"IMPROVEMENT OF SURFACE FINISH OF CERAMICS"- A REVIEW

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Abstract

Surface finish is one of the most critical quality measures in many ceramics industries. Global competition and enhanced customer awareness has increased the need for better surface characteristics like surface finish both for function and aesthetics. Nowadays grinding is one of the most popular methods of machining hard materials. The most frequent reason for grinding is that the part material is too hard to be machined economically by a non-abrasive process. Ceramics among the hardest of materials can be processed only by grinding. There are parameters such as feed rate, depth of cut that are known to have a large impact on the surface finish. The significance of the grinding parameters on the selected responses can be evaluated using analysis of variance. This paper provides valuable insights into the surface finish of ceramics.

Keywords- Surface Finish, Surface Roughness, Ceramics, Grinding

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1. INTRODUCTION

In today's world, ceramics has gained lot of value in engineering applications. This is due to the fact that ceramics has higher hardness and temperature resistant property. Due to interchangeability criteria, customers have focused on the high surface finish as well as accurate and precise dimension of the product. Ceramic products are chosen for their surface qualities like finish, lustre, glow, etc., especially in decorative products. The other criteria for choosing higher surface finish is that if the product has higher surface finish then the product can be assembled easily and it can have air tight condition so that no leakage will be there. A poor surface finish may result in rapid wear or excessive vibration for the moving parts in service. Surface finish can be improved by two methods which are as follows:

1. By grinding, lapping, polishing, etc.
2. By glazing.

Glazing can improve surface finish to higher extent without much cost but it has disadvantage that it can't remove the profile waviness and dimension of the product is not accurate. This is due to the fact that on molding the product, it is shrunk and the dimension of the product is changed to a higher extent which is undesirable. Because of these reasons the product is to be machined i.e. grinding, lapping, polishing, etc.

Since ceramics are hard material, it is difficult to remove the material and to the desired dimension and surface finish. With using conventional wheel it is difficult to grind ceramics. It requires higher time to grind ceramics using conventional wheel. Because of this fact, people use super abrasive wheel i.e. diamond wheel to grind the ceramics material. As the surface finish increases, the cost of the product also increases.

2. LITERATURE REVIEW

Anne Venu Gopal et al. [1] studied on the effect of grit size, grit density, depth of cut and work feed on surface finish and damage produced during grinding of silicon carbide. They did experimental work to find out the significant parameters that affected surface roughness and surface damage. The purpose of the study is to develop mathematical models to find out the optimum grinding parameters using genetic algorithm. They found that by increasing grit size, the finish of product increases to a great extent. By decreasing depth of cut, surface finish increases. By increasing feed rate, surface finish decreases. By increasing grit density, surface finish increases.

Xianbing Liu et al. [2] studied on the surface grinding of thermally sprayed nanostructured WC/12Co and $Al_2O_3/13TiO_2$ (n-WC/12Co and n-$Al_2O_3/13TiO_2$) coatings. Cup type diamond wheels were used to grind the coated samples. The grinding wheel had three different bond types and three grit sizes for investigating effects of bond type and grit size on grinding forces, surface finish and topography. A surface profilometer was used by them to measure surface finish (Ra). The ground n-$Al_2O_3/13TiO_2$ coatings have a minimum Ra at a certain depth of cut, which is somewhat 15 µm. When the depth of cut is smaller than 15 µm, an increase in depth of cut results in a decrease in Ra. Beyond 15 µm, Ra increases with the increase in depth of cut. At the depth of cut of 15 µm, the increase of feed rate results in a larger surface roughness Ra. It is known that resin bond is softer than vitrified bond.

For the n-WC/12Co coatings, the ground surface roughness does not show the same trend as for the n-$Al_2O_3/13TiO_2$ coatings in terms of depth of cut. For this coating, larger depth of cut results in rougher surface. It is also shown that larger feed rate results in higher roughness. For the same grit size, metal bonded diamond wheel results in higher roughness than resin and vitrified bond [2].

Sanjay Agarwal et al. [3] studied the grinding characteristics of silicon carbide in grinding under the aggressive grinding conditions with the high removal rates using a resin bonded 121 µm grit (100% concentration) diamond grinding wheel. The high removal rates were obtained by increasing feed rate. The roughness (Ra) of the ground surfaces was measured using a Taylor Hobson Profilometer (Talysurf-6 with cutoff value 0.8 mm). He found that increasing the material removal rate did not affect surface finish.

Zhaowei Zhong [4] studied that grinding/lapping operations using inexpensive machine tools can produce ductile streaks on glass and silicon surfaces under good grinding/lapping conditions. This resulted in significantly shortened polishing time to secure an acceptable surface finish. Toroidal SiC surfaces ground with flat-face cup wheels indicated 100% ductile machining, and did not require polishing. Ground ZrO_2 showed a numerous ductile streaks. Plastic deformation was the major mechanism of material removal at high wheel speeds. The finish improves with increasing grit size of the diamond grinding wheels and decreasing diamond concentration.

