23rd ABCM International Congress of Mechanical Engineering
December 6-11, 2015, Rio de Janeiro, RJ, Brazil

COMPARATIVE ANALYSIS OF PERFORMANCE OF TOOLS ON 2024 ALUMINUM'S TURNING.

Manoel Cléber de Sampaio Alves
UNESP-FEG/GUARATINGUETÁ
e-mail: manoelcsa@feg.unesp.br
Nathalia Mayumi Bernardes Miyahara
UNESP-FEG/GUARATINGUETÁ
e-mail: manoelcsa@feg.unesp.br

Marcel Yuzo Kondo
UNESP-FEG/GUARATINGUETÁ
e-mail: yuzokondo@gmail.com

Marcos Valério Ribeiro
UNESP-FEG/GUARATINGUETÁ
e-mail:mvalerio@feg.unesp.br

Abstract. *The aluminium alloys are used in many fields because of their versatility combined with the excellent aluminium's properties. This study aims to compare the performance of polished Hard Metal, Hard Metal covered with TiB2 and High Speed Steel (HSS) tools, at the aluminium 2024 alloy's turning, as a function of variation of some turning parameters such as: feed, depth of cut and cutting speed; and study the surface finish and the required power during turning by processing the output data, like analyze the chip's features for each used tool. The results provide information of the tool's material effects, when submitted to different turning conditions, about the output variable in question. In this way, it was possible to notice that although the carbide coated with TiB_2 tool has provided the better surface finish, the chip's features were better when the turning was accomplished by the Polished Hard Metal tool. In relation to the required turning's power, the lowest consumption occurred with the High Speed Steel tool.*

Keywords: *Aluminum alloy 2024, turning, cutting potency, surface roughness*

1. INTRODUCTION

Aluminum is widely used around the world because of its wide range of applications and its good performance. It is a material having mechanical and thermal properties favorable for use in various applications. According to Alcoa (2010) Aluminum Alloy 2024 has high levels of mechanical properties, which makes this alloy ideal for applications requiring high strength. Typical applications include aviation equipment and structures, computer parts, gears, shafts, pin hinges, blocks and valve components, brake components and trucks.

The mechanical and thermal properties of pure aluminum are decisive factors in machining alloys characteristics. The modulus of elasticity of aluminum has approximately ⅓ of the steel modulus of elasticity, meaning that under the same cutting force, the aluminum is deformed three times more than steel. This characteristic has negative consequences in obtaining machined surfaces of good quality and can generate unwanted deformations (DINIZ, MARCONDES and COPPINI, 2008).

According to these authors, the overall aluminum can be easily machined, since the power consumed by unit volume of metal removed is very low. Machining temperatures are usually low and high cutting speeds can be used. Regarding the machinability criteria based on roughness of the piece and chip feature, it can't be said that aluminum has high machinability, as in normal machining conditions, the chip formed is long and the surface finish obtained is unsatisfactory. For obtaining good surface finishes, high cutting speeds and suitable tool geometry could be used.

According to Diogenes (2011) the degree of machinability is measured from measurable quantities inherent to the process, as the tool life, work piece surface finish, cutting efforts, the cutting temperature, productivity, those features of a chip even abrasiveness.

The aluminum tendency to form long chips and building-up edge (BUE) during turning causes not good enough surface finishing, and therefore the machining of the material becomes a complex process.

The objective of this study is to analyze the influence of three different cutting tool materials in turning process of aluminum alloy 2024. The tool materials are high speed steel (HSS), polished carbide and TiB_2 coated carbide. They are then compared with regard to surface quality of the machined parts, power required during the process, tooling wear and aspects chip using different speeds and different cutting depths.

2. MATERIALS AND METHOD

It was carried out the machining operation by an external cylindrical machining aluminum alloy 2024 using a CNC Emco, found in figure 1. In figure 2 is one of the specimens used for the experiments.

