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The effect of turning parameters on surface smoothness of D3 cold work steel

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***Abstract*— This paper studies the effect of turning parameters such as cutting speed, feed rate, load depth, cutting time and tool radius on surface roughness in the process of turning the D3 cold-work steel. To perform this research, crude steel samples were cut into crude work piece and went under machining process using lathe turning machine after altering the turning parameters, and then surface smoothness of the obtained test samples were measured and compared using roughness measuring device.**
***Keywords*— Turning, Cold-work Steel, Surface Smoothness, Roughness**

I. INTRODUCTION

Cold-work tool steels are categorized into three types: hardening- low alloy steels in oil (O), air-hard mild alloy steels (A) and high-chromium high carbon steels (D). This steel cannot maintain hardness at high temperature but it has high wear resistance at low temperatures. Hardenability depth are high and it has low distortion during thermal treatment there is a possibility of cracking in the complex shapes during thermal treatment. Using this kind of steel for cutting is more affordable at low temperatures.

SPK steel or Special K is one of the Cold work tool steels that have been named using standard numbers of 1.2080 and X2 10Cr12. This steel is used to make cutting blades, broaching tools, blanking and punching dies, and tools by which the cold forming process is performed. Also, this steel is used for making forming rollers, sizing profile production line, cold and hot stretching dies, deep drawing and bending dies, Cold rolling machines, and Ceramics and powder form templates. SPK steel known as a steel of high hardness and because of its high level of chrome (Cr) it is high wear resistance.

TABLE I
CHEMICAL PROPERTIES OF 1.2080

C%	Si%	Mn%	P% max	S% max
1,90-2,20	0,10-0,60	0,20-0,60	0,030	0,030
± 0.05	± 0.03	± 0.04	+ 0.005	+ 0.005

One of the most important survival factors and development of a company is producing high quality products at low prices. Increasing the quality of manufactured products has always been a major problem due to increased production time and the rising price of the product. Manufacturing high-quality machined products requires advanced production lines and expensive machines and tools. Therefore, quality control of the products during the manufacturing operation without stopping the processes is of great importance [1]. Surface Quality is one of the most important parameters in most machined work pieces. Considering the fact that measuring and controlling the quality of a work piece surface compared with other parameters such as dimensional sizes or geometric forms is more complicated therefore lots of studies have been conducted in this area. Work-piece surface finish can be measured directly by employing some techniques, such as fibre optic sensors techniques, and surface quality can be controlled using ultrasonic methods during machining process. Also, some theoretical and experimental models have been suggested on the surface quality and cutting parameters.

Today, manufacturers are trying to increase the quality of products and reduce their cost. Metals' machining and cutting are some of the most important processes in metal parts production which are widely used in various industries. The final work piece quality and production costs in machining are directly influenced by the geometry of the tool and cutting parameters. In this respect, studies focused mainly on material, tool geometry and setting the machining parameters. On the other hand, one of the most important criteria for assessing the quality of machined parts is final surface finish. Surface finish depends on several factors, notably the turning tool geometry and cutting parameters such as machining depth, spindle rotational speed, feed rate, and blade tip radius [2].

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Therefore, in order to achieve the desired surface finish, cutting parameters and tools should be determined appropriately considering the work-piece material. In most practical uses, the tool and cutting parameters are determined experimentally using methods based on trial and error. However, these method in addition to their high costs, are likely to result in errors. In recent years, the use of scientific methods to optimize the manufacturing processes has increased significantly.

II. THE PROCESS OF TURNING

Turning is one of the oldest methods of shaping and machining of parts, and because of the high capabilities is one of the most widely used methods of production today. During the process the work-piece rotates and a cutting tool which is way harder than work-piece material cuts the work-piece surface with linear movement and changes it to final piece. Thus, lathe machine is able to machine the pieces that has a rotary volume such as simple and non-simple bars, helical bars, and bushes and so on which are machines' main parts and technical devices. The large number of tools such as milling blades, drills, reamers and taps has a round cross-sections. Therefore, according to the use of parts, they are made of different materials such as steel, cast iron, bronze, brass, copper, light metal, wood or synthetic materials. According to material of parts in turning, the situation of their outer surface could be different.

