

# A Study on Characteristics of Parameters Influencing Internal Grinding Process with MRR

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## Abstract

**Objective:** To generate the information about the process of internal grinding applied to envisage the grinding performance and accomplish the optimal operating procedure characteristics. In recent engineering and technology surface finish and precision are playing a major role in the manufacturing organizations. **Method/Analysis:** Different methods such as burnishing, honing, lapping and grinding are exercised for accomplishing good quality of surface finish. Grinding is the appropriate method for improving the surface finish and precision concurrently between all of those constraints. Recently lot of researches has been carried out on surface grinding process, but only few articles were elaborately described about the internal grinding procedure. In view of the fact the internal grinding processes was chosen as a main tool to characterize throughout this study. **Findings:** Similar to surface grinding various process parameters are used to get high surface finish and it could be achieved for the various components. This article relating the possibilities to get greater surface finish in internal grinding process and also it demonstrates the machining parameters involved in this process. **Application/Improvements:** The machining parameters involved in these abrasive machining technologies were speed, feed, depth of cut and material removal rate and also these constraints were considered throughout the theoretical investigation.

**Keywords:** Internal Grinding, MRR, Process Constraints, Surface Roughness, Surface Finish

## 1. Introduction

Grinding is an operation of material removal process used to produce the required shape and get the finished products which was prepared by metals or any other formed materials. Grinding process is a metal cutting operation which is generally carried out through abrasive particles where rigidly mounted on a rotating wheel of the machine. The pattern of the grinding wheel is mostly in the shape of disk and it balanced precisely for high speed

movements<sup>1</sup>. Each grain of the abrasive in the grinding wheel used serves as a microscopic single point cutting edge, which shears a tiny chip and helps in giving better surface finish and essential quality that shows the real value of the product. The precision and surface finish through the grinding operations is usually ten times better than turning or milling operations performed in the similar machines. In the production process surface finish considered as the most significant productivity reaction and it also depends on the quality of the work

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piece material. The process of grinding is the most proficient and accepted finishing operation because it takes out the unwanted material in the size of 0.25 to 0.50mm chips and the precision in an array of 0.000025 mm has been offered by this operation. The internal grinding operation provides good quality of surface finish and expected accuracy on the specimen material during machining<sup>2</sup>. During the internal grinding procedure the main constraints such as speed, feed and depth of cut were taken into account for making augmentation and through the roughness tester the accuracy of surface roughness for the specimen was measured<sup>3</sup>. The final obtained values with different parameters stated that the diminishing of material surface was occurring at the time of enhancement of the Material Removal Rate (MRR) in the prescribed material and found that 0.420µm surface finish was measured with 0.0970gm/s MRR during cylindrical grinding operation<sup>4</sup>. The result confirmed that the surface roughness were diminished and MRR enhanced by using various cooling agents. Generally water soluble oil, pure oil and pure water are the various cutting fluids used for this kind of experimental work. It was found that the EN range of steels was considered as the material<sup>5</sup>. As already stated that, the various process constraints with cutting fluid was considered for doing the operation in cylindrical grinding machine. Abrasive aluminum oxide with vitrified bond is applied for making the grinding wheel. The coolant used for testing was water miscible coolant. Two axis hydraulic CNC surface grinders was selected for the process and it was observed that the increase in cutting parameters were disturbing the various constraints such as grinding machine shuddering, surface grinding wheel, rate of elevated metal removal and extreme temperature on the work piece. Due to the above reasons lesser quality of surface finish may be occurred. The consequence of different electro discharge machining limitations like current discharge, pulse interval and sparking voltage were applied to acquire the feedback in terms of MRR and tool wear rate<sup>6</sup>.

