

Dimensioning of parts exposed to the mechanical turning process through an application for mobile devices

Dimensionamento de peças expostas ao processo de torneamento mecânico através de uma aplicação para dispositivos móveis

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ABSTRACT

The present article aims to study some common equations in calculations of the mechanical turning process, using active teaching-learning methodologies. Thus, this work has as main objective to develop an application to determine the various variables necessary for the dimensioning of the parts to be turned inside the machining. The expressions used in the application show the Cutting Speed, Advance per Rotation, and Cut Time. In addition to the great contribution to the teaching-learning of the user executing the application, it provides solutions to daily activities that involve these types of problems in Mechanical Engineering. From the obtained results, it was observed that the Cutting Speed, Rotation Advance and Cut Time presented modifications with variations of the properties connected to these cutting parameters.

Keywords: Mechanical Turning, Cutting Speed, Advancement, Cutting Time.

RESUMO

O presente artigo visa estudar algumas equações comuns nos cálculos do processo de torneamento mecânico, utilizando metodologias ativas de ensino-aprendizagem. Assim, este trabalho tem como objetivo principal desenvolver uma aplicação para determinar as diversas variáveis necessárias para o dimensionamento das peças a serem torneadas

dentro da usinagem. As expressões utilizadas na aplicação mostram a Velocidade de Corte, Avanço por Rotação, e Tempo de Corte. Além da grande contribuição para o ensino-aprendizagem do usuário que executa a aplicação, ela fornece soluções para atividades diárias que envolvem estes tipos de problemas na Engenharia Mecânica. A partir dos resultados obtidos, observou-se que a Velocidade de Corte, o Avanço por Rotação e o Tempo de Corte apresentaram modificações com variações das propriedades ligadas a estes parâmetros de corte.

Palavras-chave: Torneamento Mecânico, Velocidade de Corte, Avanço, Tempo de Corte.

1 INTRODUCTION

Machining is classified as one of the fundamental manufacturing processes and widely used worldwide by the metalworking industry. Currently the high world consumption has contributed to the expansion of machining processes increasingly used and exposed in daily life [1]. Machining is understood to be the process of removing fragments from a material in order to form a component or part, producing the chip. The chip is the portion of material removed by the tool and characterized by an irregular geometric shape [2].

The research that intensifies the restriction to the maximum (or elimination) of the use of cutting fluids in metallurgical production has increased in recent years. The conditions evidencing this process involve ecological issues, legal requirements for preservation of the environment, operational costs of production, etc. [3]. Linked to all this, the use of active teaching methodologies is extremely important, since it leverages the users' learning [4]. Using active methodologies of new ideas and teaching tools allows the student to feel more committed to the topic. Turning learning into something more stimulating for both the teacher and the student. The methods and techniques should be used to achieve the initial objectives proposed and also meet the criteria of lower cost, greater agility, efficiency and reliability of information [5].

The main applications suitable for turning of hardened material are gears, mold components, stamping bases and also in bearings. The tools consist of Cubic Boron Nitride (CBN) show good performance in the process of machining of hardened materials due to their high hardness, low solubility in iron and good fracture toughness [6].

The most important cutting parameters are Cutting Speed, Rotation Advance, Cutting Time, Finished Surface Theoretical Roughness, Machining Depth, Cutting

Thickness and Cutting Section Area [7]. Among the various cutting parameters, the three most relevant for this work will be the cutting speed, Rotation Advance and Cut Time.

The Cutting Speed is the one that has the least influence on the Specific Cutting Energy due to some factors (temperature, settling and friction). In cases of very high shear speeds, there is a sudden increase in temperature, reducing the shear strength of the material. Elevation of the Feedrate of the tool generates a reduction of the Cutting Specific Energy. This reduction of Specific Energy can result from the entire volume of the material being chipped when the Advancement is increased (small force consumed) [8].

The objective of this work is to optimize the teaching-learning of the users through a mobile application, as well as to determine in a fast and didactic way the calculations of the cutting parameters resulting from the mechanical turning process.

2 COMPUTATIONAL PROCEDURE

The expressions for calculating the cutoff parameters will be shown throughout this section. The first parameter analyzed is the Cutting Speed, shown in Fig. 1. This is measured in meters per minute and the correct value is obtained when the lathe rotates at the proper rotations.

Figure 1: Cutting Speed Scheme.



The properties that influence the Cutting Speed can be calculated according to Eq.