Figure 1 - CNC Emco Turning, Compact 5

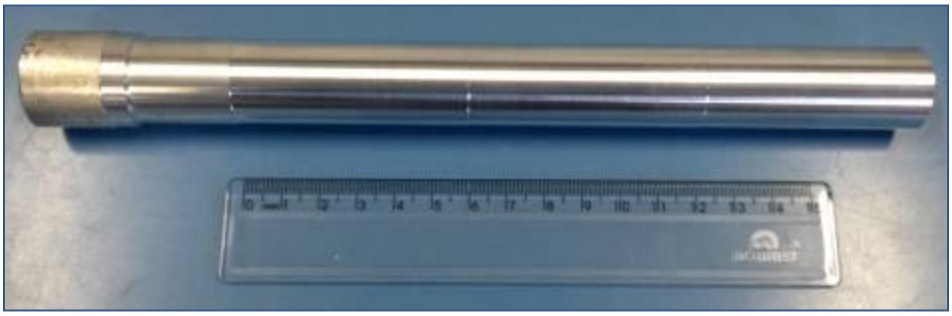

Figure 2 – Aluminum Alloy 2024 tested sample.

The CNC programming was made so that the work pieces were processed under the conditions found in figure 3 with nine machining regions, each with a feed rate value and depth of cut.

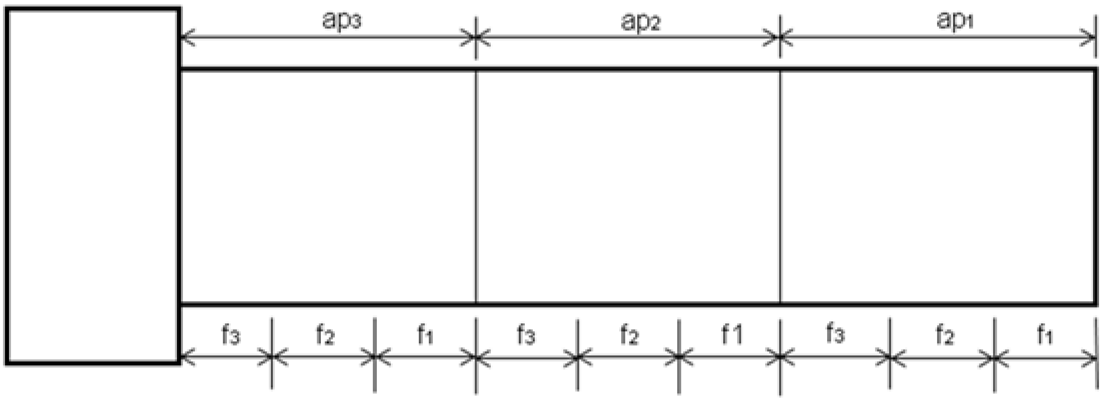

Figure 3 – Samples scheme

In figure 3 the cutting depth values are ap_1 = 0,50 mm, ap_2 = 0,35 mm e ap_3 = 0,20 mm. Feeding speeds are f_1 = 40 mm/min, f_2 = 70 mm/min e f_3 = 100 mm/min. Each of these nine regions was tested at three different cutting speeds, including Vc_1 = 81,68 m/min, Vc_2 = 102,10 m/min and Vc_3 = 122,52 m/min.

These machining conditions were tested with three different tools, high speed steel (HSS) tool, Figure 4, polished carbide tool, Figure 5, and carbide tool coated with TiB_2, Figure 6.