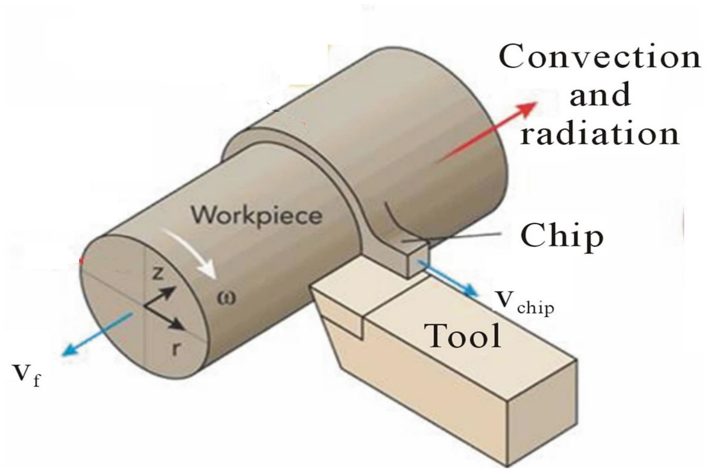

Fig. 1 Turning Method

III. EFFECTIVE PARAMETERS ON SURFACE ROUGHNESS IN THE PROCESS OF TURNING

The unevenness that exist in a very close distances on the work-piece is referred to as roughness which is measured by using a roughness measuring device, and their physical properties depends on the machining depth, material, feed rate, spindle rotation speed, geometry of tools, machining operation type, the radius of the tip of the blade and so on. The two main criteria for measuring surface finish is as follows: The maximum roughness height (Rmax), which represents the distance of two parallel lines one of which is tangent to the highest peak and the other one is tangent to the lowest. The average roughness (Ra) is the most important criteria of the roughness measurement which is used in tests and represents a calculating mean deviation of roughness from the midline.

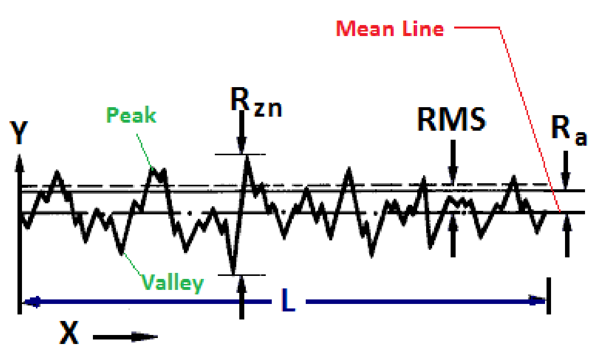

Fig. 2 roughness measuring

Many parameters affect the surface smoothness or roughness in the process of turning, the most important of which is as follows:

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Machining depth that is the amount of pen's momentary engagement with work-piece along the perpendicular to the surface consisting the main movements and feeding. Generally, in turning with a single-edged pens it's the depth of material removed from the work-piece and is measured in millimetres. The spindle rotational speed which is sometimes called rotational speed, is a quantity expressing the number of rotations per unit of time. Therefore, the type of this quantity is frequency and is defined in terms of round per second. In common engineering uses and in turning, the unit which is mostly used to express rotational speed is round per minute (RPM). The feed rate which is the pens displacement against the work-piece in the direction of feed movement for a complete round of pen or work-piece and its unit is millimetres per second. The radius of blade is the radius of blade's tip. Cutting tool can be cutting sharp edge, round edge, or chamfered edges. The different edges of blades make them suitable for different uses and provide them with different characteristics [3]. For example, round edge blades can cause a better temperature distribution on the surface on the blade's edge, and it will reduce the amount of wear. Blades with a sharp edge are good for parting operations, and chamfered edge blades are meant for rough machining operation.

Also the chip flow form, machined surface integrity, residual stresses on the work-piece surface depends on the edge of the used blade. Schematic figure of a work-piece on the lathe and various parameters are illustrated in Figure 9.