3. SELECTION OF PARAMETERS IN GRINDING

A. Depth of Cut

Depth of cut is a depth of work material removed per revolution or table pass. Depth of cut is the thickness of material removed in a grinding operation. Depth of Cut is expressed in micron.

B. Feed Rate

The speed when the grinding wheel moves through the material. The speed of grinding wheel movement is called the feed rate. The Feed rate is measured in metre per minute or millimetre per second.

C. Coolant Flow Rate

Flow Rate is an amount of Coolant passed to the grinding zone within unit time. It is expressed in litre per minute.

4. THE GRINDING PROCESS

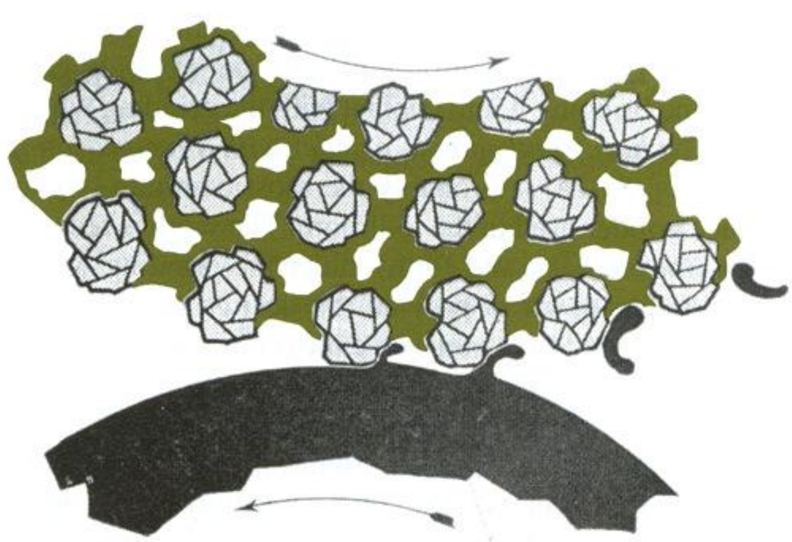

Fig. 1 Cutting action of abrasive grains

Grinding is one of the most popular methods of machining hard materials i.e. Ceramics and carbide. Usually, grinding is one of the final operations of the technological process. Properties of surface layer created in grinding influence directly to the functional properties of the workpiece such as fatigue strength, wear resistance and corrosion resistance, etc.

In the grinding process, the work piece is kept in contact with the revolving grinding wheel. Each small abrasive grains on the periphery of the wheel act as an individual cutting tool and removes a chip from workpiece as shown in Figure 1. As the abrasive grains become dull, the pressure and heat created between the wheel and workpiece cause the dull face to break away, leaving new, sharp cutting edges.

The grinding machine can be of either cylindrical, centerless, profile or surface grinding, but the grinding process is same and general rules are applied in all the cases which are given below:

1. A silicon carbide wheel for low-tensile strength material and aluminium oxide is used for high tensile strength materials. Diamond wheel is used for harder materials. Cubic Boron Nitride is used for ferrous materials.
2. A hard wheel is used for soft materials and vice versa.
3. The speed of the workpiece (rpm) can be increased if the wheel is too hard or the speed (rpm) of the wheel can be increased to make it act as a softer wheel.
4. The speed of the workpiece (rpm) is decreased or the speed of the wheel (rpm) is increased if the wheel appears too soft or wears rapidly.
5. A glazed wheel will affect the finish, accuracy, and material removal rate. The main causes of wheel glazing are:
   A. The wheel speed (rpm) is too fast
   B. The workpiece speed (rpm) is too slow
   C. The wheel is too hard
   D. The grain is too small
   E. The structure is too dense, which causes the wheel to load
6. If a wheel wears too quickly, the cause may be any of the following:
   A. The wheel is too soft
   B. The wheel speed (rpm) is too slow
   C. The workpiece speed (rpm) is too fast

D. The feed rate is high

E. The face of the wheel is too narrow

5. SURFACE FINISH

The actual cross-section of a ground surface viewed at high magnification is far different from the ideal flat, cylindrical or curvilinear surface indicated on a drawing. Geometrically, the surface is seen to have a large number of minute irregularities (peaks and valleys) superimposed on more widely spaced undulations (waviness). The figures given below are the different parameters of surface finish.

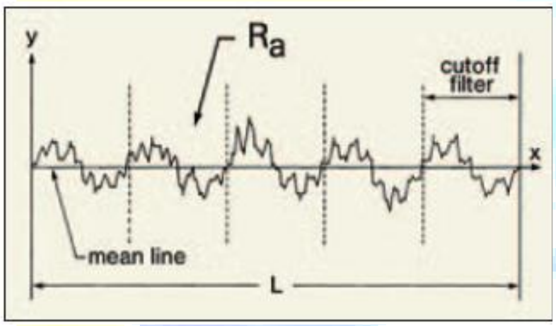

Fig. 2 Ra is the arithmetic average deviation from the mean line within the assessment lenth (L).

