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Review on Effects of Input Parameters and Design of Experiments on Surface Grinding Process in EN31 material

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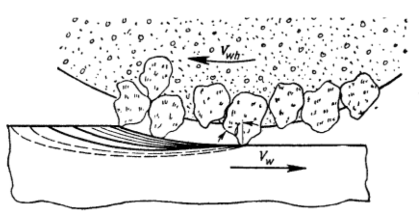
Abstract: Surface grinding is very versatile and complex process to produce smooth finish on flat surfaces. Metal removal rate and Surface quality are the two major performance characteristics to be considered in the surface grinding process. The process of grinding is affected by several parameters such as wheel speed, depth of cut, table speed, material properties and abrasive wheel grade.The main purpose of this study is to study the effects of abrasive tools on EN31 steel surface which are having applications in Ball and Roller Bearings, Spinning tools, Beading Rolls, Punches and dies. By its character this type of steel has high resisting nature against wear and can be used for components which are subjected to severe abrasion, wear or high surface loading by using three parameters (Table speed, Depth of cut & Grinding wheel speed). In this work, empirical models were developed for Material removal Rate and surface roughness by considering depth of cut, table speed, wheel speed as control factors using response surface methodology. In this Response surface methodology as applied to determine the optimum machining parameters leading to maximum metal removal rate and minimum surface roughness in Surface grinding process.

Keywords: CNC Grinding, EN31 steel, Material removal rate, surface roughness, Al_2O_3 wheel, and Design of Experiment.

Introduction to grinding: - Grinding is a material removal and surface generation process used to shape and finish components made of metals and other materials. The precision and surface finish obtained through grinding can be up to ten times better than with either turning or milling.

Grinding

Grinding is the most common form of abrasive machining. It is a material cutting process which engages an abrasive tool whose cutting elements are grains of abrasive material known as grit. These grits are characterized by sharp cutting points, high hot hardness, and chemical stability and wear resistance. The grits are held together by a suitable bonding material to give shape of an abrasive tool.

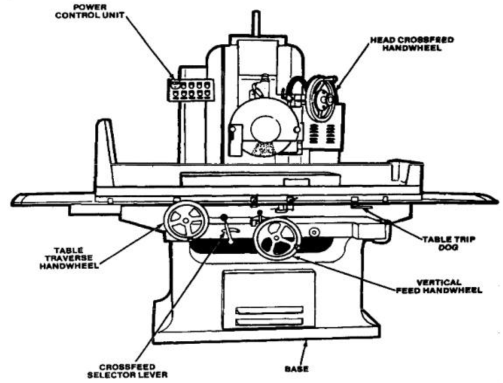


Cutting actions of Abrasive Grains

Surface Grinding:-

Surface grinding uses a rotating abrasive wheel to remove material, creating a flat surface. The tolerances that are normally achieved with grinding are ± 2 × 10^{-4} inches for grinding a flat material, and ± 3 × 10^{-4} inches for a parallel surface (in metric units: 5 µm for flat material and 8 µm for parallel surface).

The surface grinder is composed of an abrasive wheel, a workholding device known as a chuck, either electromagnetic or vacuum, and a reciprocating table. Typical workpiece materials include cast iron and steel. These two materials do not tend to clog the grinding wheel while being processed. Other materials are aluminum, stainless steel, brass and some plastics.



Schematic illustration of a Horizontal Spindle Surface Grinder

History of Grinding:-

Grinding is a complex and versatile metal cutting process, which for many centuries has been perfected via study and complicated analytical approach. It is well known that the machining process consumes more energies comparison of other machining method. Generally, grinding process is closely related to the main goal as the best cutting method to produce a dimensionally and geometrically accurate work piece. The relationship between cutting condition and the good surface finish of the work piece has been establish and verified through series of studies.