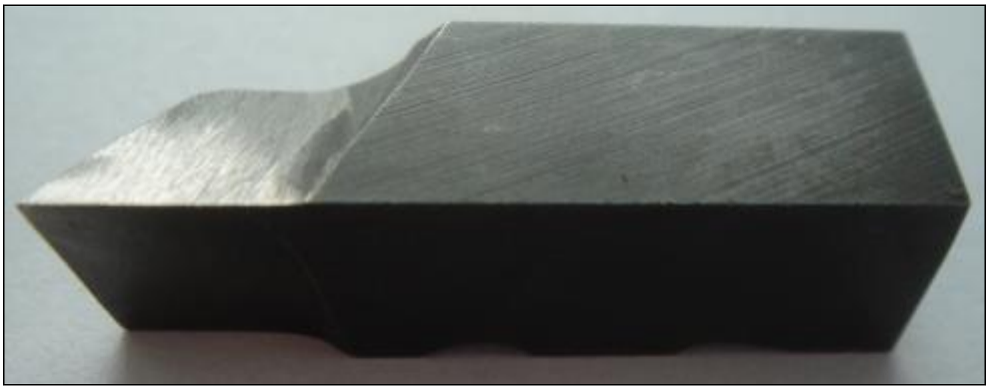

Figure 4 – High speed steel (HSS) tool.

Figure 5 – Polished Carbide tool.

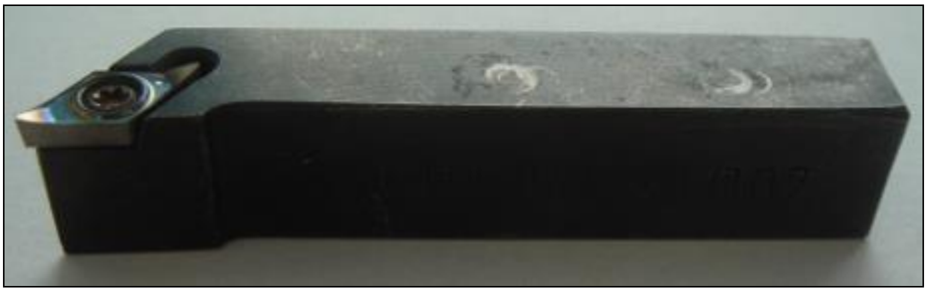

Figure 6 – Carbide tool coated with TiB_2.

The cutting performance parameter was obtained through a data acquisition system and through LabVIEW commercial software.

The surface quality parameters were obtained by measuring the R_a and R_t roughness with a portable surface roughness tester Marh MarSurf M300.

During the tests the chips were captured for further analysis. The wear of the tools were analyzed by optical microscope CoolingTech.

3. RESULTS

This topic will be displayed the results for each type of tool. They are the surface roughness values R_a e R_t, the means of cutting potencies, analysis of the chips and the wear of the tools.

3.1. High speed steel (HSS) tool

In figure 7 are the results of roughness R_a and R_t obtained when machining aluminum alloy 2024 with HSS tools. The values 1000 rot/min, 1250 rot/min and 1500 rot/min respectively correspond to speeds of 81,68 m/min 102,10 m/min and 122,52 m/min.