1.

$$V_c = \frac{\pi \cdot D_m \cdot n}{1000} \text{ (m/min)} \quad (1)$$

In which:

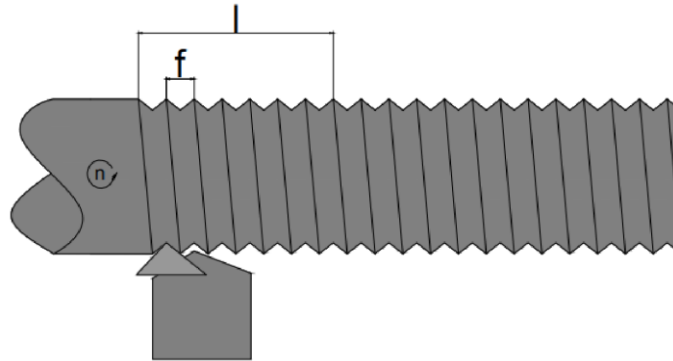
V_c : Cutting Speed (m / min)

D_m : Workpiece diameter (mm)

n : Main Axis Rotation (rpm)

The second parameter analyzed is the Rotation Cut Advancement, shown in Fig. 2, which is given by the machined length ratio (in mm) by the Principal Axis Rotation (min-1).

Figure 1: Cutting Speed Scheme.



For this cutoff parameter, the properties that influence the advance can be calculated by Eq. 2.

$$f = \frac{l}{n} \text{ (mm/rot)} \quad (2)$$

In which,

- f: Advance rate per rotation (mm / rot);
- l: Length Machined per minute (mm / min);
- n: Rotation of the Main Axis (rpm).

The third parameter analyzed is the Cut Time, expressed by the workpiece length ratio (in mm) and the machined length per minute (in mm / min). This can be seen in Eq. 3.

$$T_c = \frac{l_m}{l} \text{ (mm/rot)} \quad (3)$$

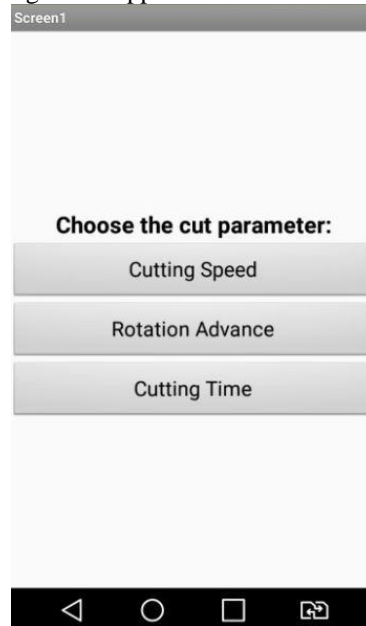
In which:

- T_c : Cut Time (min)
- l_m : Workpiece length (mm)
- l: Length Machined per minute (mm / min)

The software developed in this work was done on the platform of the MIT App Inventor 2. This space allows users to design and run their own applications. Fig. 3 shows the initial screen of the application created, which is available for devices with Android operating system.

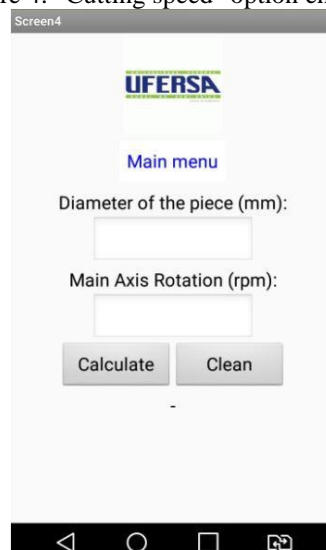
In the initial screen of the application, the user must choose the desired cutting parameter, being: Cut Speed, Advance per Rotation and Cut Time.

Figure 3: Application initial screen.



When selecting the "Cutting Speed" option, the user must enter the initial data of the turned part diameter and the axis rotation, as shown in Fig. 4.

Figure 4: "Cutting speed" option enabled.



When selecting the option "Advance per Rotation", shown in Fig. 5, the initial values of the machined length per minute and the rotation of the main axis must be added.