Earlier, various researchers have been studying on the heat dissipation and the effects on the microstructure level of material have been explored. A prominent study by E. Brinksmeler et al. (1996), try to integrate production line in manufacturing industries with grinding possibilities to produce superficial hardening in order to cutting manufacturing cost. A new term has been introduced in his study paper namely grind hardening. If we focus on microstructure level, Grind-hardening is based upon martenisitic phase transformation by short time austenization of a surface layer with following self-quenching. However, up until now, the component that was grind 2 hardened is mostly characterized by compressive residual stresses in the surface layer (E. Brinksmeler et al. 1996). An attempt also has been made by O. Zurita et al. (2002) to discover the influence of the cutting parameters on the superficial hardening of AISI 1045. She comes out with a conclusion that the increasing value of parameters lead to the higher superficial hardening on the workpiece. Other study (P.Krajnik, 2005), design the grinding factors based upon surface methodology or classically design of experiment. Superficial hardness is closely related to the amount of the residual stresses

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on the material surface during machining. Y. Matsumoto (1991) demonstrates that the residual stresses are mainly by; (1) martensite transformation near the surface (2) the plastic flow of the material on the surface and adjacent areas due to thermal stresses cause by heat generated during the process (3) plastic deformation due to the cutting forces of the grain on the surface of work piece.

Despite of that, a question related to the optimum grinding cutting parameters which can be induced superficial hardening together with great surface roughness were never being answered.

Therefore, this study work has been proposed in order to determine the optimum parameter and co relation between good surface roughness and the Material Removal Rate of Work piece.

A.Barbacki, M.Kawalec, A.Hamrol (2003) This paper presents results of investigations concerning the surface layer alterations in hardened steels induced by turning with alumina and CBN edges and grounding with CBN grinders. The surface integrity parameters such as microstructure (investigated also with transmission electron microscopy (TEM) methods), mesohardness, stress level and roughness were measured and analyzed. Influence of turning and grinding parameters on the above characteristics have been considered.

Xipeng Xu, Yiqing Yu, Hui Huang (2003) In this paper the present investigation was dedicated to elucidate abrasive-wear mechanisms during surface grinding of a titanium alloy (TC4) and a nickel-based super alloy (K417) by using silicon carbide (SiC), alumina (Al_2O_3), and cubic boron nitride (CBN) wheels. The temperature at the wheel–workpiece contact zone was measured using a workpiece foil thermocouple. SEM and EDS were used to examine the morphological features of ground workpiece surfaces and worn wheel surfaces. It is shown that the grinding with either SiC or Al_2O_3 is characterized by the high temperatures reached in the grinding zone since either of them is easily worn during the grinding processes. Along with the presence of high temperatures, strong adhesion was found between the abrasives and workpieces, which might be attributed to the chemical bonding between the abrasives and workpieces at the elevated temperatures. The increasing ductile deformation of both TC4 and K417 at the elevated temperatures may also be a factor. Therefore, the wear of SiC or Al_2O_3 is both chemical and physical. In the grinding with CBN wheels, however, the wear of abrasive grits is mainly physical since CBN is more stable to higher temperatures. At extremely high temperatures, CBN was found to undergo dislodging prior to being gradually worn. In order to reduce the grinding temperatures, a segmented wheel was incorporated into the grinding with CBN wheels.

Anne Venu Gopal, P.Venkateswara Rao (2003) In this paper they studied the efficient grinding of structural ceramics requires judicious selection of operating parameters to maximize removal rate while controlling surface integrity. Grinding of silicon carbide is difficult because of its low fracture toughness, making it very sensitive to cracking. In the present work, experiments were carried out to study the effect of wheel parameters; grain size and grain density and grinding parameters; depth of cut and feed on the surface roughness and surface damage. The significance of the grinding parameters on the selected responses was evaluated using analysis of variance. Mathematical models were developed using the experimental data considering only the significant parameters. A genetic algorithm (GA) code has been developed to optimize the grinding conditions for maximum material removal, using a multi-objective function model, by imposing surface roughness and surface damage constraints. The choice of including manufacturer's constraints on the basis of functional requirements of the component for maximizing the production rate was also embedded in the GA code.