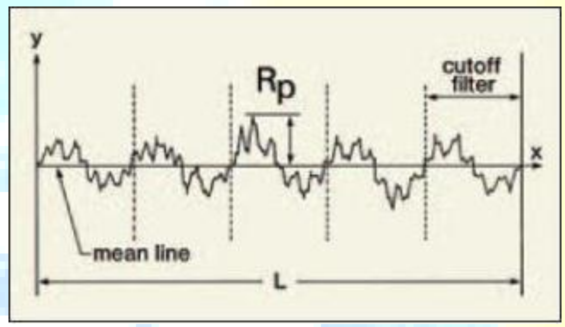

Fig. 3 Rp is the maximum height of the highest point of roughness above the mean line.

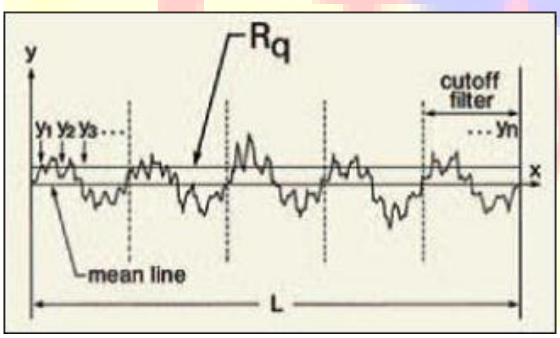

Fig. 4 Rq is the RMS value of roughness.

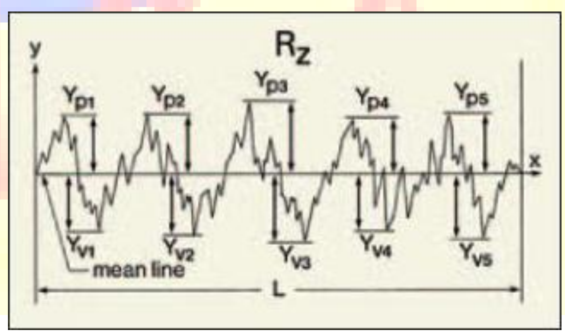

Fig. 5 Rz is the average height difference between five highest peaks and five lowest valleys of roughness.

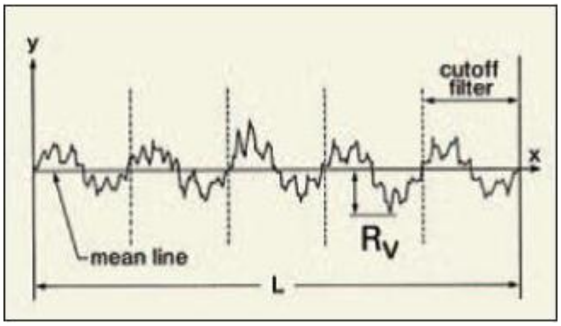

Fig. 6 Rv is the maximum depth of the lowest

point of roughness below the mean line.

INSTRUMENTS USED FOR MEASUREMENT OF SURFACE FINISH

Most of the instruments available commercially are based on a mechanical-cum-electronic principle. A diamond-tipped stylus is mechanically moved over the surface and the deflections of the stylus are converted into electrical signals are then amplified electronically and passed through an analyzer (or computer) which indicates the appropriate value on a suitably calibrated scale. In some cases there is provision for recording the surface profile in the form of a graph. A great majority of the instruments have pickup heads with spherical skids. These skids provide a datum surface which follows the major form errors of the measured surface and helps in eliminating the effect of such errors on the surface finish value.

Cutoff Filter Length

The cutoff filter length is a definition used by a United States Standards group to define the filter length for waviness and roughness data. (International Standards use a similar format). In modern profiling instruments, this is a digital filter in the analysis software incorporating a Gaussian Filter. The cutoff filter is used to specify the range of spatial wavelengths (or the spatial frequencies) in the waviness and roughness data. It is important to note that a roughness number, such as Ra and RMS, are meaningless without specifying the cutoff filter used in the roughness calculation. The concept of a cutoff filter is similar to a high pass filter in electronics. A high pass filter will pass frequencies higher than its cutoff and block lower frequencies. For surface profile data it is useful to describe a high pass filter as passing high spatial frequencies (or short wavelengths). A cutoff filter must be specified for analysis of either the roughness or waviness data [5].

Table 1 Standard Cutoff Filter Definitions

Cutoff Filter Length (mm)	Scan Length with 5 Cutoff Lengths (mm)	Number of Sections For a 100 mm Scan
0.080	0.400	1250
0.250	1.250	400
0.800	4.000	125
2.500	12.500	40
8.000	40.000	12

6. CONCLUSIONS

The findings have shown that the use of a metal bonded diamond grinding wheel results in a higher normal grinding force as compared to that obtained with resin bonded diamond grinding wheel. It is due to the fact that metal bond is harder than resin bond. Due to high normal grinding force, the surface finish of the product decreases. In the high speed grinding process, an increase in the wheel speed would reduce the maximum chip thickness, and thus the grinding force and it results in getting higher surface finish. Increasing depth of cut increases grinding force and which causes lower surface finish. Increase in grit size increases surface finish. Increase in grit density results in increasing surface finish.

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