ADDITION EFFECT OF CrB2 ON THE DIAMOND COMPOSITE PROPERTIES OF OBTAINED IN THE Fe-Cu-Ni-Sn SYSTEM*

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Abstract

With the increasing use of ornamental rocks, mainly in civil construction, sundry problems were identified in relation to rocks cutting, such as efficiency in the cutting process and rock quality lumber. In recent years several composites have been developed to solve these problems. In this context, the study of the binomial matrix metal-diamond interaction is of paramount importance for the development of new composite materials to improve the efficiency of the cutting tool. The diamond impregnated matrix metal often reveals a reaction between the diamond surface and the matrix. Besides the mechanical connection, chemical reactions can sometimes occur. Therefore, this study aims to assess the achievement of diamond composites in the system Fe / Cu / Ni / Sn via powder metallurgy, with added CRB2. Analyzes have been performed to characterize chemical / physical and mechanical. The results have showed that addition of CRB2 promote significant changes in the properties of composites, especially in wear resistance and fracture toughness. Furthermore, the presence of the composite CRB2 causes a significant improvement in thermal stability.
Keywords: Diamond composites; Ornamental rocks; Diamond tools.

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1 INTRODUCTION

The diamond tools used for cutting ornamental rocks composites which are consisted of diamond particles embedded in a metal matrix. Among the wide range of tools used in cutting and processing of rocks, there are circular saws diamond.

The diamond saws used when processing rocks are characterized by presenting as part of the main cutting elements (hereinafter referred to as segments) made of composite materials based on diamond, diamond basically composed of a matrix impregnated with the binder, usually metallic. The connection between the matrix and the diamonds must be strong enough for high performance during cutting and increased tool life. The production of the segments usually occurs through the powder metallurgy (PM) that has two processing routes, the MP and the conventional hot pressing (hot press) [1].

According to Lu et al [2] the union relationship between the matrix and the diamond is what determines the microstructural characteristics and performance of the cutting tool. The diamond impregnated matrix metal often reveals a reaction between the diamond surface and the matrix. In addition to the mechanical bond, a chemical reaction may also be formed.

By the increasing use of ornamental rocks , mainly in construction, several problems have been identified in relation to rocks cutting, especially in terms of efficiency and cost cutting process. In recent years various types of metal molds have been developed to solve these problems [3].

The objective of this work is to develop a new alloy (adding CRB2 in place of Co) which will be used for application in industrial saws used in cutting granite and stone wood north-northwest of the Rio de Janeiro state.

2 METHODOLOGY

In this current job we have used the composition of powders with the following Cu-Fe-Ni-Sn-WC and CRB_2 as key elements of the alloy. The manufacturing process of the segments were the following:

a) admixing (grinding) of powders of type Attritor mill for a period of 1 hour at 480 rpm;

b) After the mixture was added manually various size diamond, the diamond content (without coating) added refers to concentration 30, which is typically used in the industry and corresponds to 1.3 ct/cm^3.

c) During this step, it was the weighing of the mixture (more metals diamonds), the mold assembly containing the separators and filling the mold with the mixture. It is important to note that any cooking process, both of the segments as diamond saw was carried out on an industrial scale.

d) By following the sintering process parameters that were used in the industry, and by sintering the hot maximum temperature of 750 ° C at a pressure of 35MPa, for a total period of 10 minutes, this step was performed in the ABRASDI company.

After the sintering process segments were taken to LAMAV / UENF / CCT to perform characterization tests, these being: X-Ray Diffraction, Scanning electron microscopy coupled with EDS, dipping mercury porosity and flexural strength.

3 RESULTS

Figure 1 shows the X-ray diffraction patterns of the sample after the milling process (mixing) and after sintering. The peaks of the sample after mixing are related to the

materials present in the sample as Cu, Ni, Fe, WC, Sn and CRB_2 present as solid phase. The diffractogram after the sintering process shows the absence of peak Ni element, this can be attributed to the formation of compounds Ni4Sn, CuNi and $CuNi_2Sn$ [4]. According to Moriguchia Tsuduki [3] and peak of Cu is reduced when the sintering temperature increases, since there formation of higher amounts of solid solutions of Cu-Sn.
In relation to the CRB2, there was no chemical reaction with the other elements, it can be observed with WC and Fe elements They continued with the solid phase inside the liquid matrix of Cu, Ni and Sn.