P.Krajnik, J.Kopac, A.Sluga (2005) The presented paper describes a systematic methodology for empirical modelling and optimization of the plunge centreless grinding process. The assessment of microgeometric quality defining quantity is supported by post-process surface roughness measurements. The design of grinding factors is based on response surface methodology, which integrates a design of experiment, regression modelling technique for fitting a model to experimental data and basic optimization. Central composite response surface design has been employed to develop a second-order surface roughness model. The model has been fully constructed by determination of its structure and regression coefficients. The final goal of experimental study focuses on determination of optimum centreless grinding system set-up and operating conditions for minimization of surface roughness. The computer-aided single-objective optimization, solved by non-linear programming and genetic algorithm, is applied. The results of two different optimization approaches for determination of optimal operating conditions are compared. Finally, further research directions are presented.

Y.Sahin (2006) In this paper the wear resistance model for three types of steels was developed in terms of abrasive grain size, applied load and sliding distance using the Taguchi method. Wear tests were carried out using a pin-on-disc type of apparatus under different conditions. The orthogonal array, signal-to-noise (S/N) ratio and analysis of variance are employed to investigate the optimal testing parameters. The experimental results demonstrate that the type of materials was the major parameter among the controllable factors that influence the weight loss of steels. For AISI 1340 steel, the abrasive grain size exerted the greatest effect on the wear, followed by sliding distance. The applied load had a much lower effect. For AISI 1020 and 5150 steels, however, the sliding distance was found to have an effective on the weight loss. The optimal combination of the testing parameters could be determined. A good agreement between the predicted and actual wear resistance was observed within ±10%.

M. Ramachandra, K. Radhakrishna (2007) In the present experimental investigation, Al (12 wt% Si) as matrix material and up to 15 wt% of flyash particulate composite was fabricated using the liquid metallurgy route. The wear and friction characteristics of the composite in the as-cast conditions were studied by conducting sliding wear test, slurry erosive wear test and fog corrosion test. The sliding wear behaviors of the MMCs were investigated by varying parameters like normal load, percentage flyash, and track velocity. Pin-on-disc wear testing machine was used for investigating sliding wear behavior. In slurry erosive wear studies, percentage flyash and pH value of the slurry were used as variables. Corrosion studies were carried out using fog corrosion test. The specimens were exposed to a fog of NaCl. The worn surfaces were analyzed using optical microscope and scanning electron microscope. The results indicate that the wear

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resistance of the flyash reinforced material increased with increase in flyash content, but decreases with increase in normal load, and track velocity. The microscopic examination of the worn surfaces, wear debris and subsurface shows that the base alloy wears primarily because of micro cutting. But the MMCs wear because of delamination, micro cutting, oxidation and thermal softening. Corrosion has increased with increase in flyash content.

HarunMindivan, E.SabriKayali, HuseyinCimenoglu(2008) in this paper studied the tribological behavior of squeeze cast aluminum alloy (2618, 6082, 7012 and 7075) matrix SiC particle-reinforced (50 vol.%) composites was examined using a reciprocating wear tester by rubbing a 10mm diameter Al_2O_3 ball on the composite surfaces in air and in water. Wear tests conducted in air revealed that, at low test loads (≤3 N), the tribological performance of the composites were not remarkably influenced by the properties of the matrix alloy. At high test loads (≥4.5 N), where 7012 and 7075 aluminum alloy matrix composites exhibited superior tribological performance relative to 2618 and 6082 aluminum alloy matrix composites, the wear rate and coefficient of friction decreased with increasing matrix hardness. When compared to the sliding conditions during testing in air, the coefficient of friction and the wear rate of the composites were dramatically lower in water. Even at test loads as high as 24 N,tribological performance of composites tested in water was comparable to that of in air low load (≤4.5 N) testing conditions.