During product manufacturing the surface finish is act as a significant constraint for productivity with regard to good quality and also optimum quantity. During the study was carried out the different constraints which affects the surface roughness were deliberated and scrutinized<sup>7</sup>. The various best possible values of the work piece material established by using Taguchi optimization technique provide minimum surface roughness. EN24, EN31 and Die steel were the chosen work piece materials for

grinding operations using the above technique. The universal grinding tool, cutter grinding machine and  $Al_2O_3$  white grinding wheel are used for the investigation of various grinding parameters. The different process constraints such as work speed of the grinding, wheel grades and hardness of the material were considered for the study<sup>8</sup>. An experimental investigation was carried out as per the dimensions of orthogonal array and the surface roughness of different constraints put together was measured by DA5 tester and resulted that the surface roughness diminishing during the enhancement of material hardness<sup>9</sup>. The characters of friction stir welded joints for primed composite were examined in weld region and the welding quality characteristics were found in two different circumstances. The above process was assured that the feature and quality of friction stir welded joints of the prepared composite in the weld region both in theoretical and experimental aspects<sup>10</sup>. In 304-stainless steel we can get a good quality of surface finish with most favorable grinding circumstances under the cylindrical grinding operations. To minimize the quality problem in surface finish, the best possible procedures may be adopted during cylindrical grinding operations for getting close tolerance<sup>11</sup>. Many problems were occurred like the vibration of the grinding machine, grinding wheel, more MRR and excessive temperature on the work piece which leads to poor quality of surface finish. When experimental study was done on the persuade through EDM parameters on surface quality the material removal rate, electrode wear rate, and micro hardness of AISI O<sub>2</sub>, primarily MRR has been increased after reaching the maximum value and found decrease with increase in gap voltage<sup>12</sup>. Initially the tool wear rate was increased by means of the increase in pulse-on-time but after a certain value it decreases<sup>13</sup>.

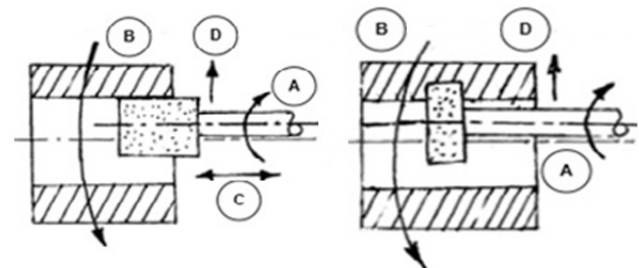
A study on the effects of mechanical properties, heat treatment on the microstructure and quality of casting of LM25 alloy was carried out. Alloying, mould vibration, chemical modification during solidification and heat treatment were found to be effective in modifying the microstructure. It was found that the influence of all such techniques modifies microstructure and enhances the mechanical properties and quality of casting<sup>14</sup>. For attaining final conclusion liable surface methodology was adopted for best possible machining parameters which guided to maximum MRR and least surface roughness in surface grinding process<sup>15</sup>. EN24 steel was selected as work material and the EN24 material was available in round bar, flat bar and plate. The various applications

of EN24 material are crankshaft, gear shaft and propeller shaft. For an experimental investigation the process parameters such as speed of the wheel, table speed and depth of cut were considered for estimating the grain size properties on work piece material surface roughness<sup>16</sup> and also grinding forces. A steel of AISI-1050 was preferred as material and to determine and also record the forces created throughout the grinding process the dynamometer was employed<sup>17</sup>. The experimental results revealed that the grain particle size affected the grinding surface roughness values and grinding forces when the selected grinding wheels were considered for the grinding process<sup>18</sup>. Similarly an analysis was carried out with MRR on H-13 die tool steel through electro discharge machining by using the application of Taguchi technique. The investigation was carried out to study the consequence of the various constraints on MRR with peak current, pulse on time and feed rate<sup>19</sup>. The conventional internal grinding confirms that for higher hardness grinding wheels the higher grinding speeds to be considered. The evaluations have proved that various criteria for the review of procedures the grinding ratio 'G' may be an added advantage for enhancement to the rigidity of grinding wheel and also its velocity<sup>20</sup>. The real efficiency of the process were evaluated and analyzed on the basis of one standardized index of various criteria assessment. One of the advanced manufacture technologies is high efficiency abrasive machining. The fatigue life of the product along with camber angle influence with radial fatigue testing machine was done and the same was pointed out through amalgamate finite element analysis, which is one of the best method for forecasting the fatigue life of different alloy materials<sup>21</sup>. Large scale manufacturing industries are always increasing the efficiency, finished quality and manufacturing cost<sup>22</sup>. Nowadays, developments in abrasive technology particularly high efficiency grinding machining such as high efficiency deep cutting grinding, super high speed grinding, abrasive belt grinding, creep feed deep grinding and heavy duty machining are remarkable<sup>23</sup>. The thermal scratch is one among a significant control of grinding process which may be avoid using appropriate cooling on the surface of the work piece. Cooling and lubrication plays an important role to ensure work piece quality in grinding<sup>24-25</sup>. Due to high heat it causes the thermal deformation, residual stresses, micro crack etc were generated on ground surfaces and it affects the productivity of the process. Proper cooling and lubrication system to be developed to overcome these kinds of defects. Lean

