

LITERATURE REVIEW ON OPTIMIZATION OF FINISHING OPERATION IN A CERAMIC MATERIAL

Ashutosh Shivdhar Shukla

Mechanical Engineering. Department, SBM Polytechnic, Mumbai, India.

Dr. Sanjay Kumar

HOD, Automobile Engineering, Saboo Siddik College of Engineering, Mumbai, India.

ABSTRACT

Super finishing is a micro-finishing process that produces a controlled and smooth surface condition on work pieces. It is not primarily a sizing operation, its major purpose is to produce a surface on a work piece capable of sustaining uneven distribution of a load by improving the geometrical accuracy. The wear life of the parts micro finished to maximum smoothness is extended considerably. According to the design of experimentation, mathematical model for Lapping operation on advance ceramic material is proposed. In order to get minimum values of the surface roughness, optimization of the mathematical model is done and optimal operation of the examined factors is going to be determined. The obtained results will be, according to the experiment plan, valid for the testing of ceramic material by Lapping operation.

The test results can be probably applied to other materials, however, has to be proved for each separate case.

Keywords: Ceramics, Lapping, MRR, Optimization, Roughness, Surface Finish, Process Parameters

1. INTRODUCTION

Ceramics encompass such a vast array of materials that a concise definition is almost impossible. However, one workable definition of ceramics is a refractory, inorganic, and nonmetallic material. Ceramics can be divided into two classes: traditional and advanced. Traditional ceramics include clay products, silicate glass and cement; while advanced ceramics consist of carbides (SiC), pure oxides (Al₂O₃), nitrides (Si₃N₄), non-silicate glasses and many others. Ceramics offer many advantages compared to other materials. They are harder and stiffer than steel; more heat and corrosion resistant than metals or polymers; less dense than most metals and their alloys; and their raw materials are both plentiful and inexpensive.

Ceramic materials display a wide range of properties which facilitate their use in many different product areas. In this paper literature review is conducted on optimization of lapping operation on advance ceramic. Literature review is conducted for checking uniqueness and feasibility of the topic. To finalize lapping parameters, methodology and experiment procedure literature review is very helpful along with other tools.

The author selected advance ceramic seal as a product to conduct experiments. Advance ceramic is widely used in automotive, aerospace, medical, military, Electronic parts, etc.

Lapping is the removal of material to produce a smooth, flat, unpolished surface. Lapping processes are used to produce dimensionally accurate specimens to high tolerances (generally less than 2.5 μm uniformity). The lapping plate will rotate at a low speed (less than 80 rpm) and a mid-range abrasive particle (5-20 μm) is typically used. Lapping removes subsurface damage caused by sawing or grinding and produces the required thickness and flatness. Although the lapping process is less damaging than grinding, there are two regimes of lapping: free abrasive lapping and fixed abrasive lapping. Material removal rate can also be checked during experiment.

2. LITERATURE REVIEW

2.1. Review of Literature

R. Sedlacek, J. Jorgensen [1] conducted experiments on processing of ceramics – surface finish studies. Expanded ring test was used to determine the tensile strength of high purity, dense alumina. The test materials were prepared in five different nominal grain sizes ranging from 10 to 50 μm . The blanks were diamond ground to final dimensions by a technique developed earlier in the program. It was found that in grinding this material extensive damage took place which had not been observed in any other alumina body ground under identical conditions. The only difference in strength was found between groups of specimens having grain sizes equal to or smaller than 30 μm . The author concluded that the strength of material depends upon the surface finish of the material. M. Komaraiah et al [2] conducted experiments on different work materials –glass, porcelain, ferrite, alumina using various tools- titanium, stainless steel. The surface roughness of the different work pieces were analyzed with respect to hardness of the tool material and abrasive used. The results showed that surface roughness decreases with decrease in the grain size and harder tool material gives low surface roughness. C. Y. Wang, X. Wei, and H. Yuan [3] conducted experiments on polishing of ceramics Tests were carried out in a special manual grinding machine for ceramic tiles. Two grinding wheels were fixed in the grinding disc that was equipped to the grinding machine. The diameter of grinding disc was 255 mm. The rotating speed of the grinding disc was 580 rpm. The grinding and polishing wheels are isosceles trapezoid with surface area 31.5 cm² (the upper edge: 2 cm, base edge: 5 cm, height: 9 cm). The pressure was adjusted by means of the load on the handle for different grinding procedures. A zigzag path was used as the moving trace for the grinding disc. To maintain flatness and edge of the ceramic tiles, at least one third of the tile must be under the grinding disc. During the grinding process, sufficient water was poured to both cool and wash the grinding wheels and the tiles. Surface reflection glossiness and surface roughness of the ceramic tiles and the wear of grinding wheels were measured. The performance of grinding and polishing wheels will affect its life and the surface quality of ceramic tiles, the optimization of the combination of grinding wheels and polishing wheels for all the steps will shorten machining time and improve surface quality. Optimization must be determined for each ceramics tiles. V. Kumar [4] used design of experiment and regression approach for the statistical analysis of the ultrasonic machining of Glass. The response of the material removal rate of the glass was identified with the range of different parameters such as power rating, abrasive type, abrasive size, and slurry concentration. It was found that the grit size was most