IV. EMPIRICAL EXPERIMENTS

Work-pieces used in the tests are cylindrical shafts made of cold work steel D3 DIN 1.2080 with a diameter of 40 mm and a length of 1200 mm, and its profile determined in the table 1. The main advantage of this steel is its excellent wear resistance and can under nitration process. This steel used in manufacturing high quality cutting tools, deep drawing and extrusion template, cold rolling mill rollers, measuring tools, plastic injection melds, cold rolling mill rollers' coat, and so on.

For the survival of the industry to achieve optimal quality fast with low cost is essential. In the machining process, it would be possible with proper and intelligent selection of machining parameters. In this study, using professional knowledge base, an algorithm has been provided on machining parameters during the process of machining which carries out the smart selection of machining parameters to achieve desired quality with respect to the presented information. In the turning process the most important parameter are feed rate, cutting speed and depth of cut. Typically, quality refers to a better surface finish and production tolerance. In this respect, the depth of cut, material and surface finish of the work-piece are considered as the input, and the cutting speed and feed as the output. To estimate the surface roughness after machining some proper functions have been employed. Finally, to do this work a software is prepared and presented results are favourable. Machining is one of the most widely used manufacturing processes and plays a key role in the quality of most products. For example, with accurate analysis and expressing the complexity of the machining process it can be understood that increasing the cutting parameters can be more economical than increasing the tool's life by reducing the cutting parameters. It means that, 20% increase in cutting parameters will decrease the costs by 15%. However, increasing tool's life by up to 50%, will only reduce the total cost of production by 1%. [4]. Or according to estimates 80 percent of the production time of the final products is spent on modern manufacturing and production systems and machining, however, in traditional machine tools only 5% of time spent on machining operation [5]. Considering this data, the correct meaning of smart and intelligent selection of economical machining parameters can be better understood.

Surface Quality is one of the most important parameters in most machined work pieces. Considering the fact that measuring and controlling the quality of a work piece surface compared with other parameters such as dimensional sizes or geometric forms is more complicated, therefore lots of studies have been conducted in this area. For example, some scientists based on cutting parameters and tool vibration predicted the surface roughness and also they have offered a model to predict surface quality using Perceptron Multilayer network during the turning process and noted the high accuracy of neural networks to predict the surface qualities [6]. Others have offered some theoretical and empirical models of surface quality and cutting parameters and discussed a model to predict surface finish and tool wear with the help of neural networks and regression method, and showed that neural networks are more accurate than the regression method [7]. Therefore, according to the mentioned information to achieve favourable quality by selecting the maximum values of the cutting parameters can be more economical. In this study, using professional knowledge base, an algorithm has been provided on machining parameters during the process of machining which carries out the smart selection of machining parameters to achieve desired quality according to the presented information. The depth of cut, material and surface finish of the work-piece are considered as the input, and the cutting speed and feed as the output. Finally, a software is prepared to do this work and presented results are favourable.

In this paper, a model has been proposed to predict surface finish for 50.2 steel machined with CNC machine using artificial neural networks and linear and nonlinear regression method. For this purpose parameters such as (F) feed rate in meter per minute (V)

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cutting speed in mm, cutting depth in millimetres per round have been considered as variable parameters. Also, the test conditions have been selected in a way that have the minimal changes in other variables such as tool vibration, tool wear, temperature and so on. Exist. For this purpose, 60 samples with various cutting speed, feed rate and depth of cut have been machined according to the conditions of table (1) and samples surface finish were measured in micron meter.