and green production is use to develop industrial compliances through the effluent regulations. Green products and services are the requirements of country which are possible only by eco friendly, energy conserving processes and optimum resource utilization<sup>26-27</sup>. Based on the above literature the comparative study was carried out and the necessary conclusions were made.

## 2. Internal Grinding Process

Internal grinding is a process carried out with a small wheel grinds within the internal surface diameter of the specimen. The internal contour part is position through contour dressed wheels which takes radial displacement into the appropriate work piece. The work piece was hold by a rotating chuck placed in the headstock and the grinding wheel revolves at very high rotational speed. To produce the internal cylindrical surface during the grinding operation the work piece hold by the chuck rotates and the grinding wheel reciprocates on the specimen. Usually the specimen surface is offered in the shape of straight, tapered, grooved or profiled. Different internal contours formed within the work piece by means of internal bore diameter grinding are shown in Figure 1.



A- Rotation of grinding wheel      B- Work piece rotation  
C- Reciprocation of work table      D- In feed

**Figure 1.** Internal grinding operations.

## 3. Results and Discussion

In this section, we have presented the results elaborately by comparing two different material like EN24 and EN353 in different input and output parameters.

**Different Parameters:** The parameters affecting the internal grinding process are cutting speed, depth of cut, material removal rate, cutting fluid, work piece, surface roughness, table speed, material hardness, grinding wheel grades, grain size and grinding forces<sup>28</sup>. The Figures 2 and

3 indicates the pictorial representation of general internal grinding was done.

**Table Speed :** Figure 4 and 5 shows the various table speed with respect to surface roughness and material removal rate. When the table speed increases, surface roughness and the material removal rate also increases for both of the materials EN24 and EN 353. Due to the fact that MRR was obtained at higher speed because there are two ways of grinding processes occur at the equal time, one in rotational and another in linear direction.

**Feed Rate:** The various feed rate related to MRR and surface roughness were calculated with an experimental investigation and the same was illustrated in Figure 6 and Figure 7 clearly. For two different materials (EN 24 and EN353) the investigation was carried out and found that there is an enhancement of surface roughness and MRR by means of feed rate enhancement<sup>28</sup>. The elevated feed rate progression of grinding tool is more against to the specimen and leads to remove a larger amount of materials on the specimen surface. Resulted the specimen surface roughness was increased since extra cutting forces were produced due to the fast advancement of tool and vibrations occurred during the process and it deteriorates the quality of surface finish improvement. From figure 6, it was clearly observed that, there was a very poor quality of surface finish during feed rate and surface roughness rate enhancement. The table speed and the depth of cut were clearly identified as constant parameters for the above process. Similarly the figure 7 identified that there was an enhancement of MRR occurred during feed rate enhancement for the EN24 and EN353<sup>29</sup>.