vital parameter and slurry concentration was the least significant parameter and having minimum contribution to the MRR. It was conjointly ascertained that the carbide has additional impact on MRR as compared to the mixture of aluminum oxide + silicon carbide. The 60% power rating resulted in better MRR as compared to 20% and 40% slurry concentration. This might result to its additional power rating could lead to additional erosion of the work. The grit size of 280 resulted in more MRR as compared to the 400 and 600 grit size. Sunil Jha and V. K. Jain [5] used nanotechnology to measure surface roughness of ceramics by various operations and he concluded that non conventional method for super finishing is better than conventional method but non conventional method is costlier than conventional method. R. Cebalo, D. Bajić and B. Bilić [6] conducted experiment on optimization of the super finishing process. In this paper impact factors on surface roughness are determined. According to the factors test plan and regression analysis, extend equation for mean arithmetical roughness is given. In order to get minimum values of the surface roughness, optimization of the mathematical model is done and optimal values of the examined factors are determined. The obtained results are, according to the experiment plan, valid for the testing of material 34CrNiMo6. Author concluded that machining time affects surface roughness. B. Tholt, W.G. and R. Prioli [7] conducted experiment on Surface Roughness in Ceramics with Different Finishing Techniques Using Atomic Force Microscope and Profilo meter and concluded that when the ceramic surface was ground and polished, the 3 types of ceramic restorations reacted differently to each tested polishing kit. Some of the polished surfaces obtained were at least equivalent to glaze-fired ceramic surfaces. By combining the Profilo meter and Atomic Force Microscope, the surface topography can be characterized over a length scale from 0.01 μ m to 4 mm and, consequently, the results are more reliable and precise. S.S. Chaudhari, Dr. G.K. Awari, and S.S. Khedkar [8] conducted experiment on Optimization of the super finishing Process. According to the design of experimentation, mathematical model for four different types of abrasive stones used is proposed. In order to get minimum values of the surface roughness, optimization of the mathematical model is done and optimal values of the examined factors are determined. The obtained results are, according to the experiment plan. It is observed that surface roughness decreases with increase in contact pressure; however there is limit on the maximum contact pressure that can be employed. Very high contact pressure may result in scoring the surface finished produced. Optimal value of influencing parameters is also determined. Optimal machining parameters in super finishing are usually selected to achieve a high volume of material removal, thereby to remove the macro-geometrical and damaged layers with minimum process time which is directly inclined towards economy of the process. Eduardo Carlos Bianchi, Paulo Roberto de Aguiar [9] conducted experiment on Optimization of Ceramics Grinding and concluded Based on the obtained results on this work, it can be concluded that, when grinding ceramics with diamond wheels, in similar conditions to the ones tested: In terms of surface roughness, conventional lubri-refrigeration was the method which provided the best results, due to its better ability to clean the wheel, by removing the machined chips which lodge in the wheel pores. Traditional MQL presented the worst results, because, despite being very efficient in lubricating the wheel/work piece interface, it was the worst condition for wheel cleaning. In terms of roundness, the results were similar to surface roughness. Conventional lubri-refrigeration was the most satisfactory method, while traditional MQL (minimum quantity of lubrication) was the less satisfactory. Acoustic emission signals generated from the process was strongly influenced by lubrication capability of the lubri-refrigeration methods (it can be inferred that it is an indirect measurement of this capability). Thus, the higher acoustic emission values were obtained when using conventional lubri-refrigeration, while the lower was obtained for traditional MQL. The lubri-refrigeration condition which provided the higher diameter wheel wear was the less efficient when considering wheel cleaning (traditional MQL). However, the condition most efficient in

