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An Overview on Nano Metric Surface Finishing Techniques

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Abstract: This paper deals with free form optics, ELID, partial ductile mode grinding, ductile regima grinding, four domains of material removal, selection of tool materials, ultra precision grinding, aspherical surface generation grinding wheel. Advantages, disadvantages, applications, operation of the above methods were also discussed in brief manner for understanding the concepts. This paper would be useful for the readers to know the basic concepts in the nano metric surface finishing techniques.

Keywords: ELID, partial ductile mode grinding, ductile regima grinding, ultra precision grinding, aspherical surface generation grinding wheel

1. INTRODUCTION

ELID is used for Material removal of hard and difficult-to-cut engineering materials. Free form optics is asphere with non-rotational symmetry. It is also called as conformal optics. Nano meter order surface roughness is obtained by using partial ductile mode grinding. Ultra precision grinding is used to brittle materials to a very close tolerance.

2. FREE FORM OPTICS

It is not symmetric about any axis of revolution. It is asphere with non-rotational symmetry [1]. It is also called as conformal optics. It is the combination of aspheric, spherical, cylindrical, conical, diffractive, Plano or o-give shapes. Fabrication requires multi – axis machining.

2.1 Comparison of free form surface

Process	Surface finish, RMS (nm)	Form accuracy (nm)
Diamond mill	1.5	0.204
Diamond turning	3	0.052
Diamond grinding	4.4	0.214

3. ELECTROLYTIC IN-PROCESS DRESSING (ELID) GRINDING

It is used for Material removal of hard and difficult-to-cut engineering materials. ELID = Electrolytic reaction + Grinding. In this process, Electrolysis occurs between conductive anodic wheel and highly conductive cathode in the process of a special electrolyte [2]. Wearing of anodic oxide allows efficient grinding.

Grinding
↓
Laser technologies
↓
Electro discharge dressing
↓
Electro chemical dressing
↓
ELID

Figure 1 Process involved in ELID

3.1 ELID cell

It has four main components

1. Metal bonded grinding wheel
2. Cathode
3. DC power supply
4. Electrolyte

3.2 Steps in ELID

1. Start of dressing

2. End of dressing
3. Start of ELID
4. Stabilization of ELID

3.3 Advantages of ELID

1. High surface finish is obtained.
2. It is used to machine ceramics, glasses and silicon wafers.
3. It is used to achieve final surface finish at sub micron level.
4. Nano – surface finish of brittle materials is obtained.
5. It is used for finishing with super abrasive diamond grids.

3.4 Applications of ELID

1. Surface grinding
2. Cylindrical grinding
3. Internal grinding
4. Centre less grinding
5. Precision of CVC – SiC
6. Reflection mirrors

4. PARTIAL DUCTILE MODE GRINDING

The conventional grinding process produces 100% fractured surface [3]. It is used for machining brittle materials such as

1. Glass
2. Silicon
3. Germanium
4. SiC
5. Ceramics

Nano metre order surface roughness is obtained.100% ductile mode machining of brittle materials is obtained.

4.1 Ductile regima grinding

For smaller dimensional material removal, plastic flow of material will take place without fracture. It is used to machine brittle materials like glass, ceramics using single or multi point diamond tools [4]. Materials are removed by plastic flow leaving a crack free surface. This is called as ductile regima machining. Material removal is due to shearing. Material is planed off at a micro – scale level.

4.2 Four domains of material removal

Domain 1

Material removal takes place by

1. Chemical
2. Mechanical
3. Thermal effects

Small quantity of material is removed.

Domain 2

Material is ideal crystal. No dislocation is present. Dislocation occurs due to brittle fractions.

Domain 3

Plastic deformation and crack initiation is responsible for material removal.

Domain 4

Material removal is due to cracks.

4.3 Selection of tool materials

Materials	Tools
Brittle materials	Diamond
Hardened steels	CBN abrasive
Normal steel cast irons	Aluminum oxide
Non - ferrous	SiC

4.4 Features

1. High accuracy servo mechanism resolution of 1.25 to 10 nm is obtained.
2. High loop stiffness is obtained.
3. Full flood coolant
4. Depth of cut less than 1 μm is obtained.

4.5 Advantages

1. Nano metric surface finish
2. Provision of controlled, predictable machining
3. Impart desirable compressive stresses
4. Provision of predictable surface finish patterns
5. Broadening the range of machinable materials.

4.6 Drawbacks

1. It produces vibration
2. Lubricant penetrate into the cutting zone
3. Problems occur due to shatter contact time

5. ULTRA PRECISION GRINDING (UPM)

It is used to brittle materials to a very close tolerance.

Depth – 10 nm to 1 μm.

5.1 Operation

It is similar to conventional grinding. Grinding takes place at the speed of 10,000 to 70,000 rpm. Diameter of grinding wheels is 3 mm to 15 mm. Smooth friction free spindle rotation is done by turbine drive [5].

5.2 Features of UPM

- Slide geometric accuracy is less than 1 μm.
- Spindle error motions are less than 50 nm.
- Control and feedback resolutions are less than 10 nm.
- Dimensional accuracy is 1 μm.
- Surface form accuracy is 100 nm.
- Surface texture accuracy is 5 nm.
- It produces high degree of thermal stability.
- It produces high degree of stiffness.
- It produces high degree of damping.
- It produces high degree of smoothness.

5.3 Applications

1. Free form optics
2. Eye wear
3. Electro – optics
4. Defense and automotive industries
5. Mirrors for surveillance
6. LTV lens for lithography
7. X – rays for lithography
8. Laser rods and windows for defense
9. Semiconductor
10. Lithography
11. Imaging technology

6. ASPHERICAL SURFACE GENERATION GRINDING WHEEL

6.1 What is Aspherical Surface?

It is a surface with basic conical section form [6].

6.2 What is the need for Aspherical Surface?

It is used

1. To produce better image quality
2. To reduce spherical aberration in lens
3. To meet the demand in the advancement in the field of optics, astronomy and IR applications

6.3 What are all the manufacturing methods for producing Aspherical Surface?

6.3.1 Molding

Small glass or plastic aspheric lenses are made by molding.

6.3.2 Advantages

1. Cheap
2. Mass production
3. Good performance

6.3.3 Applications

It is used to manufacture small aspheric lenses for

1. Inexpensive consumer cameras
2. Camera phones
3. CD players
4. Laser diode collimation
5. Coupling light into and out of optical fibers

7. CONCLUSION

This paper has dealt with free form optics, ELID, partial ductile mode grinding, ductile regima grinding, four domains of material removal, selection of tool materials, ultra precision grinding, and aspherical surface generation grinding wheel. Advantages, disadvantages, applications, operation of the above methods were discussed in brief manner for understanding the concepts. This paper would be useful for the readers to know the basic concepts in the nano metric surface finishing techniques.

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