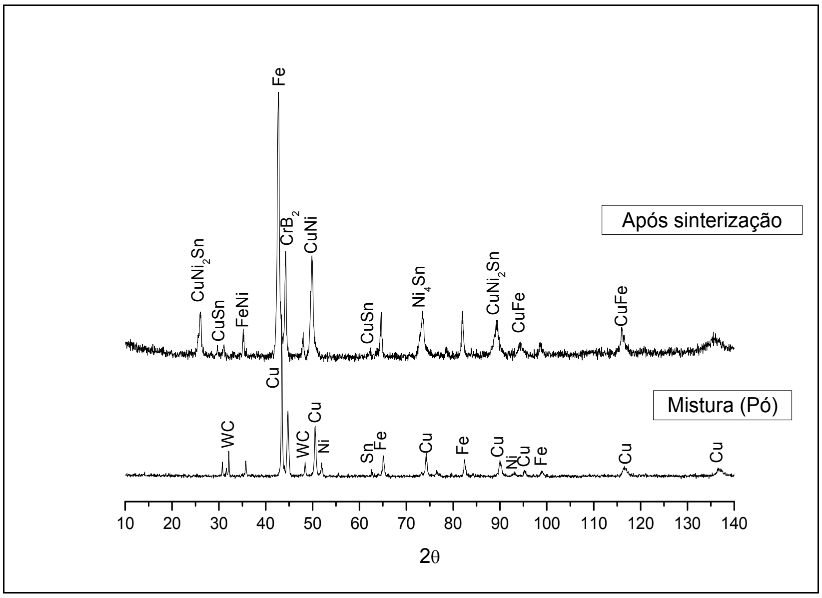
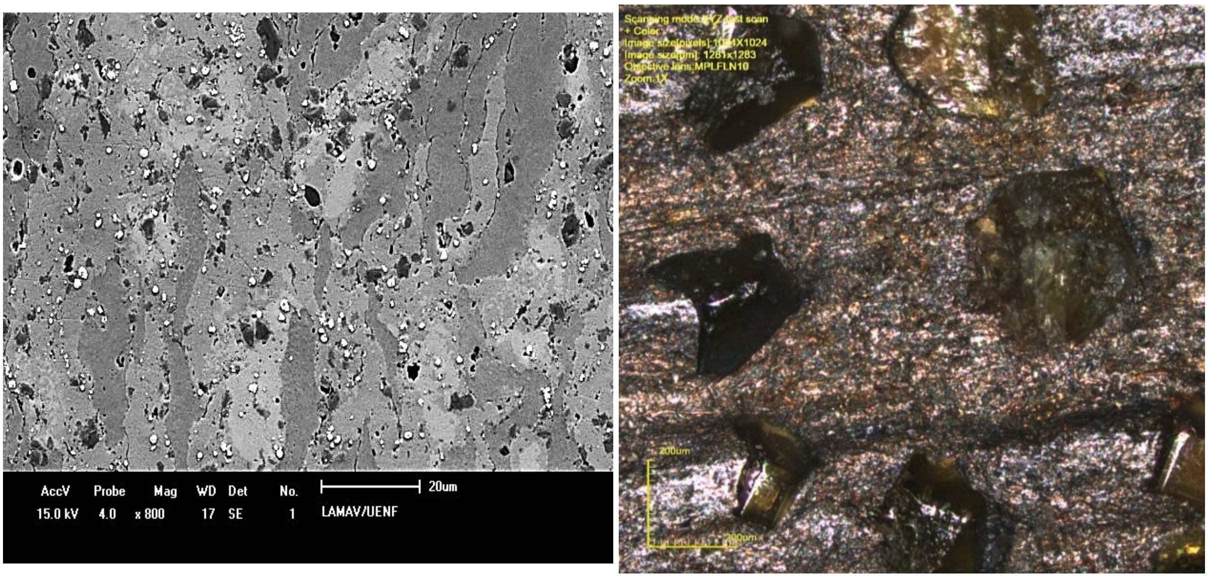