Jianyi Chen, JianyunShen, Hui Huang, XipengXu (2010) In their research an investigation was undertaken to explore the grinding characteristics and removal mechanisms in high speed grinding of three engineering ceramics-alumina, silicon nitride, and zirconia by using brazed diamond wheels of two different grit sizes. The grinding forces and surface roughness were measured and the morphological features of ground workpiece surfaces were examined. The results indicate that material removal mechanisms are different for the three ceramics at high grinding speeds. For alumina, the removal is dominated by brittle fracture. For silicon nitride and zirconia, the ductile removal prevails in the grinding. For each of the three ceramics, grinding power per unit width is found to be nearly proportional to the rate of plowed surface area generated per unit time per unit width, indicating that the grinding energy expended is mainly associated with sliding and plowing**.**

U.S.Dixit, S.N.Joshi, J.P.Davim (2011) As per their research which they have studied that manufacturing process modeling is gaining importance in view of stiff global competition to produce the goods of specified design in an optimal way. In particular, metal forming and machining (both traditional and non-traditional) have been extensively modeled using numerical techniques. Three basic steps of modeling of manufacturing processes are analytical representation of working principle of the process, modeling of material behavior and method of solution. In this paper, a comprehensive review of various approaches of material behavior modeling has been presented. The material behavior modeling has great influence on the design of process, tools and the final product. This aspect is highlighted in the present review. Metal forming processes, traditional machining processes and non-traditional machining processes are considered for the study. Different material models are compared with respect to their suitability for the design of process, tooling and product. Finally, the paper suggests the directions for further research in this area.

M.Janardhan and Dr. A.Gopala Krishna (2011) through this paper they want to prove that cylindrical grinding is one of the important metal cutting processes used extensively in the finishing operations. Metal removal rate and surface finish are the important output responses in the production with respect to quantity and quality respectively. The Experiments are conducted on CNC cylindrical grinding machine with L9 Orthogonal array with input machining variables as work speed, feed rate and depth of cut. Empirical models are developed using design of experiments and response surface methodology. The adequacy of the developed model is tested with ANOVA. The developed model can be used by the different manufacturing firms to select right combination of machining parameters to achieve an optimal metal removal rate (MRR) and surface roughness (Ra).The results reveals that feed rate, depth of cut are influences predominantly on the output responses metal removal rate (MRR) and surface roughness (Ra).The predicted optimal values for MRR, Ra for Cylindrical grinding process are 62.05g/min and 0.816μm respectively. The results are further confirmed by conducting confirmation experiments.

K.Kadirgama, M.M.Rahman, A.R.Ismail and R.A.Bakar (2012) In thisstudied the quality of the surface produced during carbon steel is important as it influences the performance of the finished part to a great extent. This paper discusses the optimization of cylindrical grinding when grinding carbon steel (AISI 1042) and effect of three variables (work speed, diameter of work piece and depth of cut) towards surface roughness with aluminum oxide as grinding wheel. Surrogate modelling was used to minimize the number of experiments and developed mathematical model to predict surface roughness hence optimization of cutting variables was found. This model has been validated by the experimental results of aluminum oxide grinding. Prediction model show that diameter of the work piece and work speed effect mostly compare with depth of cut. The optimum cutting parameters for minimum Ra are work speed 120 RPM, diameter 18 mm and depth of cut 20μm. The theoretical analysis yielded values, which agree reasonably well with the experimental results.

