Study on the NC Cutting Technology of Glass Bulb Panel’s Surface

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Abstract: Tool path of NC machining is one of the important parts to determine NC machining process. Whether the tool path quality is good or bad will directly affect the machining and the machining cost of part. For this, representative part aiming at little fluctuation of cutting force of superficial quality milling cutting tool path creative method of representative part is studied in this paper. Throw optimized several cutting tool paths of the D28 panel model’s surface and the other same Figure, we get the best strategy about NC programme.

Introduction

Punches surface processing is generally performed on CNC machine, requirements of which are strict for machine, fixtures, cutting tools, tool holders and processing tool path strategies. Unreasonable path will cause cutting load mutations, leading to impact, low quality, and damage to the tool, which is much more severe in ball-end mill processing because of its high parameters than other processing. Therefore, it is necessary to optimize the tool path on punches surface so as to minimize study the cutting load mutations.

Aim for optimization of tool path on punches surface

Optimization of tool trajectories based on minimum cutting force fluctuation

Experiment Condition

Work piece: Punches surface as shown in Fig.1, aiming at optimizing ball-end mill and tool influence on cutting force, 3Cr13 stainless steel, dry cutting.

Tool: Φ30 cemented carbide indexable inserts SRG30C, Mitsubishi
Machine: Vertical CNC, Toshiba
Measuring Instrument: Pressure indicator, as shown in Fig.2

Figure 1. Punches Surface. Figure 2. Pressure indicator.
Experiment Method

- **Milling parameter**: spindle speed \( n = 1400 \text{r/min} \), cutting speed \( V = 132 \text{m/min} \), feed rate \( V_f = 900 \text{ (mm/min)} \), \( ap = 2 \text{mm} \), \( ae = 3 \text{mm} \)

- **Experiment tool path**: The experiment tool paths are shown as the figure below, programs of which are generated with UG.

1. Y-axis section method as shown in Fig.3, the tool trajectory is the intersection line between the D28 punches surface and a set of plane sections, which are perpendicular to Y-axis. The direction of feed rate is along X-axis. The stepover along Y-axis is 3mm.
2. X-axis section method as shown in Fig.4, the tool trajectory is the intersection line between the D28 punches surface and section, which are perpendicular to X-axis. The direction of feed rate is along Y-axis. The stepover along X-axis is 3mm.
3. Contour method as shown in Fig.5, the tool trajectory is the intersection line between the D28 punches surface and a set of plane sections, which are perpendicular to Z-axis. The punches surface is processed from the top in circuit cut. The stepover along Y-axis is 3mm.
4. Optimal contour method as shown in Fig.6, the punches surface is processed from the top in circuit cut. The stepover along curved surface is 3mm.
5. 3D offset method as shown in Fig.7, the punches surface is processed from the top in circuit cut, with equal distance on X-axis, Y-axis and Z-axis respectively. The stopover along curved surface is 3mm.
Experiment Scheme
D28 punches surface semi-finished product installed on dedicated fixture plate with bolts, is processed within 5 tool paths respectively. Record the cutting force value and surface quality, compare the cutting sound respectively.

Experiment result and analysis
Comparison of average cutting force among 5 tool path is shown in Fig.8, comparison of difference values of maximum and minimum cutting force among 5 tool path is shown in Fig.9, by recording and analyzing the cutting force.

As shown in Fig.8 and Fig.9, the least cutting force fluctuation exists in 3D offset method (Fig.7), while the greatest exists in contour method (Fig.5). The ascending order of cutting force fluctuation of 6 tool paths is 3D offset method-- Optimal contour method-- X-axis section method(sections perpendicular to X-axis)-- Y-axis section method(sections perpendicular to Y-axis)-- Contour method(sections perpendicular to Z-axis)

For 3D offset method and contour method, the stepover of tool trajectory along curve surface is uniformly distributed, the cutting area hardly fluctuates, leading little cutting force fluctuation. For section method, the stepover of tool path is uniformly distributed along axis, nonuniformly along curve surface, result in great change on cutting area and fluctuation of cutting forces.

For section method, the fluctuation of cutting force is mainly influenced by the surface curvature. In the condition of D28 punches surface (Rx=1300mm, Ry=1000mm, Rz=900mm ), the
value and fluctuation of tool path curvature change as the section orientation differs. The least curvature value is in contour method, followed by Y-axis section method and the greatest curvature value is in X-axis section method. As shown in Fig.8 and Fig.9, the greatest value and fluctuation of cutting force is in contour method, followed by Y-axis section method and X-axis section method.

Analysis on each tool path is below:

1. Contour method: the value and fluctuation of cutting force is measured greatest, while the processing time is little and worst surface quality. Chips impede severely on processing the top of the D28 punches surface. Unstable status leads to uneven grooves on the surface.
2. Y-axis section method: the value and fluctuation of cutting force are both great on X-axis and Y-axis and little processing time. Obvious tool marks exist on the top of punches surface.
3. X-axis section method: the value and fluctuation of cutting force are both little on X-axis and Y-axis and longest processing time. The roughness of surface is poor, especially obvious tool marks exist on the top of punches surface.
4. Optimal contour method: the value and fluctuation of cutting force are generally little on X-axis and Y-axis except the fluctuation on the top of D28 punches surface. Stable surface quality and long processing time.
5. 3D offset method: the value and fluctuation of cutting force are both least on X-axis and Y-axis and long processing time. As same distance on X-axis, Y-axis and Z-axis, spiral feed to process greatest surface quality.

Summary
This article explores the requirements for ball-end mill on D28 punches surface, experimentally research the optimization on tool path based on the control of cutting force fluctuations, and proposed a programming strategy on the basis of the D28 punches surface. Following are the conclusions.

1. For ball-end mill tool path, spiral feed and arc feed are the best choice, and offset path is better than parallel path.
2. The tool path that stepover is uniform along the curve surface should be selected based on the characteristics of machining surface to minimize the fluctuation of cutting force.
3. The experiment indicates that the cutting force fluctuation is related to curvature of surface. As the curvature increases, cutting force decreases.
4. The orientation of maximum curvature should be selected as orientation of tool trajectory to minimize the cutting force.
5. The orientation of minimum curvature fluctuation should be selected as orientation of tool trajectory to minimize the cutting force fluctuation.
6. The conclusion above can be applied to the programming strategy for D28 punches surface and the mould in similar shape feature.

References: