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# Prediction of Surface Roughness In Ceramic Cutting Tool Using SPSS Model

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**Abstract**

The aim of this study is to predict surface roughness of workpiece which machined by ceramic cutting tool using SPSS program and compare the results with the experimental values which performed under different cutting conditions.Cutting speed (60,80, 90,100,110 m/min ) and feed rate ( 0.1, 0.08, 0.3, mm/rev ) and depth of cut ( 0.25, 0.5 ,0.7mm ) . Experiments were conducted to predict the surface roughness of workpiece , the estimated result shows that there is good greement between average experiments values such as Ra ( 1.27,0.92 ) and predicted values of Ra ( 1.2024, 0.8254 ) and Ra (2.15 ) also value ( 2.2774 ) and experimental values of Ra ( 2.51, 1.78 ).

**Keywords**: ceramic cutting tool, surface roughness, mechanical machining.

# التنبؤ بالخشونة السطحية لعدة القطع السيراميكية بأستخدام SPSS موديل

**الخلاصة**

أن الهدف من هذه الدراسة هو تخمين خشونة السطح للمشغولة التي يتم تشغيلها بأستخدام عدة القطع السيراميكية وبأستخدام برنامج ( SPSS ) ومن ثم مقارنة النتائج مع التجارب العملية والتي تنتج عند ظروف قطع مختلفة من سرع قطع تتضمن ( 60, 80, 90, 100, 110 ) متر/ دقيقة ومعدل تغذية يتراوح (.0.1, 0.08. 0.3 ) ملم/دورة مع عمق قطع ( 0.25, 0.5 ,0.7 ) ملم والنتيجة أدت الى التقارب أو التوافق مابين العملي والتخمين لقيم الخشونة عند القيم ( 1,2024, 0.8254 ) كذلك الخشونة ( 2.15 ) والقيمة( 2.2774 ) مع قيم الخشونة التي تم قياسها وهي ( 1.78 , 2.51 ).

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## 1-Introduction

Metal cutting is one of most important manufacturing processes in the area of material removal (Chen&smith,1977) , black (1979) defind metal cutting as the removal of chip from a workpiece in order to obtain a finished product with desired attributes of size, and surface roughness , Tonshoff et al, (1975) studied the effect of tool composition and tool wear on surface integrity in hard turning of case hardened ASTM 5115 Steel so roughness has been one of most important quality measure in many mechanical products [1,2,3] ceramic are mostly compressed and sintered aluminum oxide powder with sometimes the addition of small amount of other metallic oxide. This type of material is harder than most others, retains it hardness and strength up to 1750 C° and has a low coefficient of heat conductivity and a low coefficient of friction . Alumina – based ceramic were introduced as cutting insert during world war II , and were for many years considered too brittle for reqular machine –shop use , improved machine toolsandfiner-grain , tougher compositions incorporation zirconia or silicon carbide .[4,5]. One of the most effective ceramic cutting tool materials developed in U.K is Syalon (from silicon- aluminium-oxide). The material combines high strength with hot hardness, shouck resistance and other properties. Syalon cutting inserts are made by Kennametal and Sandvik and sold as kyon 2000 then most ceramics used for machining are still based on high purity, fine grained alumina( alumina oxide), , (Abburi&Dixil 2006) developing the knowledge based system for prediction surface roughness in turning process but employ property , this study concentrated on developing the regression program to predict surface roughness for carbon steel using ceramic cutting tool under various cutting condition. tool parameters such as tool material , tool coating, and tool geometry design (edge preparation, rake angle, etc) need to be appropriately chosen for die still fferent operations (roughing-semi roughing or finishing) the optimal performance of cutting tool requires.[6]

## 2-Theoritical procedure:

Although very large numbers of useful ceramic materials are now available, only a few combinations have been found to combine such properties as minimum porosity , hardness , wear resistance , chemical stability , and resistance to shock to the extent necessary for cutting tool inserts , materials based on alumina are widely used moderate amounts of other compounds, eg magnesium oxide, and calcium oxide , are added to form a glassy phase [7,8,9] .