AshishBhateja, AdityaVarma, AshishKashyap and Bhupinder Singh (2012) This Study is based upon the empirical study which means it is derived from experiment and observation rather than theory. Main Objective is to Study the Effect on the Hardness of three Sample Grades of Tool Steel i.e. EN-31, EN-8, and D3 after Heat Treatment Processes Such As Annealing, Normalizing, and Hardening & Tempering. This survey also helps to find out the place of the work to be carried out i.e. availability of set up, techniques used for such, estimated time & cost requires for such study to be carried out for such industrial survey to be carried out we designed a Survey questioner and selects various places who offers heat treatment services Ludhiana based. After literature review and industrial survey aims to prepare heat treatment performance Index HTPI 2012 which is supposed to be very effective tool for defining the objective function. After selection of material & heat treatment processes further aims to perform mechanical & chemical analysis i.e. composition testing of the three tool steel EN-31, EN-8, and D3 before treatment. After composition testing aims to do heat treatment processes i.e. Annealing, Normalizing, and Hardening & Tempering to be carried on such material & after treatment aims to perform harness testing on the treated and untreated work samples.

Roshani U. Shingarwade Prof. M. S. Harne (2013) In this paper, reaming operation with two different mineral based cutting fluids were carried out to determine optimum conditions for surface roughness during reaming of grey cast iron of grade SAE D7003. K20 cemented carbide reamer was used as cutting tool. Taguchi L9 orthogonal array was used for the experiment plan. Spindle speed, feed rate, reverse feed rate were considered as machining parameters. Mathematical models for cutting parameters were obtained from regression analyses to predict values of surface roughness. S/N ratio and ANOVA analyses were also performed to identify significant parameters influencing surface roughness. The test results shows that satisfactory hole quality can be achieved during reaming by employing high spindle speed, low feed rate and low reverse feed rate.

H. Aouici, MA Yallese, A Belbah, Mfameur and M Elbah, (2013) Inthis experimental investigation was conducted to determine the effects of cutting conditions on surface roughness and cutting forces in hard turning of X 38 Cr Mo V 5-1. This steel was hardened at 50 HRC and machined with CBN tool. This is employed for the manufacture of helicopter rotor blades and forging dies. Combined effects of three cutting parameters, namely cutting speed, feed rate and depth of cut, on the six performance outputs-surface roughness parameters and cutting force components, are explored by analysis of variance (ANOVA). Optimal cutting conditions for each performance level are established. The relationship between the variables and the technological parameters is determined through the response surface methodology (RSM), using a quadratic regression model. Results show how much surface roughness is mainly influenced by feed rate and cutting speed. The depth of cut exhibits maximum influence on cutting force components as compared to the feed rate and cutting speed.

Hemant S. Yadav, Dr. R. K. Shrivastava (2014) In this Paper Researcher the main characteristics of grinding in comparison to other machining process are the relatively large contact area between the tool and work piece surface. The major limiting factor in grinding is thermal damage. The main purpose of grinding fluid can be categorized into lubrication, cooling, transportation of chips, cleaning of grinding wheel and minimizing corrosion. In this paper, the effect of process parameters such as depth of cut, coolant flow rate and coolant nozzle angle are taken as variables. The present work aims at optimizing process parameters to achieve surface quality and high material removal rate in SAE 8620 steel material. Response surface method a powerful tool in design of experiments is used for optimization process.

Tejendrasinh S. Raol, Dr. K. G. Dave, Dharmesh B. Patel, Viral N. Talati (2014) The aim of this paper is to investigate the effect of process parameters on surface roughness of fused deposition modelling built parts. Rapid prototyping (RP) refers to a class of technology that can automatically construct the physical models from computer aided design (CAD) data. Fused deposition modelling (FDM) is process for developing rapid prototype objects from plastic material by lying track of semi molten plastic filament on to a platform in a layer wise manner from bottom to top. Response surface methodology (RSM) was used to conduct the experiments. The parameters selected for controlling the process are layer thickness, part built orientation and raster angle. Surface roughness of fused deposition modelling built parts is measured by surface roughness tester. From the results of the experiments, mathematical model have been developed to study the effect of process parameters on surface roughness.