**Depth of Cut:** During an investigation there has been difference between depth of cut and surface roughness for the selected steel and the same was calculated and the values were given in Figure 8. From the calculated values we came to know that there was an augmentation in depth of cut and in the surface roughness also<sup>29</sup>. Similarly the difference between the constraints of depth of cut and MRR for the same selected materials was evaluated and the calculated values were given in Figure 9. From the calculated values, we concluded that MRR augmentation was occurred during the depth of cut improvement due to the quantity of material eradicated from the material surface through a single stroke of selected tool displacement<sup>29</sup>. More over the enhancement of surface roughness may be in the same order due to the enhancement of dissemination of grinding tool abrasives on the specimen surface. Consequently, if there is a bigger chips exclusion of material takes place during the grinding operation which may

causes scratching the surface of work piece. There is a minimum percentage of development in quality of surface roughness during a constant feed rate and table speed was taken<sup>30</sup>. More the depth of cut more will be the MRR and more material removed with the particular depth of cut.

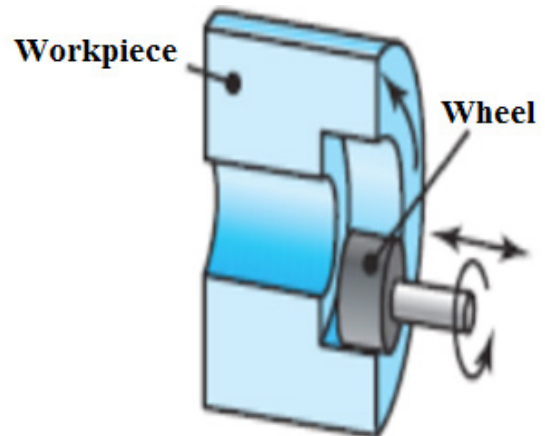


Figure 2. Transverse grinding.

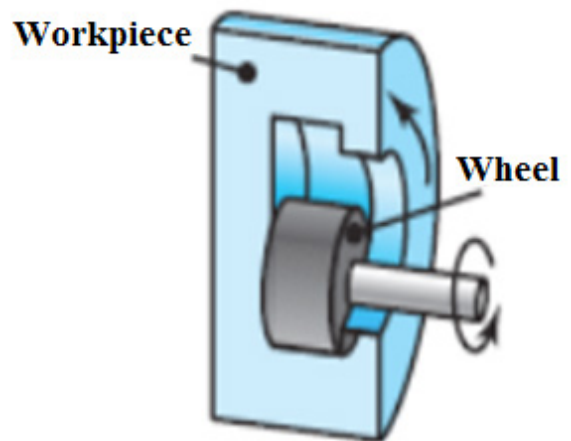


Figure 3. Plunge grinding.

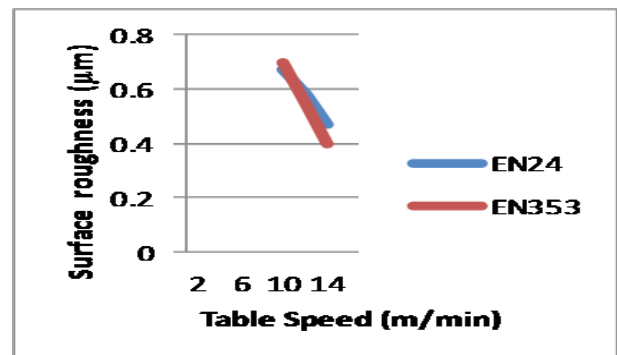


Figure 4. Table speed Vs. Surface roughness.

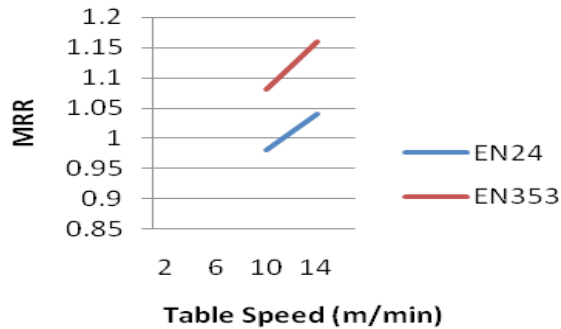


Figure 5. Table speed Vs. Material removal rate.

