter location points for fillet-cut
   - Trace fillet-cut paths
   - CL-data for fillet cut
Steps for Material Left Removal Operation

• Parallel drive planes cutting the STL model in each of XZ, YZ, and XY planes.

  Discretized Scanning line and projection on to the faceted offset shape. Smoothening of the curve linking the projected points for each line, using tangent vector of each point with that of the next point. (Looking for closed curves in case of XZ plane)

• Detecting Pencil points.
  Compare the tangent vectors of each point with that of the next.
  Compare the normal vector of the next point with the previous point and the successive point.
  Check for material left condition using the middle point (the candidate for Pencil point)
  Create the Pencil point with the two normal vectors.
Sample Results: Cuts on Part
XY Drive plane cuts to detect nearly Vertical Pencil point curves
Pencil point

Fig: Pencil point detection. Each Pencil point has two Normal vectors to the faceted Shape. Angular tolerancy is the primary measure used in detection. Material left check is a more stringent check which is computationally time-consuming.
Steps for Material Left Removal Operation

• Linking of Pencil points to get a Pencil Curve

   Pencil points are stored separately according to the cuts (drive planes) that generated them.

   For each such stored list, look for a starting Pencil point and proceed to look for the next point to be linked along its own cut and along the immediate neighboring ‘grid lines’ which results in searching for linkable points in a cuboid.
Pencil point Curve for later use
Fillet-Cut: Future work

Fig: Fillet-Cut path generation for removing the material left by previous operations.
Pencil points from XY drive plane cuts
And Material left curves display.
Linking of Pencil points (work in progress)
Close up of Linking of Pencil-points
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References


Thank you