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cleaning the wheel (abundant fluid flow) was not the one which provided lower wheel wear, since it has poor lubrication capability. Pankaj Kumar Shrivastava and Avanish Kumar Dubey [10] conducted experiment on Intelligent Modeling of Surface Roughness during Diamond Grinding of Advanced Ceramics and concluded Diamond grinding is the only conventional method to achieve the above keeping in view of the material removal rate. This paper presents experimental study of diamond grinding of Sintered Silicon Carbide (SiSiC). In the paper two different approaches, multiple regression analysis (MRA) and artificial neural net work (ANN) have been used to predict the surface roughness values. The results show that ANN model has better accuracy as compared with MRA model. Mr. Nilesh B Nagare, Mrs. Niyati Raut [11] used CNC wire cut EDM machine for optimizing process parameters on die steel, Material removal rate was 0.56gm/min and machining value obtained for surface roughness is 1.2 micron.

B.L. Ramu, R Krishnamurthy, C.V Gokulrathnam [12] investigated tool penetration rate and tool wear rate under the significant parameters such as abrasive of boron carbide of 280 grit, slurry characteristics, and different tool material with static loading. Zirconia ceramic and cold impact alumina were taken as work piece in ultrasonic drilling. It used piezoelectric crystal type dynamometer for measuring the dynamic forces on work pieces and tool materials. It was found that higher hardness of ZrO₂ results in lower material removal rate as compare to Al₂O₃. V. Saravana Kumar, Hridul Pavithran, Sachin K. V [13] optimized process parameters on SS410 material in cylindrical grinding process using Taguchi approach and Minitab software during the experiment effects of various machining parameters on Surface Roughness are studied with the help of Taguchi method in Minitab software and optimum conditions for machining were found out. It is observed that level 1 of doc i.e. 0.02mm, feed of level 3 i.e. 15.400mm/s, level 2 of speed i.e. 160rpm, and level 3 of flow rate i.e. 0.276L/s as the optimum conditions to achieve maximum surface finish and value was found to be 0.28µm. R. S. Jadoun et al [14] investigated the effect of process parameters on the production accuracy (hole oversize, out-of-roundness and conicity) obtained through ultrasonic drilling of holes in alumina based ceramics using silicon carbide abrasive using the Taguchi model. The machining was carried out on the alumina based ceramic with silicon carbide abrasive. The parameters considered were work piece material, tool material, grit size, power rating, and slurry concentration. The optimal levels of various process parameters for minimum out-of-roundness were: work piece material; 70% Alumina, Tool; Tungsten carbide, Grit size; 500, Power rating; 40%, Slurry concentration; 30% and the optimal levels of various process parameters for minimum conicity were: work piece material 50% Alumina, Tool; Tungsten carbide, Grit size; 500, Power rating; 40%, Slurry concentration ; 25%. Process depends on the work material properties mainly hardness and fracture toughness, tool properties (hardness, impact strength and finish), abrasive properties (hardness, coarseness and viscosity) and process settings (power input, static load, amplitude and frequency of vibration). The success in terms of MRR and Surface roughness purely depends on the selection of machining process parameters. Proper selection of process parameters plays a significant role in ensuring the product quality, reducing the machining cost, increasing productivity. The machining of materials such as Glass, super alloys, ceramics, Tungsten carbide etc. to their final dimension by conventional methods is extremely tough and generally not possible. To overcome such kind of problems USM can be utilized. Some others materials i.e. titanium, titanium alloys and other tougher and harder materials such as nickel alloys, polycrystalline diamond compact etc for their wide application in the various kind of industry.