Engineering ceramics are oxide , nitrides ,borides, and silicates, such materials are widely use in engineering for such items as furnace components , tool tips and grinding tools, [10,11,12] then table (3) gives data on the properties of ceramic a statical model was created by regression function in **SPSS** to predict surface roughness which introduce when used ceramic cutting tool . the regression coefficient predict based on the un code d original factor values the magnitudes of the regression coefficient are not compatible either.this is why it is usually more unformative to look at the **ANOVA** parameter predict, however ,the regression coefficient can be useful when making predictons for the dependent variable based on the original metric of the factors. **ANOVA** (Analysis of variance) , a numerical tool that yields asset of parameters upon which a particular case or model is evaluated. **ANOVA** input can be ( as predicted by the current values model) and the observed values. The parameter e predicts and **ANOVA** table are based on the assumption that the residual are normally distributed.

**3-Expermentalprocedure:**

The experimental setup of this study is shown in tables (4,5,6) all machining was done in lathe machine with Fifteen full test were run using to performe experments and several equipments were used as follows:

- Lathe machine was used , and workpiece in form bar of medium carbon steel , using ceramic cutting tool , with cutting speed , feed rate were selected according to tables.

- Surface roughness apparatus was used to measure surface roughness .

4-**Result and discussion**

The predicted Ra as a function of cutting speed and feed rate, depth of cut. The height of the surface represents the value of Ra table (7) shows the Ra, among the main effects, this table indicates that Ra increased with increasing feed rate considerably . in this investigation, the average surface roughness values (Ra) obtained by a machining process with a full factorial design of (5) cutting speed and (3) feed rates using ceramic cutting tool as shown in tables (4,5,6) the results of the variouse analysis of cutting parameters, the main effect of cutting speed and feed rate on surface roughness were significant significant. according to ceramic cutting tool , the lowest average surface roughness was obtained by machining processes and agree with prediction values of surface roughness according to table (7) and values of roughness in figure (1,2,3) at different cutting speed (60,80,90,100,110)mm/min , Figure (1) shows that measured values of Ra (1.27, 0.92) that's agree with predicted values of Ra ( 1.2024, 0.8254 ) Also , Figure (2) shows that the experimental value of Ra (2.15) agrees with the predicted value (2.2774) , Figure (3)also shows that the measured values of Ra (2.51, 1.78) agrees with the predicted values of Ra ( 2.6688, 1.9406) at cutting speed (100,110) m/min and according to the values in table ( 7) . Also tables (4,5,6) show that increasing cutting speed from (60-80) at feed rate 0.08 improvs surface roughness from Ra ( 2.141 µm) to Ra (0.921 µm) in table (5) and from Ra ( 5.152 µm) to Ra (2.513 µm) in table(6).

**5- Conclusions**

This study demonstrates the effect of cutting conditions (cutting speed, feed rate, depth of cut ) on the surface roughness that produced by ceramic cutting tool with SPSS model calculations and reached to the following conclusions: 1- The prediction accuracy of the surface roughness in this researchwith SPSS calculations are 90% .

2-The multiple regression model by SPSS predict surface roughness (Ra) with close agreement with experimental values .

3-Prediction of surface roughness by SPSS program lead to improve tool insert design and cutting condition.

4-Experments prove that increasing cutting speed from 60 m/min to 110 m/min lead to improve the quality of surfaceroughness .

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**Table (1) ANOVA**

| Model | Sum of Squares | df | Mean Square | F | Sig[a] |
|---|---|---|---|---|---|
| 1 Regression | 28.717 | 5 | 5.743 | 32.123 | .000[a] |
| Residual | 1.609 | 9 | .179 | | |
| Total | 30.326 | 14 | | | |

a. Predictors: (constant) X1X2X3, X1,X3,X2,X1X3
b-Dependent Variable Ra

**Table (2) Coefficients[a]**

| | Un standardized Coefficients | | Standardized Coefficients ts | | |
|---|---|---|---|---|---|
| **Mode** | **B** | **Std .error** | **Beta** | **t** | **Sig** |
| 1 Constant | 1.428 | | | | |
| | | .026 | | | |
| X1 | -1.77BE-02 | | | | |
| X2 | -4.534 | | | .798 | .446 |
| X3 | -11.832 | | -.215 | -.688 | .509 |
| X1X3 | 14.118 | | -.317 | -.383 | .710 |
| X1X2X3 | 6.384 | | 1.828 | 2.211 | .054 |
| | -8.004E-02 | .081 | -1.040 | -.990 | .348 |
| | 4.714E-03 | .179 | .025 | .026 | .980 |