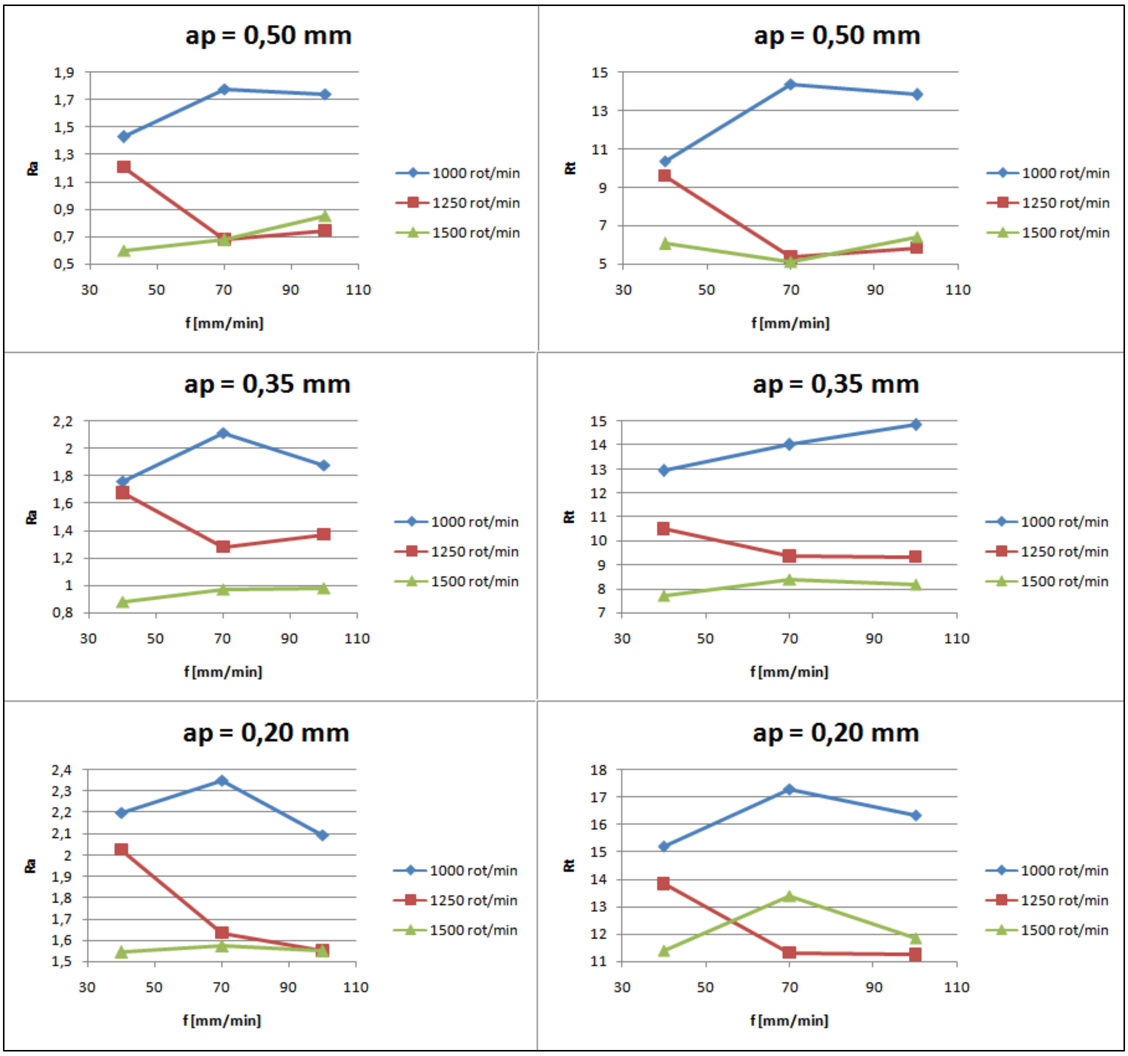

Figure 7 - R_a e R_t roughness graphics, in µm, according to feed speed and cutting depth for HSS turning tool.

Table 1 represents the cutting potencies, in watts, in turning with high speed steel tool.

Table 1. Potencies values required for turning with high speed steel tool.

	ap = 0,20 mm			ap = 0,35 mm			ap = 0,50 mm		
Feeding [mm/min]	40	70	100	40	70	100	40	70	100
Mean	216,35	230,40	245,88	230,50	257,05	279,35	235,73	267,54	294,69

For Vc_1 = 81,68 m/min chips obtained have the form of tape. At speeds Vc_2 = 102,10 m/min and Vc_3 = 122,52 m/min the chip was in tapes for lower feed speeds. With the increase of feed speeds the chips passed to be fragmented into splinters.

Regarding to wear, no wear of the tool was found because aluminum is a ductile and low resistant material. But there was aluminum deposition in high-speed steel tools indicating the build-up edge formation.

3.2. Polished carbide tool.

In Figure 8 are the results of the surface roughness Ra and Rt for turning with polished carbide tool. As in Figure 8, the 1000 rot/min, 1250 rot/min e 1500 rot/min values correspond respectively to 81,68 m/min, 102,10 m/min e 122,52 m/min speeds.