Fig. 2 CNC machine using in this study

V. THE TESTS RESULTS

A. The tests results for each parameter investigated separately.

B. The test results for three different blade tip radius illustrated in Figure 3.

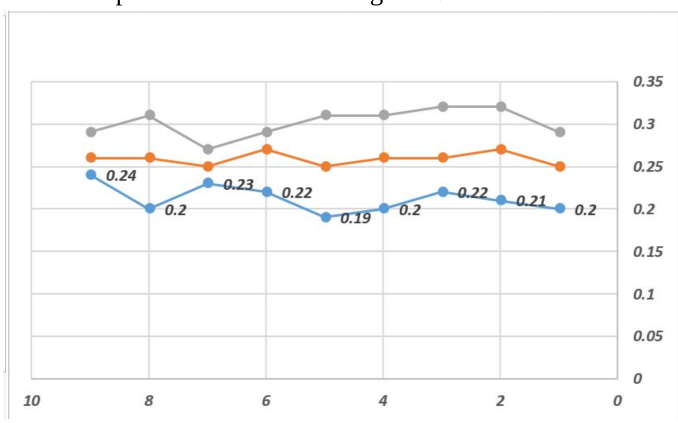

Fig. 3 Effect of blade's tip radius

Surface roughness based on the samples number for blade tip with different radius. The surface roughness based on the blade tip radius. Since it is not possible to get to a general conclusion from this graph, the results of each blade tip radius are calculated and the values are shown in Figure 3. Figure shows that as the blade tip radius decreases surface roughness will increase and a better quality will be achieved which can be caused by invariable blade contact with the surface during the machining process. The effect of feed rate for each blade are shown in Figures 4.

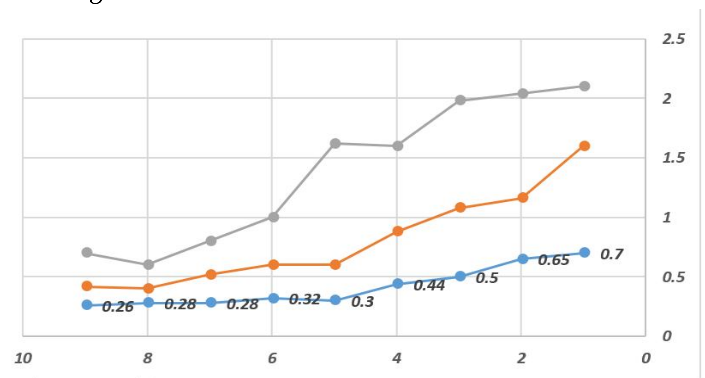

Fig. 4 Effect of feed rate

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Figures 4 showed with the increasing feed rate, the surface roughness increases and the surface finish smoothness decreases because when the feed rate increases, the blade will cut more chips off the work-piece in every turnaround and reduces the surface finish smoothness the effect of the spindle rotational speed for each blade are shown in Figures 5.

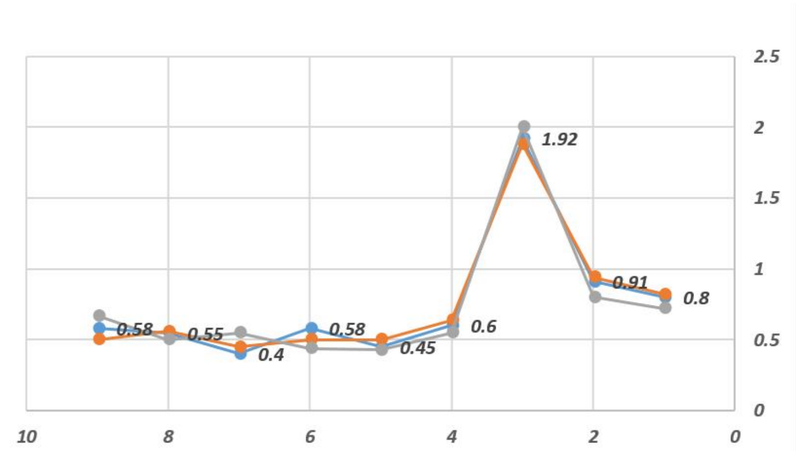

Fig. 5 Effect of spindle rotation

With increasing the amount of material removal from the surface will increase at every level, and thus surface roughness reduces. However, as shown in Figures for the blade with a tip radius of 1.2 mm by changing the depth of material removal, surface smoothness will reduce.

VI. CONCLUSIONS

There are various methods to study processes including forming processes which are the best and most accurate methods for conducting practical tests using real materials. In this study, by performing practical tests the effects of different parameters on surface roughness for cold work steel 2080 have been studied

The results of this study show that:

A. With increasing blade’s tip radius the amount of surface finish decreases.
B. By increasing the cutting depth the amount of surface roughness reduced
C. Spindle rotational speed does not affect the surface finish.
D. By increasing the feed rate the amount of surface finish decreases.

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