Figure 1. XRD (diffractograms) patterns of the sample after the mixing process (grinding) and (b) after sintering

By the result of X-ray diffraction, it is possible to observe that the solubility of Cu, Ni and Sn in the alloy at a sintering temperature of approximately 750 ° C. Then the matrix is composed of hard phases such as Fe, CRB_2 and WC in a soft matrix of Cu, Ni and Sn [5].
Figure 2 (a) shows the microstructure of the alloy of Cu-Fe after sintering. We observe a large number of irregular and spherical pores showing the final stage of sintering process, they are formed at the interface of these grains. The dark spots on the array are the toilet and CRB_2, according to the results of X-ray diffraction, have not experienced any chemical interaction. Thus, they appear well distributed in the matrix and constituting the hard phase. The diamond grains are well distributed and presenting good grip on the array. Furthermore, the addition of chrome restores ductility intermediate temperature (700 °C), with the goal of increasing the ductility of the compound [6].
Figure 2 (b) is observed that this sample microstructure after being used in the cutting ornamental stones. It is evident the anchoring degree of diamonds in the matrix, which results in a higher cutting efficiency of the tool.



(a) **(b)**

Figure 2. The microstructure of the alloy with addition of CRB2 (a) with an increase of 500x e (b) is observed in the Confocal in the alloy with the addition of diamond

Table 1 presents the results obtained for the porosity and density of the samples. It was conducted in the metallic matrix with and without the diamonds addition and for a commercial sample with the comparison purpose of with diamond composites produced in this work.

Table 1. Experimental results for flexural properties of material MAT1 and MAT2. Average Values obtained in 20 trials.

	Porosidade? (%)	Apparent Density (g/ml)
Commercial sample	2,91	7,92
M3 without diamond	24,44	7,38
M3 with diamond	12,00	10,13

The results concerning to the pore size distribution can be viewed through the curves of the incremental mercury intrusion depending on the pore diameter, as showed in the figures 3 and 4, there is a small variation in the pore size when they are in the range of 4 0.1 micrometers. According to Aldea et al [7] this result is within the range of classification of the macropores.