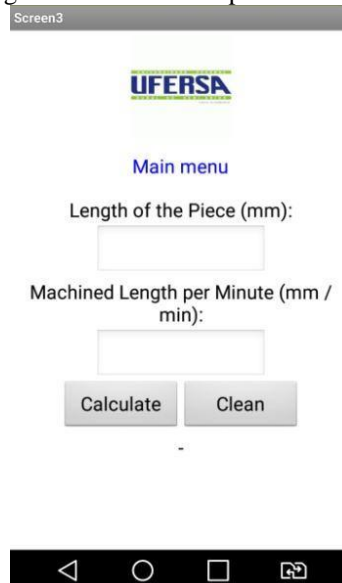
Figure 5: "Advance per Rotation" option enabled.



The screenshot shows a mobile application interface for UFRSA. At the top, there is a header with the UFRSA logo and the text 'Main menu'. Below this, there are two input fields: 'Machined length per minute (mm / min):' and 'Main Shaft Rotation (rpm):'. Each input field is followed by a 'Calculate' button and a 'Clean' button. The interface is displayed on a screen labeled 'Screen2'.

The third option that can be chosen by the user, shown in Fig. 6, is the "Cut Time". In this case, it is important that the values of the length of the workpiece in mm, and the machined length per minute in mm / min be entered.

Figure 6: "Cut Time" option enabled.



The screenshot shows a mobile application interface for UFRSA. At the top, there is a header with the UFRSA logo and the text 'Main menu'. Below this, there are two input fields: 'Length of the Piece (mm):' and 'Machined Length per Minute (mm / min):'. Each input field is followed by a 'Calculate' button and a 'Clean' button. The interface is displayed on a screen labeled 'Screen3'.

It is important to say that if the user selects the unwanted option, there is the presence of the "Main Menu" so that it can start the process of inserting the desired parameter again.

The option is found at the top of the application in any of the selected options. Another option appropriate to the error is to "Clear". This is also present in all user-selected cut parameter options.

3 RESULTS AND DISCUSSIONS

Some initial values were proposed for calculations to be made through the developed application.

The initial data appear, separately, in the tables exposed below. Tab. 1 presents the dependent variables for the Cutting Speed, Tab. 2 shows the variables for determining the Cut Advancement and Tab. 3 presents the variables to indicate the Cut Time.

Table 1 - Initial parameters for the application to calculate the Cutting Speed

| Cutting Parameter | Diameter of the workpiece (mm) | Main Axis Rotation (min-1) |
|-------------------|--------------------------------|----------------------------|
| Cutting Speed | 50 | 700 |

Table 2 - Initial parameters for the application to calculate the Advance by Rotation

| Cutting Parameter | Main Axis Rotation (min-1) | Length Machined per minute (mm / min) |
|----------------------|----------------------------|---------------------------------------|
| Advance per Rotation | 500 | 120 |

Table 3 - Initial parameters for the application to calculate the Cut Time

| Cutting Parameter | Length Machined per minute (mm / min) | Workpiece Length (mm) |
|-------------------|---------------------------------------|-----------------------|
| Cutting Time | 200 | 100 |

In the first situation, shown in Fig. 7, when the first option of the cut parameters presented in the initial screen of the software is selected, and the values of the workpiece diameter and the rotation caused in the main axis (shown in Table 1), the application calculated the Cut Velocity value, which was 109.9 m / min.

Figure 7: Cutting speed calculated by the application.

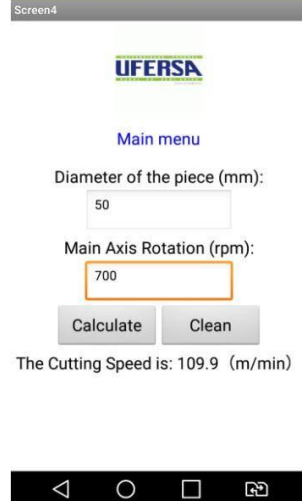


Fig. 8 shows the value of the cut advancement calculated by the software. In this second option, the user enters the value of the machined length per minute and the rotation of the main axis. The calculated Rotation advance was 0.24 mm / rev.

Figure 8: Rotation advance calculated by the application.