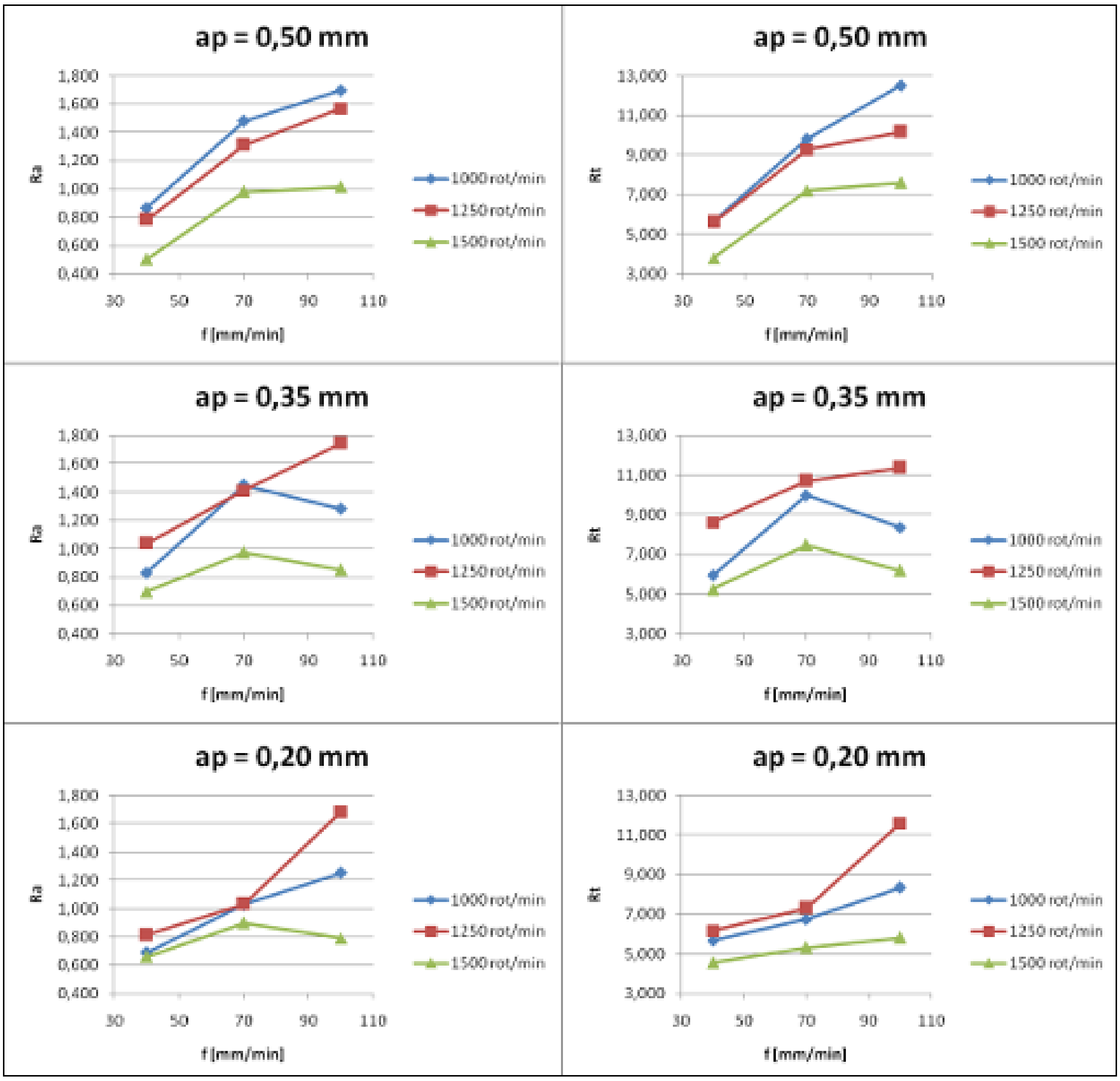

Figure 8. R_a e R_t roughness graphics, in µm, according to feed speed and cutting depth for polished carbide turning tool.