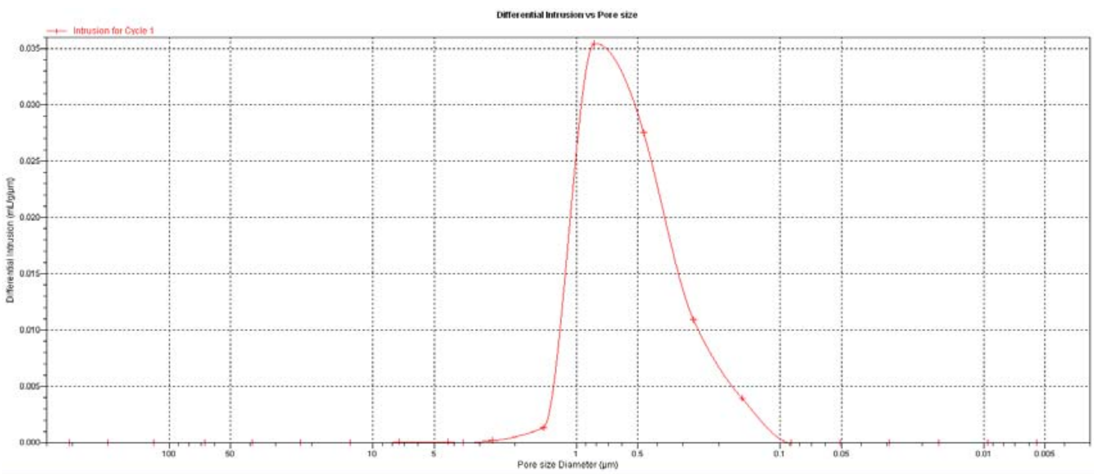


Figure 3. Variations in pore size characteristic of the alloy without diamond

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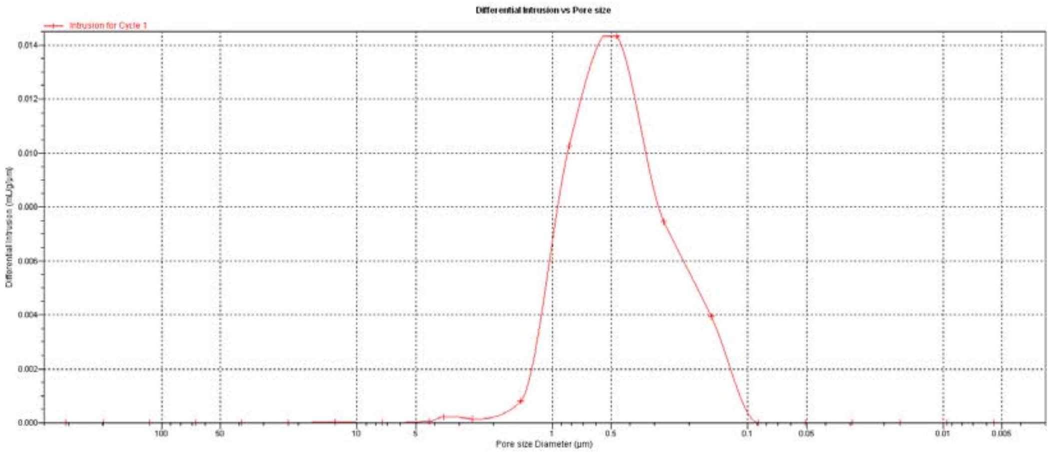

Figure 4. Variation in the pore size for matrix impregnated with diamonds.

Figure 5 presents the results from the chemical analysis of microstructures off and regions rich in Cu, Fe, Ni and Sn in a well distributed form, and the dark spots can be identified as CRB_2.