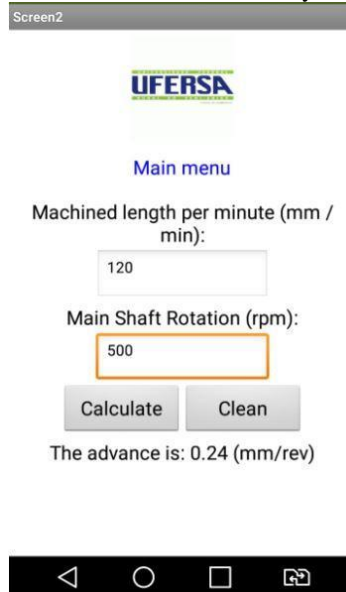
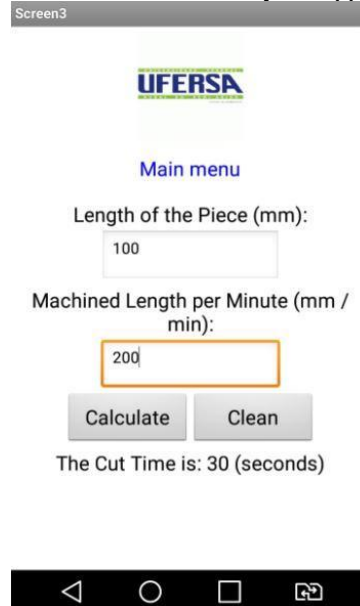


Fig. 9 shows the calculated Cut Time, in which it was 30 seconds. This time, when you select this option, you provide the length of the workpiece and the machined length per minute.

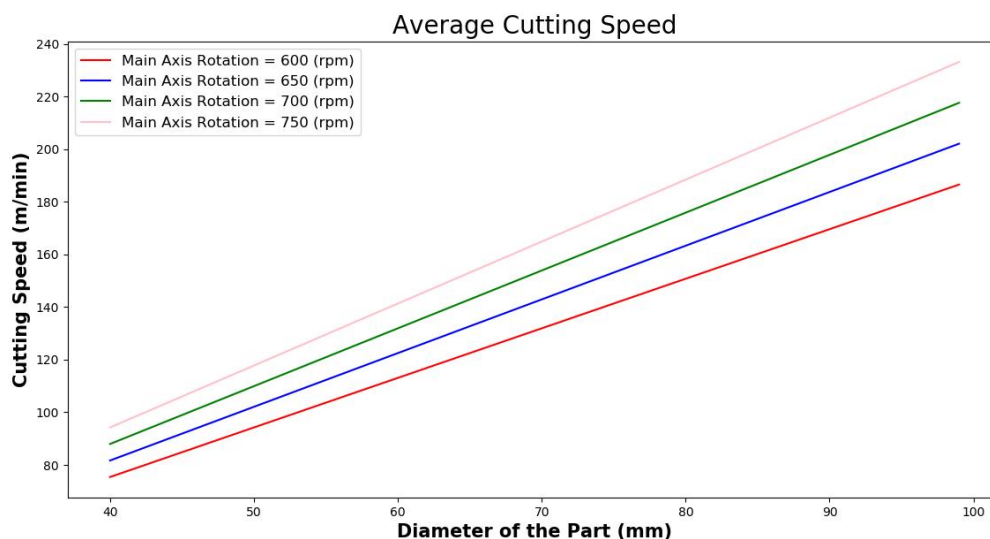
Figure 9: Cut time calculated by the application.



Two graphs were plotted for each situation studied according to the cut parameters. There was a need to keep some values constant and others varying. All this for possible comparisons and observations of the behavior of these parameters.

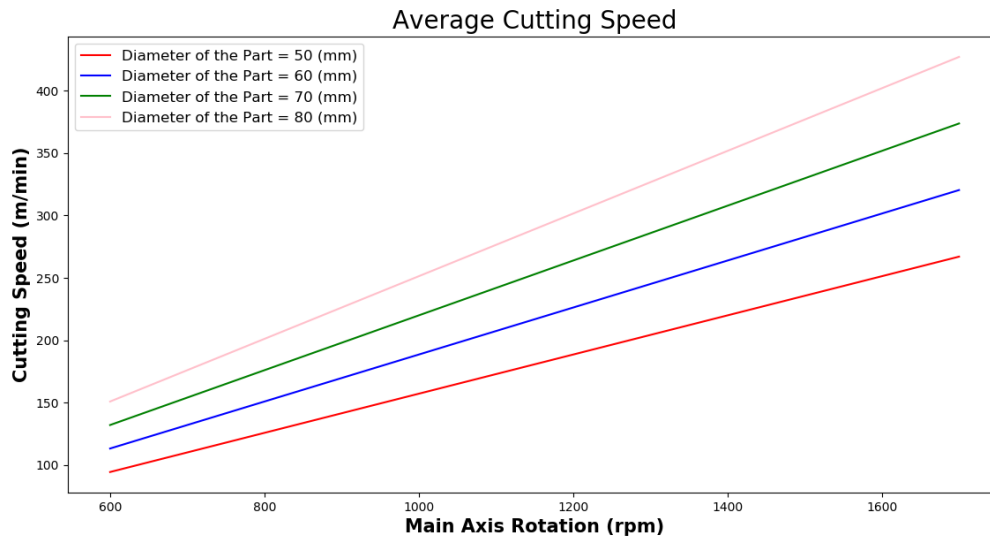
The first parameter was the Cutting Speed. Fig. 10 shows the Average Cutting Speed with variations for the workpiece diameter, plotting lines for different values of rotation of the main axis.