Dr. Swaroopkumar Magar, Dr. Bhandari Aruna J, Dr. SanjayB. Lagdive, Dr. Gangadhar S.A.[15] evaluated the surface roughness of two glazed, unglazed and polished ceramic materials. From the present study, Authors concluded that, Regardless of the type of ceramic tested (IPS Empressor In-Ceram Alumina/ Vitadur Alpha) or pretreatment, any adjusted

ceramic restoration should be reglazed or subjected to a finishing sequence that is followed through to a final stage of polishing with diamond paste and Unglazed IPS Empress 2 is rougher than unglazed In-Ceram Alumina/Vitadur Alpha. D. Karunakaran, A. Jeyachandran [16] Analysed Mechanical Properties of Al₂O₃Coated Dental Implants. Aluminium oxide is a largely used ceramic material for coating. Aluminium oxide is coated on titanium implants using thermal spraying process to increase its mechanical properties. The implant was then characterized by scanning electron microscopy (SEM). The tribological wear behavior is investigated using pin-on-disc equipment for specific intervals of time by applying constant load and Micro hardness was found out. Analyses of the mechanical properties of Titanium implant material and Aluminium oxide coated titanium implant material was carried out. The microstructure analysis was carried out by using SEM. Bhargav Simariya, Dr. P. M. George, and Dr. V. D. Chauhan [17] conducted experiment on effect of grinding variables on surface finish of ceramics. Design of Experiment (DOE) approach is used to study the effect of grinding variables on the surface finish of ground ceramic surfaces. In the present work, experiments are carried out to investigate the effect of depth of cut, feed rate and coolant flow rate on surface finish. Average surface roughness (Ra) value is measured using portable surface roughness tester (Mitutoyo SJ-201P). Analysis of variances is used for examining the impact of grinding factor and factor interactions on surface finish. A surface roughness model is developed using the experimental data considering only the significant factors and feed rate depth of cut and force plays important role to decide surface roughness of the work piece. Prabaha Das, Pranab Das, Probal Kumar Das and Gurumoorthy Hebbar [18] conducted experiments on Surface Finish Studies of a Dense Alumina Ceramic Material Using 3 - AXIS CNC Grinding Machine. The raw materials used are polycrystalline alumina powder (A-16-SG, Almatia Alumina Pvt. Ltd, India) and MgO powder (Merck, India). 0.5 wt.%MgO was mixed with Al₂O₃ powder in deionized water using attrition milling in the 2.5 kg attritor for 3 hours using 3 mm alumina balls. After milling the mixture was dried overnight in the air oven at 120^oC for moisture removal. Finally, the dried powder mixture was sieved through 60 mesh B.S. screen in the sieve shaker for granulation and collected. Circular pellets of nearly 35 diameter were uniaxially pressed at 4000 kg/cm² followed by cold is static pressing at 150 MPa for 1minute. Green dimensions were taken to calculate respective shrinkage values. Samples were then sintered at 1650^oC with a dwell of 2 hours in ambient. The heating and cooling rate was maintained at 5^oC/min. Density and apparent porosity values of the sintered circular discs were measured by Archimedes water immersion technique using deionised water. Dimensions of the sintered specimens were also measured using a digital vernier calliper to calculate the shrinkage values. To evaluate the effect of machining parameters on the surface finish of the sintered alumina using the 3 axis ELB surface grinding machine, samples were ground using different spindle rpm, depth of cuts and x-stage movement. After each machining stage, surface roughness values of the ground specimens were measured using either non-contact type or contact type surface profilometer. They concluded that that irrespective of measuring direction, the green shrinkage value after CIP was ranged in between 3.4 to 4.7% while after sintering it was close to 15.5%. Density values of the sintered specimens indicated that that after sintering at 1650^oC for 2 hours, the average relative density reached to ~99%. This suggested that 1650^oC was sufficient for achieving desired level of densification in the studied alumina ceramics. M. R. Pratheesh Kumar, B. S. Arun, and R. Aravind Babu [19] conducted experiment on Optimization of Process Parameters In Lapping of Stainless Steel. They conducted experiment on Stainless Steel (SS316), which is identified as most commonly used materials in the manufacturing of relief valve seats and thus selected for the experiments. Prior to lapping, the surface grinding operation is carried out on the work piece. The thickness of the specimen is