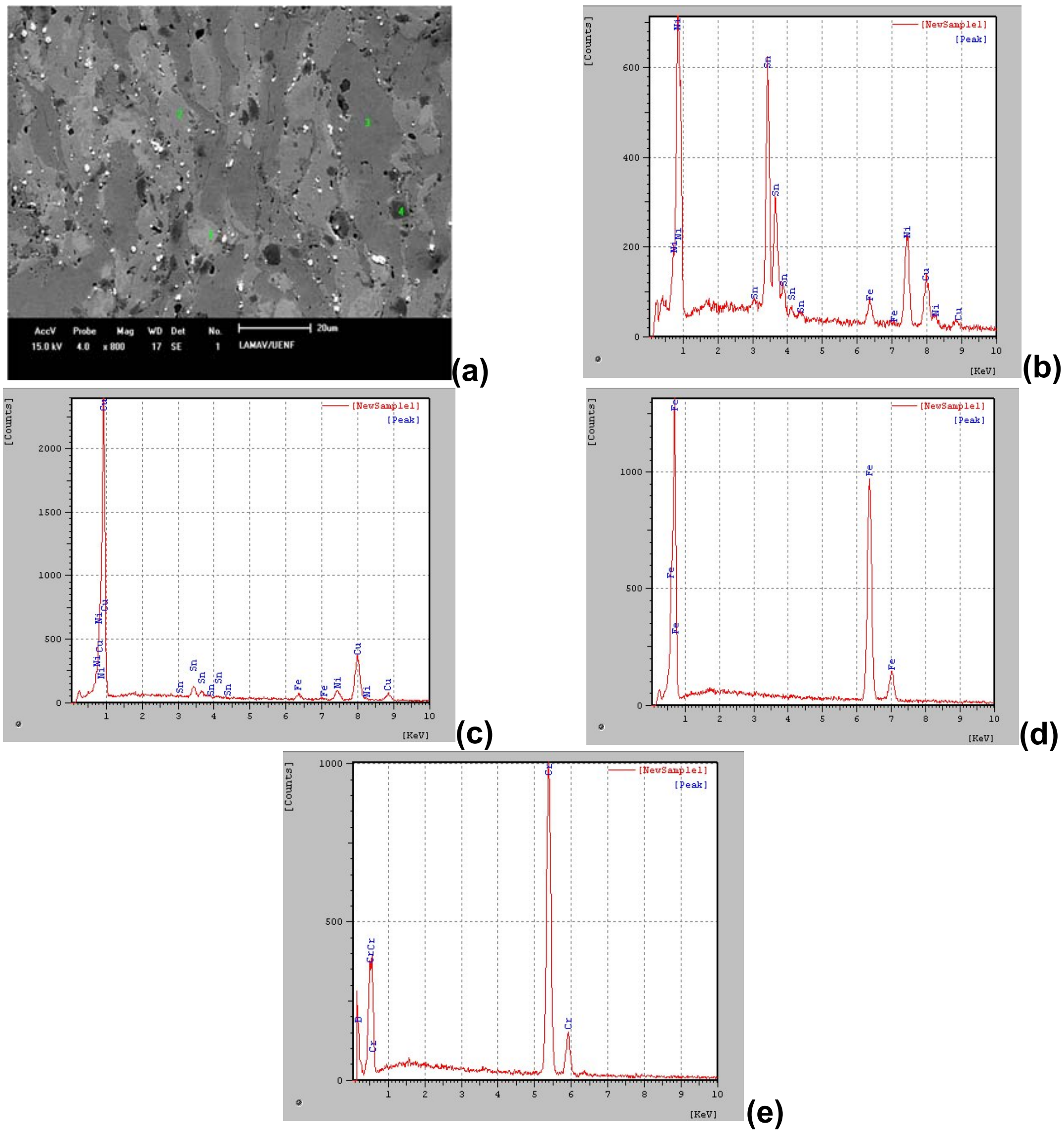

Figure 5. Results of chemical analysis of the microstructure (a) selected in the sample and emission spectra characteristic X-ray (b) Point 1 (c) point 2 (d) and section 3 (e) Point 4.

Figure 5 (a) shows the micrograph highlighting the regions where the analysis was punctual, it also shows the emission spectra of characteristic X-ray of the points selected in this league.
Microanalysis by-point, it is concluded that the points 1 and 2 show a composition of Fe-Cu-Ni-Sn at the point of three phase pure Fe and point 4 represents CRB_2, which exhibits a darker color in the sample.
The main test of flexion is very important to analyze the total resistance of the sample to use technology in cutting tools. It Was tested the diamond composite matrix after sintering, and the comparison method was used in the commercial sample. By the test results, were extracted maximal breaking strength and stress-strain curves.
Table 2 shows the values of maximum bending strengths. It can be observed that the samples did not show diamond values corresponding to the industrial sample. According to the results, the samples need to be able to absorb or resist loads imposed during cutting, especially in relation to elastic loads, as permanent deformation (plastic) can cause the loss of the unique properties of the tool. Accordingly, the load generated by the plastic deformation of the cutting process can lead to premature loss of diamond crystals (pull-out). This fact was not observed after testing.

Table 2. bending strength results

Samples		Bending strength (N)
Industrial		1777 ± 122
Without diamond	M3	1314 ± 145
With diamante	M3	123015

4 CONCLUSION

The CrB_2 did not react with the elements present in the alloy composition. As for the other matrix components, it was noted the formation of new phases, such as CuSn, $CuNi_2Sn$, CuFe and Ni_4Sn. By analyzing the influence of the technique applied in this work, namely the grinding / mixing the metal powders before sintering process, it is noted that there are beneficial effects, such as the highest level of densification of the composites and reducing pore size. The mechanical properties of the matrix and the composite produced with the addition of CrB_2 have showed good results. When compared with the commercial composite, the matrix developed in this study has showed a greater bending strength. According to the obtained results one can infer that there is a good possibility of using the matrix developed for the cutting tools industrial production,

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