Introduction to micro manufacturing

Business, Industries

Introduction

A microlens array is composed of a series of micro lens distributed in a regular pattern and has been usedin a wide range of photonic products.

A micro lens is a small lens, generally with a diameter less than a millimetre (mm) and often as small as 10 micrometers (µm). The small sizes of the lenses means that a simple design can give good optical quality but sometimes unwanted effects arise due to optical diffraction at the small features. A typical micro lens may be a single element with one plane surface and one spherical convex surface to refract the light. Because micro lenses are so small, the substrate that supports them is usually thicker than the lens and this has to be taken into account in the design.

More sophisticated lenses may use aspherical surfaces and others may use several layers of optical material to achieve their design performance. Since surface roughness affects the performance of the lens, one needs to generate finely machined surface with minimum roughness Single Point Diamond Turning machining is a technique which removes materials from a few microns to sub-micron level to achieve ductile mode machining on hard-to-machine materials such as electro less nickel plating, silicon, quartz, glass and ceramics with no subsurface defects.

Such a machining process is able to achieve mirror surface finish of less than 10 nm and form error of less than 1um easily. If properly applied to a specific range of diamond turnable materials, the process is far superior to grinding and polishing where shape control is more difficult and processing time is longer. The selecting and optimization of machining parameters is one of the main factors that could influence the machining accuracy. The main machining parameters are tool feed rates, spindle speed and depth of cut.

The tool feed rate is normally expressed in terms of either distance travelled by the tool per unit time (mm/min) or distance travelled per unit rotation (mm/revolution). It is most common to see the distance per revolution as it is directly related to the anticipated theoretical surface finish. For a given tool feed rate, larger the tool nose radius, lower the roughness and the better the optical surface finish. The surface quality depends to great extents on the material characteristics like: grain size, micro structure or crystal boundary, crystal uniformity and annealing procedures adopted. Casual selection of combination of machining parameters may affect the surface quality, so it is required to optimize the machining parameters before final SPDT process. Machining of aspheric surface is more complicated than spherical and flat surfaces because of complicated tool path and uneven material removal. To achieve required profile tool path should be optimized. Surface roughness withrespectto variable Feed rate Feed rate is most important parameter and variation of this havea great impact on the surface finish. Theoretical surface finishdepends on feed rate and tool radius.

Depth of cut 2m andRPM 1000 kept constant and tool feed rate is varied from 0. 5 m/rev to 5. 0 m/rev. the results of the experiments are asfollows. From the above experiments, it is observed that the surface finish is going down as we reduce feed. The surface roughness is 54. 8 nm at feed 0. 5 m where the depth of cut is 2 m and 1000 RPM was maintained. It is investigated that although look of the surface was good but it is not of optical quality at these parameters. We have varied the depth of cut at feed rate of 0. 5. Surface roughness with respect to variable depth of cut

From the above experiments, it is observed that the surface finish is depending on the depth of cut but its behavior is different. As we increase the doc from 1 m to 2 m the roughness decrease from 117 nm to 54 nm and again increase the roughness on of doc. Same is again repeated on 8 m doc. The surface roughness is 54. 8 nm at feed 0. 5 m/rev where the depth of cut is 2 m and 1000 RPM. But it is investigated that surface is not optical at these parameters, the surface quality was dull after 10 m doc and there no use of increasing the doc more than 10 m.

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Surface roughness with respect to variable RPM From the last experiment we have seen that the depth of cut 2 m giving the better surface. During this experiment feed rate 0. 5 m/rev and depth of cut remained unchanged and RPM varied from 800 to 4000, to get the further better surface on the work piece. Analysis of turned work piece at different RPM is carried out. Output result is shown in above table. By experiments we have seen that polycarbonate surface turned to the surface finish of below 25 nm, which is achieved at RPM 3000. A good surface finish is achieved at 800 RPM also but it is not economical.

At RPM 1500 we have observed the star pattern on surface of PC. So, RPM 3000, Feed 0. 5 m/rev and depth of cut 2 m are the optimum parameters where optical surface is achieved. An empirical formula is developed for predicting surface roughness of diamond turned polycarbonate at different turning parameters (feed rate, depth of cut and RPM). Empirical formula is derived as follows. Optimum turning parameter are suggested where the optical surface finish in obtained. Tool feed rate : 0. 5 m/revolution Depth of cut : 2 m RPM : 3000

Tool Path Compensation

Another study shows the greatest challenge lies in selecting the optimum combination of the process parameters to get the best surface quality. The parameters chosen for optimization are as: Spindle speed (SS), Feed rate (TFR), Depth of cut (DoC). Another parameter to optimize the machining is the tool path. The tool path compensation cycle starts with the definition of desired aspheric surface by the conic equation: It is observed that by modifying the tool path, profile error ofaspheric surface is significantly reduced.

Conclusions:

- Tool feed is the dominant parameter for surface roughness followed by the spindle rotational speed. Depth of cut shows minimal effect on surface roughness compared to other parameters.

- Depth of cut is the leading parameter for peak to valley error, followed by spindle rotational speed. Feed rate does not have considerable effect on Pt.
- Effect of depth of cut on Pt varies with spindle speed. However, for achieving good optical surface on the polycarbonate work piece, lower depth of cut is preferred.
- Spindle rotational speed of 2000rpm, tool feed rate of1 m/rev and depth of cut of 2 are selected for precisemachining of polycarbonate.
- The process of the optimization of tool path helps to optimize the machining process further.

References:

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