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20mm with diameter of 30mm. The available loads are 5kg, 6kg and 7 kg. The three levels of time for lapping is taken as 5, 10, 15 minutes. The abrasives are mixed in the ratio of 1:4, 1:5, and 1:6. (Ex: Theratio1:4 denote, one part of abrasive mixed with four parts of oil by weight). The surface finish produced on the component depends on the number of factors like abrasive concentration, time of lapping, etc. So, these factors have to be controlled efficiently for a good surface finish. The surface finish obtained also depends upon the grain size of the abrasives being used. The fine grains take away very less material and provide a good surface finish. Also, fine grains generate less heat. Though each grain cuts less, there are more grains per unit area which helps in removing more amount of material. Coarse grains are good for higher material removal rate as the depth of cut increases. Considering all these factors and the experimental results obtained, it is found that the good combination of input parameters helps in obtaining a good surface finish in the lapping process. AlhanoufA Alhabdan and Ahmed A El-Hejazi[20] compared surface roughness of ceramics after polishing with different intraoral polishing system using profile meter and SEM. Eighty ceramic discs (5mmx2mm) were prepared from 2 ceramic materials (VM9 and e.max) using stainless steel mold. The discs were then randomly divided into 4 subgroups for each material (n=10). A Fine diamond bur was used to remove the glaze layer on one side of the disc (the other side serving as a control), and the samples were then polished by one of the 4 polishing systems (Sof-lex discs, Optrafine, EVE, and Jazz). Surface roughness was measured quantitatively by Profilo meter and qualitatively by SEM. Three roughness readings were taken for each sample before being polished, after removal of the glaze layer, and after being polished. After successful completion of experiments authors concluded that the mean Ra value for the glazed surface (control) was (Ra=0.557). The lowest mean Ra value was recorded for the Sof-lex polishing system with the e.max material (Ra=0.195). The highest mean Ra value was recorded for the Jazz polishing system with the VM9 material thus The use of ceramic polishing kits was effective in reducing surface roughness. The polished ceramic samples were as smooth as their controls. Therefore, any needed adjustment to the ceramic restoration can be achieved by the use of a ceramic polishing kit, without the need for glazing, Guilherme Briao Camacho, DionísioVinha, Heitor Panzeri Tomio Nonaka, and MarianeGoncalves [21] conducted experiments on Surface Roughness of a Ceramic After Polishing with Different Vehicles and Diamond Pastes The purpose of this study was to evaluate the efficiency of different vehicles associated with diamond pastes indicated for dental ceramic polishing. Two polishing pastes (Crystar Paste and Diamond Excell) associated with four vehicles (rubber cup, Robinson bristle brush, felt wheel and buff disc) were evaluated. Disc-shaped specimens were fabricated from Ceramco II dental ceramic. Surface roughness means (Ra) of the ceramic specimens were determined with a rugosi meter. Data were analyzed statistically by two-way ANOVA and Tukey's test at 5%significance level. There was no statistically significant difference ($p>0.01$) between the polishing pastes. However, there were statistically significant differences ($p<0.01$) among the tested vehicles. Vehicle-paste interaction showed statistically significant difference ($p<0.05$) as well. It may be concluded that:

1. Robinson bristle brush, felt wheel and buff disc were efficient vehicles to be used in association with a diamond polishing paste;
2. The use of rubber cup as a vehicle showed poor efficiency for mechanical polishing of the ceramic" surfaces;
3. Both pastes provided similar and efficient polishing and may be recommended for use with an appropriated vehicle.

3. CONCLUSIONS

The literature review of the super finishing operation (Lapping) on ceramic material is proposed in the report provides some useful indications on how to optimize process parameters by various methodology. The set of strategic and operational levers to be implemented within a

company for finishing of ceramic is today still rather poor and needs to be enriched in order to provide systematic managerial approaches. Interesting prospects for further research are to identify and analyze in-depth the tools and operational approaches that companies have informally implemented, and to assess what kind Of strategy will lead to a greater level of adoption of super finishing operations on advance Ceramics.

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