$$Ra= \alpha 1+\beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X1X2 + \beta 5X1X3 + \beta 6X2X3 + \beta 7X!X2X3$$

$$Ra = 1.428 - 1.778 * 10^{-2}X1 - 4.534X2 + 14.118X3 - 8.004 * 10^{-2}X1X3 + 4.714 * 10^{-3}X1X2X3$$

Table (3) Mechanical properties of ceramics oxide [2]

| Material | Density | Coefficient of expansion | Elastic modulus GPa | Max use temp C° | Resistivity Ωm |
|---|---|---|---|---|---|
| Alumina 99% | 3.7 | 5.9 | 380 | 1600 | $10^{12}$ |
| Alumina 95% | 3.5 | 5.6=5.9 | 320 | 1400 | $10^{12}$ |
| Alumina 90% | 3.4 | 5-6 | 360 | 1200 | $10^{12}$ |

Table (4) Cutting conditions at feed rate 0.08 and depth of cut 0.25 mm

| No | Cutting speed m/min | Feed rate mm/rev | Depth of cut mm | Surface roughness Ra µm |
|---|---|---|---|---|
| 1- | 60 | 0.08 | 0.25 | 2.141 |
| 2- | 80 | 0.08 | 0.25 | 1.823 |
| 3- | 90 | 0.08 | 0.25 | 1.270 |
| 4- | 100 | 0.08 | 0.25 | 0.921 |
| 5- | 110 | 0.08 | 0.25 | 0.234 |

Table (5) Cutting conditions at feed rate 0.1 and depth of cut 0.5 mm

| No | Cutting speed m/min | Feed rate mm/rev | Depth of cut mm | Surface roughness Ra µm |
|---|---|---|---|---|
| 1- | 60 | 0.1 | 0.5 | 4.21 |
| 2- | 80 | 0.1 | 0. 5 | 3.830 |
| 3- | 90 | 0.1 | 0. 5 | 3.221 |
| 4- | 100 | 0.1 | 0. 5 | 2.150 |
| 5- | 110 | 0.1 | 0. 5 | 1.411 |

Table (6) Cutting conditions at feed rate 0.3 and depth of cut 0.7 mm

| No | Cutting speed m/min | Feed rate mm/rev | Depth of cut mm | Surface roughness Ra µm |
|---|---|---|---|---|
| 1- | 60 | 0.3 | 0.7 | 5.152 |
| 2- | 80 | 0.3 | 0.7 | 4.941 |
| 3- | 90 | 0.3 | 0.7 | 3.325 |
| 4- | 100 | 0.3 | 0.7 | 2.513 |
| 5- | 110 | 0.3 | 0.7 | 1.782 |

**Table (7) Experimental and prediction roughness caswise Diagnostics [a]**

| Case Number | Std Residual | Predict values Ra | Predict values Ra | Residual |
|---|---|---|---|---|
| 1 | -.455 | 2.14 | 2.3333 | -.1923 |
| 2 | .576 | 1.82 | 1.5794 | .2436 |
| 3 | .160 | 1.27 | 1.202 | 6.759E-02 |
| 4 | .226 | .92 | .8254 | 9.557E-02 |
| 5 | -.507 | .23 | .4485 | -.2145 |
| 6 | -.875 | 4.21 | 4.5801 | -.3701 |
| 7 | .949 | 3.83 | 3.4287 | .4013 |
| 8 | .915 | 3.24 | 2.8531 | .3869 |
| 9 | -.301 | 2.15 | 2.2774 | -.1274 |
| 10 | -.688 | 1.41 | 1.7017 | -.2907 |
| 11 | -1.016 | 5.15 | 5.5816 | -.4296 |
| 12 | 1.929 | 4.94 | 4.1252 | .8158 |
| 13 | -.170 | 3.33 | 3.3970 | -7.20E-02 |
| 14 | -.368 | 2.51 | 2.6688 | -.1558 |
| 15 | -.375 | 1.78 | 1.9406 | -.1586 |