M. Aravind, Dr. S. Periyasamy (2014) In this study, the surface grinding process parameters were optimized by using Taguchi method and Response Surface Methodology (RSM). The process parameters considered in this study are grinding wheel abrasive grain size, depth of cut and feed. An AISI 1035 steel square rod of 100 mm x 10 mm x 10 mm was considered for grinding. The output response was selected as Surface roughness (Ra and Rz). In Taguchi method, L27 orthogonal array was selected and S/N ratios were analyzed to study the surface roughness characteristics. In response surface methodology, Box Behnken method was used for optimization. Thirteen experiments were conducted in the surface grinding machine. The surface roughness values were entered in the Design Expert software and the optimal solution was obtained. Both methods showed that wheel grain size and depth of cut influences the surface roughness a lot. Feed of the surface grinding has a very minimal effect on the surface roughness value. This study showed that when the input parameters can be varied within the selected levels, Response surface methodology has an edge over Taguchi method. The confirmation experiments were conducted both for the optimal solution obtained from Taguchi and Response surface methodology.

Comparatives of all Researchers:-Various methods have been used by so many researchers and they jumped in the field of Surface Grinding for the sake of Industrial perspectives to improve various parameters i.e. less Surface Roughness and maximize Metal Removal Rate (MRR), and have been trying to use various important Parameters which influence the characteristics and performance of materials,

Firstly, these researchers **XipengXu, Yiqing Yu, Hui Huang** in 2003 had experimented Mechanisms of abrasive wear in the grinding of titanium (TC4) and nickel (K417) alloys. They used silicon carbide (SiC), alumina (Al_2O_3), and cubic boron nitride (CBN) Grinding wheels on that materials.

Secondly, **Anne Venu Gopal, P.Venkateswara Rao** in 2003 had done Selection of optimum conditions for maximum material removal rate with surface finish and damage as constraints in SiC Grinding.

In this investigation they considered various factors which effect on Surface Roughness and Surface damage, these are as given below;

Effect of wheel parameters; grain size and grain density
Grinding parameters; depth of cut and feed
Output parameters: surface roughness and surface damage.
Grinding wheel Materials: Silicon Carbide (SiC),