Figure 10: Average Cutting Speed with variations of the Workpiece Diameter.



In the second graph constructed for the Average Cutting Speed, Fig. 11, there is variation of the Main Axis Rotation, plotting lines for different values of the diameter workpiece.

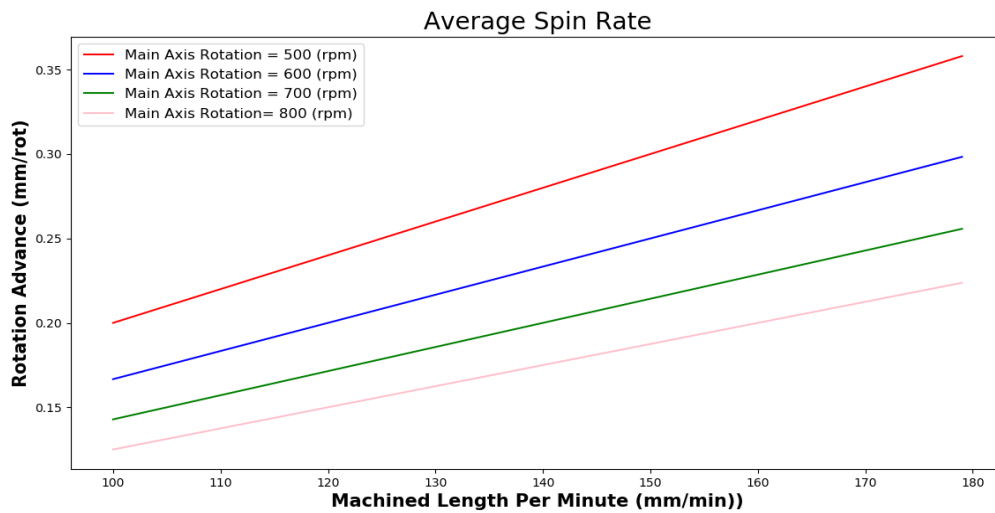
Figure 11: Average Cutting Speed with the changes of the Main Axis Rotation.



The second parameter analyzed was the Rotation Advancement In the graph of Fig. 12 constructed to analyze the behavior of this parameter the value of Machined Length per minute was varied, plotting lines for different values of rotation of the main axis.

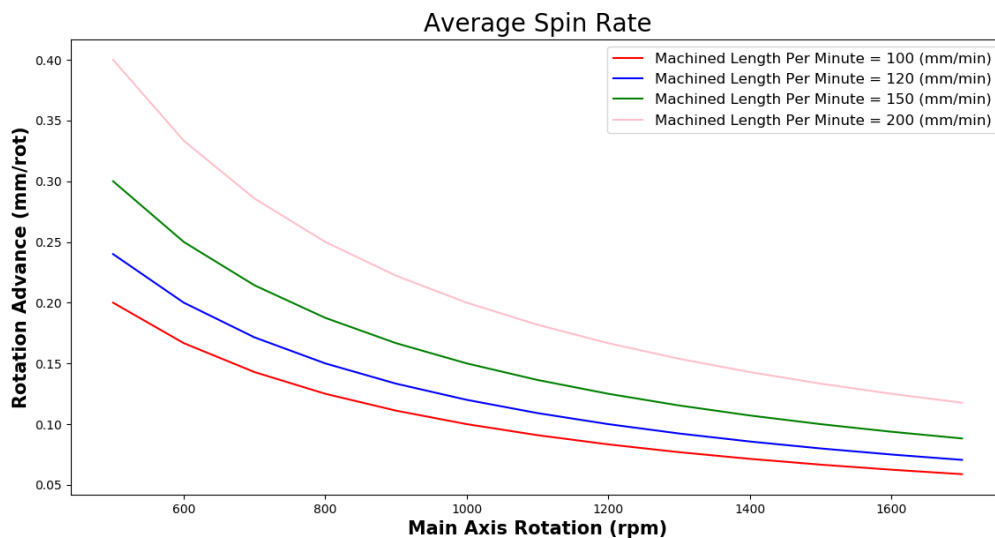
As the Rotation Advancement is directly proportional to the Machined Length per minute, it was found that the lines formed had increasing variations. Then, the higher the Machined Length per minute, the higher the Rotation Advancement.

