Wide area machining of surface texture with regular pattern

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Background

- It is difficult to make the texture with wide area by machining.

Example of texture

Problems
- The huge data (Image, CAD data)
- Time consuming to create the CL data for small tool
- Disagreements of boundary of data

Transcription of CL data with similar shape

Making of wide area texture

(a) Design  (b) Classification by shape  (c) Generation of CL Data
(d) Generation of wide area CL data  (e) Mapping of CL data  (f) Machining

Proposed procedure to machine the surface texture
Design

• Design using CG/CAD software or mathematics function
• Design the narrow area where shape of texture can be recognized

convert to STL format

Classification of shapes on the surface texture (1/2)

(a) STL data
(b) Calculation of critical point
(c) Calculation of course lines
(d) Classification of shapes

(a) Peak
(b) Pit (Valley)
(c) Saddle point
Classification of shapes on the surface texture (2/2)

Generation of CL data on the similar shape (1/2)

- CL data: X, Y, Z coordinate, Tool vector (A, B, C)
- Tool path: Spiral

- Plane □ 3 axis machining
- Mapped texture □ 5 axis machining
Generation of CL data on the similar shape (2/2)

- Smoothing of CL data
  - Doo-Sabin subdivision (twice)
  - Application of curved Bezier surface

- Calculation of surface curvature to offset the radius of ball end cutter

Generation of CL data with wide area

Movement and rotation of CL data of each similar shape

Narrow area

Wide area
Mapping of CL data

Designed shape: 3D sine curve

\[ Z = A \sin(X/\lambda x - \phi_x)\sin(Y/\lambda y + \phi_y) \]

Machined samples

Machine: Roland MDX-650A
Conditions
Spindle speed: 40,000rpm
Feed rate: 600mm/min
Radius: R1.0mm
Machining time: 4h15m
Amplitude A: 1.0mm
Cycle: 5.0mm

Machine: Roland MDX-650A
Conditions
Spindle speed: 40,000rpm
Feed rate: 600mm/min
Radius: R0.25mm
Machining time: 9h15m
Amplitude A: 0.2mm
Cycle: 1.0mm
Assessment of machined texture

Machine: DMG ULTRASONIC 70-5
Conditions
Spindle speed: 14,000rpm
Feed rate: 800mm/min
Radius: R1.0mm