Methodology: ANOVA
They studied the efficient grinding of structural ceramics requires judicious selection of operating parameters to maximize removal rate while controlling surface integrity. Grinding of silicon carbide is difficult because of its low fracture toughness, making it very sensitive to cracking and experiments were carried out to study the effect of wheel parameters; grain size and grain density and grinding parameters; depth of cut and feed on the surface roughness and surface damage.
Thirdly, **Y.Sahin (2006)** optimal testing parameters on the wear behaviour of various steels
Methodology: Taguchi method
Materials used: low-carbon steel (AISI 1020), carbon steel (AISI 1340) and low alloyed steel (AISI 5150).
In their investigation the wear resistance model for three types of steels was developed in terms of abrasive grain size, applied load and sliding distance using the Taguchi method.
In this **M.Janardhan and Dr. A.Gopala Krishna** (2011):-Multi-objective optimization of cutting parameters for surface roughness and metal removal rate in surface grinding using Response Surface Methodology. They considered the three important variable parameters i.e. Wheel Speed, Table Speed, and feed. And used these to measure the less Surface Roughness and to maximize the Material Removal Rate. In this investigation material was the EN24 and performed on CNC Surface Grinding Machine. The predicted optimal values for MRR, Ra for Cylindrical grinding process are 62.05g/min and 0.816µm respectively.
In this research paper **M.Janardhan and Dr. A.Gopala Krishna (2011)** determination and optimization of cylindrical grinding process parameters using Taguchi method and Regression analysis
Once again in their research work, they tried to find the best results with various Input parameters i.e. wheel speed between 150 to 250 RPM, feed from 780 to 1250 mm/min and depth of cut between 20 to 30 µm. They utilized every parameters to got effective output minimum Surface Roughness and maximize the Metal Removal Rate. Experiment was performed on CNC Cylindrical Grinding Machine, Material was used: EN8
Machine used:
Method used Taguchi method and Regression analysis
Through this paper they want to prove that cylindrical grinding is one of the important metal cutting processes used extensively in the finishing operations. Metal removal rate and surface finish are the important output parameters which influence the performance of the materials while in working conditions.
In this paper**AshishBhateja, AdityaVarma, AshishKashyap and Bhupinder Singh (2012)**
Study the Effect on the Hardness of three Sample Grades of Tool Steel i.e. EN-31, EN-8, and D3 after Heat Treatment Processes Such As Annealing, Normalizing, and Hardening & Tempering.
Experimental Material used: Tool Steel i.e. EN-31, EN-8, and D3
Experimental work: Heat Treatment Processes Such As Annealing, Normalizing, and Hardening & Tempering
This Study is based upon the empirical study which means it is derived from experiment and observation rather than theory. Main Objective is to Study the Effect on the Hardness of three Sample Grades of Tool Steel i.e. EN-31, EN-8, and D3 after Heat Treatment Processes Such As Annealing, Normalizing, and Hardening & Tempering. This survey also helps to find out the place of the work to be carried out i.e. availability of set up, techniques used for such, estimated time & cost requires for such study to be carried out.
In this paper researchers "**K.Kadirgama, M.M.Rahman, A.R.Ismail and R.A.Bakar**" (2012): A surrogate modeling to predict surface roughness and surface texture when grinding AISI 1042 carbon steel
Effect of three variables: work speed between 40 to 120 R.P.M., Diameter of workpiece b/w 18 to 22 mm, Depth of cut b/w 5 to 20 µm and Output parameter: Surface Roughness
Experiment performed on: cylindrical grinding machine
Material used: AISI 1042 Carbon Steel
In this studied the quality of the surface produced during carbon steel is important as it influences the performance of the finished part to a great extent. This paper discusses the optimization of cylindrical grinding when grinding carbon steel (AISI 1042) and effect of three variables (work speed, diameter of work piece and depth of cut) towards surface roughness with aluminum oxide as grinding wheel.
In their research work Roshani U. Shingarwade Prof. M. S. Harne (2013) Effect of Reaming Process Parameters on Surface Roughness Using Taguchi Method
Experimental material used: grey cast iron of grade SAE D7003
Machining parameters: Speed (rpm) ranges from 900 to 1500, Feed (mm/min) b/w 90 to 180 and Reverse feed rate (mm/min) ranges from 5000 to 10000
Experimental setup: CNC vertical Milling Machine
Tool used: Reamer (K 20 solid carbide)
In this paper, reaming operation with two different mineral based cutting fluids were carried out to determine optimum conditions for surface roughness during reaming of grey cast iron of grade SAE D7003. K20 cemented carbide reamer was used as cutting tool. Taguchi L9 orthogonal array was used for the experiment plan. Spindle speed, feed rate, reverse feed rate were considered as machining parameters. Mathematical models for cutting parameters were obtained from regression analyses to predict values of surface roughness. S/N ratio and ANOVA analyses were also performed to identify significant parameters influencing surface roughness.
H. Aouici, MA Yallese, A Belbah, Mfameur and M Elbah, (2013) Experimental investigation of cutting parameters influence on surface roughness and cutting forces in hard turning of X38CrMoV5-1 with CBN tool.
Input Parameters: Cutting speed *Vc*(m/min) ranges from 120 to 180, Feed rate *f* (mm/rev) between 0.08 to 0.16, Depth of cut(mm) from 0.15 to 0.45,
Material used: Steel (X38CrMoV5-1)
Cutting tool: Cubic Boron Nitride (CBN)
Output parameters: surface roughness parameters and cutting force components,
Response Surface Methodology (RSM), using a quadratic regression model
Inthis experimental investigation was conducted to determine the effects of cutting conditions on surface roughness and cutting forces in hard turning of X 38 Cr Mo V 5-1. This steel was hardened at 50 HRC and machined with CBN tool. This is

employed for the manufacture of helicopter rotor blades and forging dies. Combined effects of three cutting parameters, namely cutting speed, feed rate and depth of cut, on the six performance outputs-surface roughness parameters and cutting force components, are explored by analysis of variance (ANOVA).