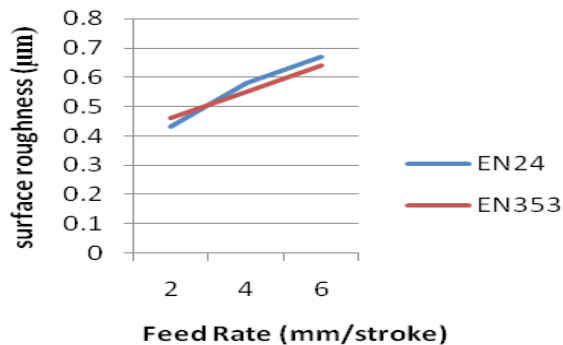


Figure 6. Feed rate Vs. Surface roughness<sup>28</sup>.

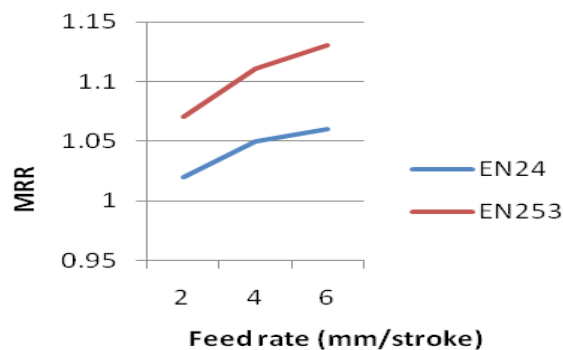


Figure 7. Feed rate Vs. Material removal rate<sup>28</sup>.

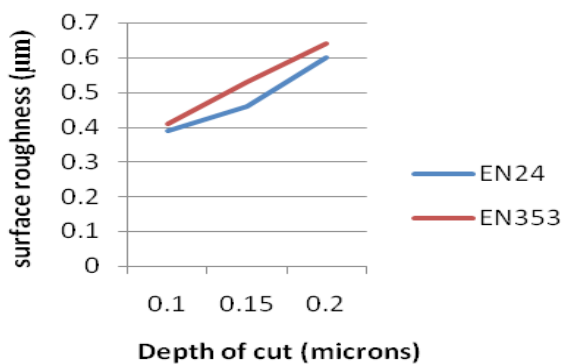


Figure 8. Depth of cut Vs. Surface roughness.

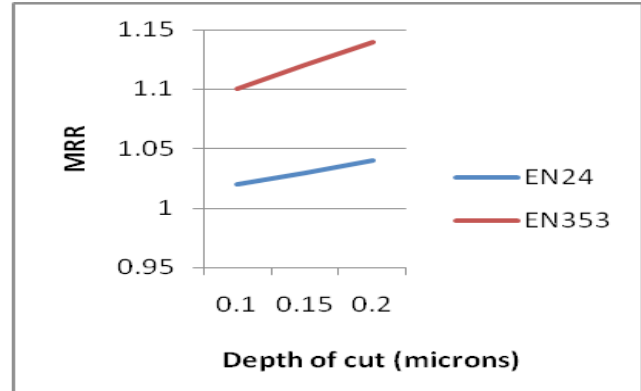


Figure 9. Depth of cut Vs. Material removal rate.

## 4. Summary and Conclusions

- The survey on internal grinding process with different tool materials was thoroughly studied and comparative study on EN24 and EN353 materials and influencing parameters on various factors was also carried out.
- The major parameters affecting the inner grinding process were identified and the influence of those parameters on dissimilar work pieces and tool materials has been monitored.
- The grinding of EN353 provides better MRR when compared to EN24 material and also in the case of feed rate.
- Surface quality is an essential output of machining which is higher in case of EN24 material when compared to EN353 material.
- Internal grinding process provides excellent quality of surface finish to the component and imparts high quality of accuracy of shape and dimension as per the requirements.
- Also found that the internal grinding is maintaining the tool geometry of cutting tools, flattening and forming of surfaces.

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