Figure 12: Advancement by Rotation with variations of Machined Length per minute.



The second graph for the Advance per Rotation, shown in Fig. 13, was created with different lines for the Machined Length per minute value and with variation for the Main Axis Rotation. It is observed that the greater the Rotation of the main Axis, the smaller the Rotation Advance, this is due to the fact that the advance is inversely proportional to the rotation of the main axis.

Figure 13: Advance per Rotation with variations of the Main Axis Rotation.



The third parameter analyzed was the Cut Time. The first graph, shown in Fig. 14, was plotted by varying the Workpiece Length, lines were plotted for different values of Machined Length per Minute, it can be observed that the longer the Workpiece Length,

the longer the Cut Time. This is due to the fact that the Total Workpiece Length is directly proportional to the Cut Time.

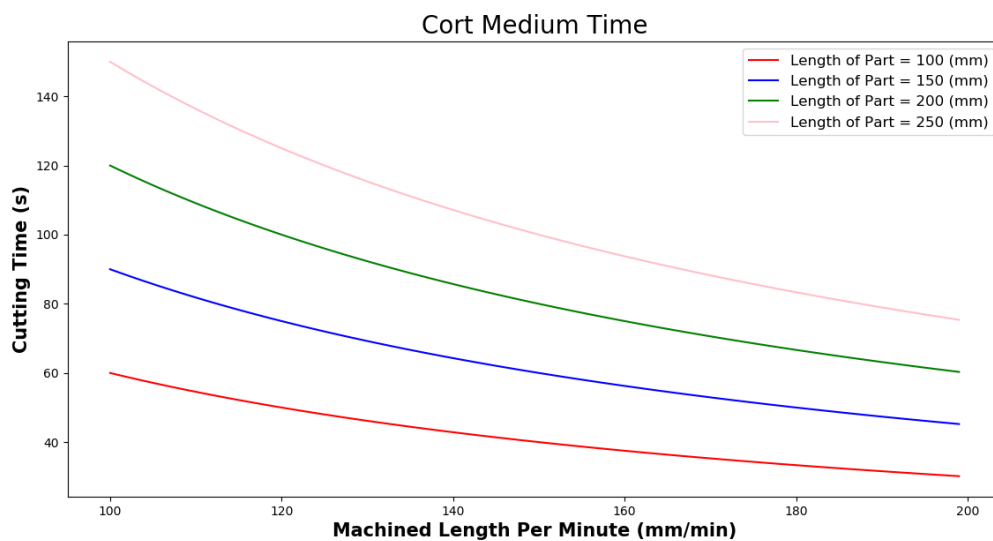
Figure 14: Cutting Time with Variations of the Workpiece Length.



In the second graph related to the cutting time, Fig. 15 was determined by changes in the value of the machined length per minute, and were plotted lines for some different values of the workpiece length.

It is notable that the lines are decreasing since the Machined Length per minute is inversely proportional to the Cut Time.

Figure 15: Cutting Time with variations of Machined Length per minute.



4 CONCLUSION

The use of the mobile application developed in this work is extremely important for the teaching-learning of the users who use it. In addition to this contribution, the use of the software determines the three main cutting parameters: Cutting Speed, Rotation Advance, and Cut Time.

To interpret the behavior of the parameters, it was necessary to plot two graphs for each study situation with the cut parameters. In the analysis of the Average Cutting Speed shown in Fig. 10 indicates an increase in Cutting Speed as the Diameter of the workpiece also increases. In the graph of Fig. 11, the Cutting Speed increases as the Main Axis Rotation increases. In the Study of Rotation Advance, Fig. 12, shows the increase of this parameter as there is an increase in Machined Length per minute.

The graph depicted in Fig. 13 matches a decrease of the Advancement per Rotation when the Main Axis Rotation is increased. On the observation of the Cut Time, Fig. 14, shows that the Cut Time is longer the longer the Workpiece Length. In the second graph, shown in Fig. 15, the Cut Time decreases when the Machined Length per minute increases, since these two properties are inversely proportional.

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