M. Aravind, Dr. S. Periyasamy (2014): Optimization of Surface Grinding Process Parameters by Taguchi Method and Response Surface Methodology.
Input parameters: Grain size (mesh) between 36 to 60**,** Depth of cut (mm) ranges from 0.05 to 0.15**,** Feed (mm) between 0.2 to 0.8. Measured parameters: surface Roughness
Material used: AISI 1035 steel square rod, Dimensions 100 mm x 10 mm x 10 mm

In this study, the surface grinding process parameters were optimized by using Taguchi method and Response Surface Methodology (RSM). The process parameters considered in this study are grinding wheel abrasive grain size, depth of cut and feed. An AISI 1035 steel square rod of 100 mm x 10 mm x 10 mm was considered for grinding. The output response was selected as Surface roughness (Ra and Rz). In Taguchi method, L27 orthogonal array was selected and S/N ratios were analyzed to study the surface roughness characteristics. In response surface methodology, Box Behnken method was used for optimization.

Hemant S. Yadav, Dr. R. K. Shrivastava (2014): Effect of Process Parameters on Surface Roughness and MRR in Cylindrical Grinding using Response Surface Method
Machine used: Cylindrical Surface Grinding M/c, Experimental material: SAE 8620 steel, Input parameters: Depth of cut, coolant flow rate and coolant nozzle angle, Output parameters: minimize Surface Roughness and Max. Material Removal Rate Methodology used: RSM

In this Paper Researcher the main characteristics of grinding in comparison to other machining process are the relatively large contact area between the tool and work piece surface. The major limiting factor in grinding is thermal damage.

These researchers**Tejendrasinh S. Raol, Dr. K. G. Dave, Dharmesh B. Patel, Viral N. Talati (2014)** has an Experimental Investigation of Effect of Process Parameters on Surface Roughness of Fused Deposition Modeling Built Parts,
Working material: polycarbonate material; Experimental Investigation: Fused Deposition Modeling (FDM); Methodology used: RSM

The aim of this paper is to investigate the effect of process parameters on surface roughness of fused deposition modelling built parts. Rapid prototyping (RP) refers to a class of technology that can automatically construct the physical models from computer aided design (CAD) data. Fused deposition modelling (FDM) is process for developing rapid prototype objects from plastic material by lying track of semi molten plastic filament on to a platform in a layer wise manner from bottom to top. Response surface methodology (RSM) was used to conduct the experiments.

Conclusion: - after deep study of various researchers' paper in the field of surface grinding. It has been observed that grinding is a very complex method to achieve good surface finish. Various researchers have been using various method and technique to get the best possible result in best way. They have been observed or considered various parameters like wheel speed, depth of cut, feed and coolant etc. they have been performed all these parameters on the many materials like EN8, EN10, and EN24 etc. on various machines like CNC turning and CNC surface Grinding. They have been using various method and technique like Taguchi method, Response surface Methodology and ANOVA etc. they have used all of these influential parameters to get the surface roughness and metal removal rate.

Work is to be done:-

After studied all the papers and various influential parameters, now I am going to take various parameters to perform the experiment on the workpiece. Workpiece made up of EN31 and with the help of other parameters. The experimental works are to be done on the CNC surface grinding machine.
On this machine i am going to use various parameters like Wheel speed, depth of cut and feed. The experiments will be done on different values of these input parameters as mentioned above. Then these values will be analyses on the Design of Experiment software. In this software considered the two output parameters i.e. Surface Roughness and Metal Removal Rate, then after getting all values after machining of the specimen on CNC surface Grinding Machine, every value are to be investigate on the ANOVA and analyze the each and every graph in the RSM methodology. I need to check the best possible result after machining, to analyze the Good surface roughness and maximum MRR.

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