a- Dependent Variable :Ra

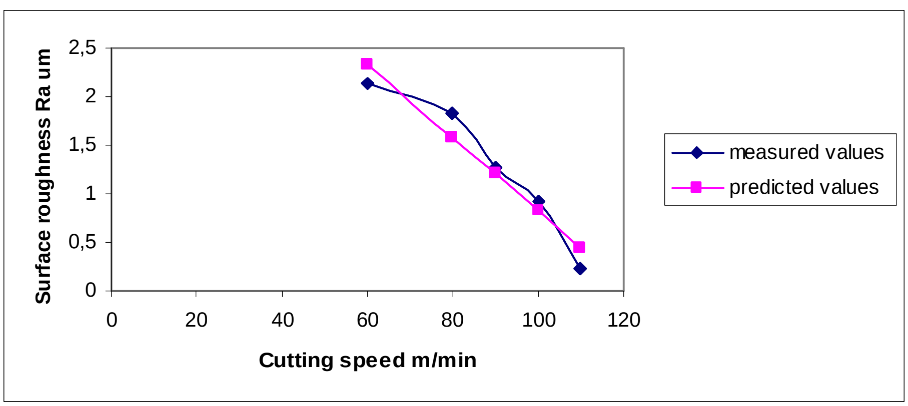


**Figure (1) Relationship between cutting speed and surface finish at feed rate 0.08mm/rev and depth of cut 0.25mm**

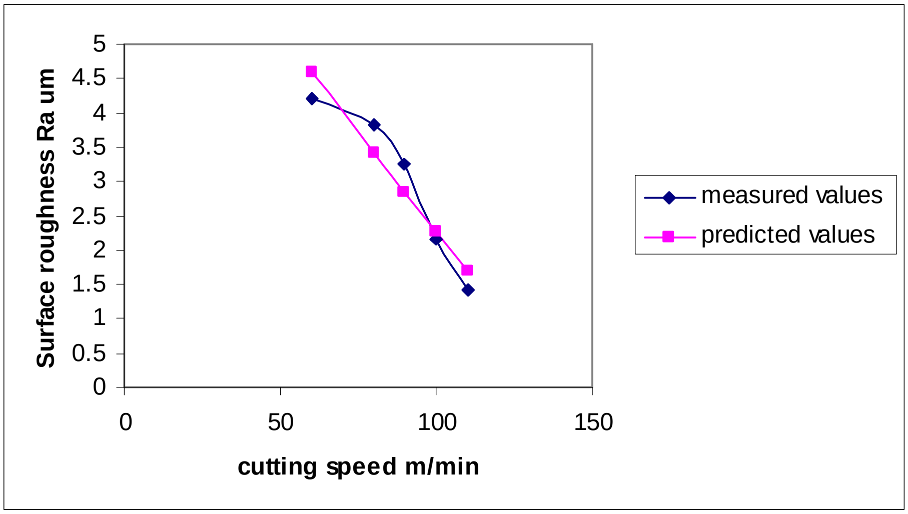


**Figure (2) Relationship between cutting speed and surface finish at feed rate 0.1mm/rev and depth of cut 0. 5mm**

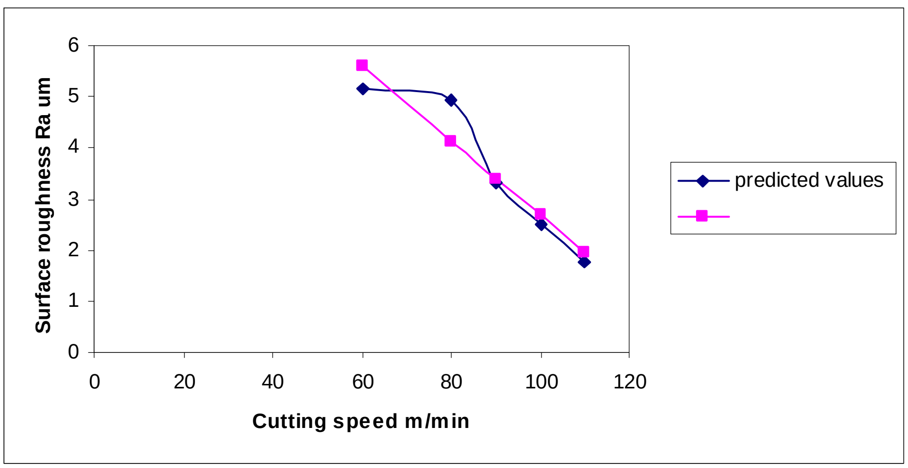


**Figure (3) Relationship between cutting speed and surface finish at feed rate 0.3 mm/rev and depth of cut 0. 7mm**