It can be seen that the roughness values decrease as the feeding speeds values increase.

Table 2 shows the results obtained for the cutting performance parameter for polished carbide tool.

Table 2. Required potencies for turning using polished carbide tool, in Watts.

	ap = 0,20 mm			ap = 0,35 mm			ap = 0,50 mm		
Feeding [mm/min]	40	70	100	40	70	100	40	70	100
Mean	236,98	255,02	276,41	254,82	291,62	316,08	261,87	307,31	343,71

For the cutting speed of 81,68 m/min chips obtained for lower feed rates were the chips with long helical shape. For the cutting speed of 102,10 m/min, the chips were of the long helical shape for lower feeding speeds. With increasing feed speed there was a tendency to form helical short chips. In speed of 122,52 m/min there was a trend of change of long helical chip for fragmented into chips with a progressive increase of the feed speed.

There was no tool wear during the tests, but there was aluminum deposition on the tool.

3.3. Coated carbide tool with TiB_2.

In Figure 9 are the results of surface quality parameters for the turning of aluminum 2024 alloy with carbide coated tool with TiB_2.

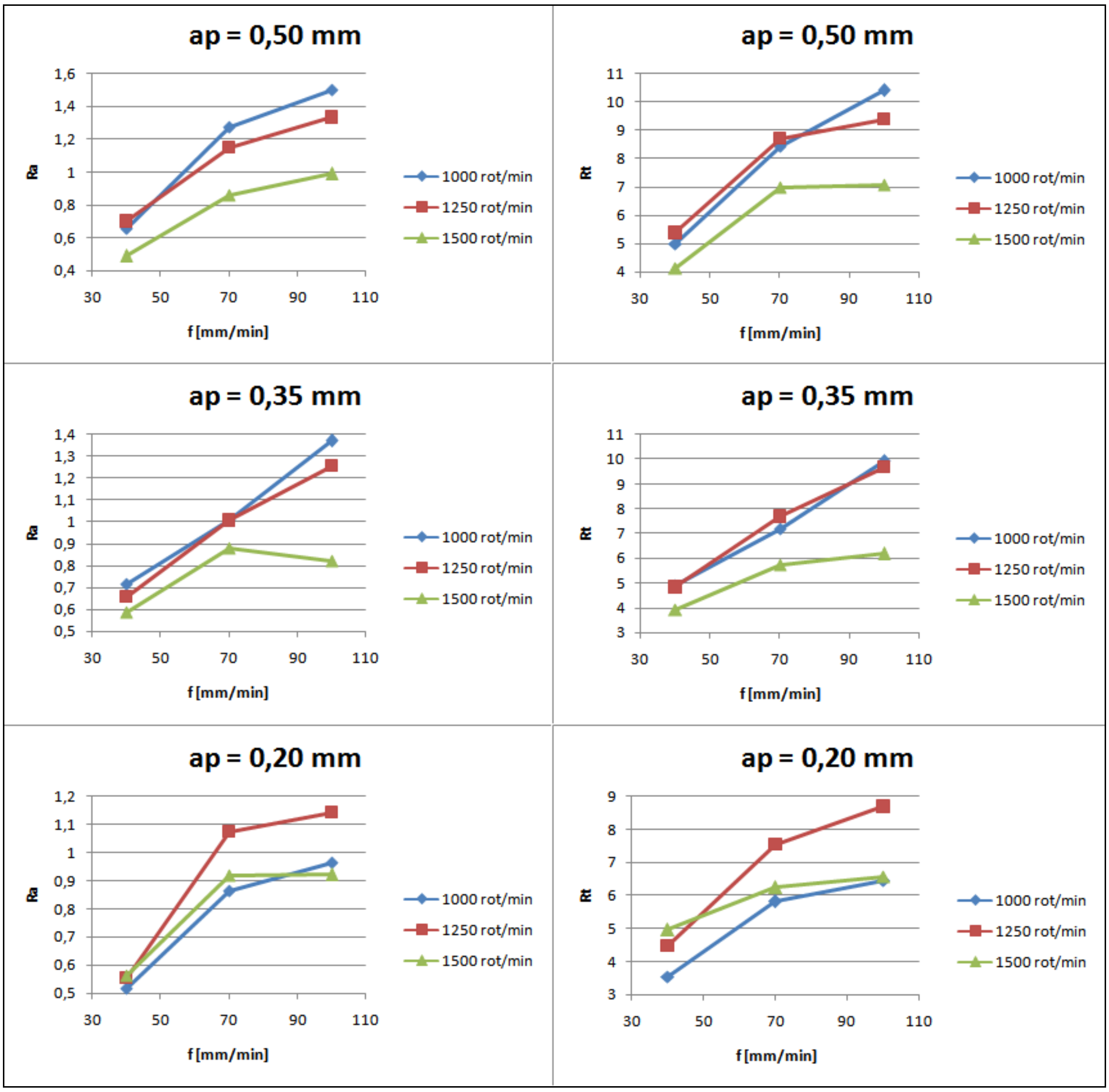

Figure 9. R_a e R_t roughness graphics, in µm, according to feed speed and cutting depth for carbide turning tool coated with TiB_2.

Table 3 shows potency values for turning with coated carbide tool.

Table 3. Potencies values required for turning with carbide tool coated with TiB_2, in Watts.

	ap = 0,20 mm			ap = 0,35 mm			ap = 0,50 mm		
Feeding [mm/min]	40	70	100	40	70	100	40	70	100
Mean	223,58	248,01	264,64	240,55	275,03	300,97	249,83	295,57	329,24

The formed chips obtained in coated carbide tool were in major long helical forms, with exception for 122,52 m/min speed where the increasing of feeding speeds results in a long helical form to fragmented chips form transition.

With respect to tool wear was observed aluminum deposition without noticeable tool wear.

4. CONCLUSION

From this work it was concluded that the different cutting tool materials have an influence on the turning process of aluminum in 2024, when it comes to surface finishing, potency consumed, wear tool and type of chip obtained.

Overall, it was concluded that although the insert with TiB2 coating has promoted a better surface finish, the obtained chips had long form in most cases, which is unfavorable for several reasons, among these reasons is the operator's safety , the volume that the chip takes to be stored and losses due to stoppages for removal of chip equipment.

It was observed that the surface finish is improved as the cutting speed increased, therefore the chip forming dynamic.

It can also be concluded that, regardless of the tool used, the power required during the process was higher as was increased while the feeding speed used increased. However, higher potencies are required for the turning of the polished carbide tool, while the smaller potencies, for turning with high-speed steel tool.

Finally, tools wear was not observed in any case by the fact that aluminum is a ductile material, however it was noted that in all cases there was aluminum deposition on the tool, or the formation of build-up edge, which it was noticeable through the obtained surface finish, especially when machining with high speed steel tool.

5. REFERENCES

ALCOA – Aluminium Company Of America. **CATÁLOGO DE LIGAS E TÊMPERAS**. Disponível em: <https://www.ALCOA.com/brasil/pt/resources/pdf/industria/catalogo_ligas _temperas_2010.pdf>.

DINIZ, Anselmo Eduardo; MARCONDES, Francisco Carlos; COPPINI, Nivaldo Lemos. **TECNOLOGIA DA USINAGEM DOS MATERIAIS**. 6. ed. São Paulo: Artliber, 2008. 262 p.

DIÓGENES, Anderson Carmo. **ESTUDO DA USINAGEM POR TORNEAMENTO DE LIGAS DE ALUMÍNIO.** 2011. 69 f. Monograph (Mechanical Engineering Graduation) – UNESP, Guaratinguetá, 2011

6. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.