

MICROSTRUCTURE, DENSIFICATION AND HARDNESS OF SINTERED Fe-49.5wt%Cu-24.1wt%Co AND Fe-50wt%Cu-25wt%Nb ALLOYS

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ABSTRACT

Most of the alloys used as bonding matrix in diamond tools show a high content of cobalt - which is undesirable due to a series of reasons. In the last decade, some attempts were made towards the reduction of the Co content in these alloys. NEXT 100[®] alloy (25.2wt%Fe-49.5wt%Cu-24.1wt%Co) by Eurotungstene is an example of it. Therefore, the development of new alloys for the adhesion of diamonds, based on the introduction of niobium (Nb), to replace Co in ferrous alloys for direct use in cutting tools of stone industry and construction has been great importance – aim of this work. The metallic powders were hot pressed in a graphite matrix at 35MPa/800°C/3 minutes. In these sintered samples, it was made densification by the Archimedes method, hardness HRB and SEM to observe the structural differences. The NEXT 100 alloy presented densification and hardness of 99.559% and 125.5 HBR, respectively. Regarding the matrix with 25%Nb the values obtained was 97.289% and 90.5 HRB respectively. The NEXT 100 had values above the alloy with 25%Nb, with results better than literature. This may be due to the parameters of sintering and solid solution formation CoFe, responsible for the hardness of the material. The best densification, Next 100 alloy, is related to the amounts present in solid particles that induce a high strain in Cu which act by increasing the driving force for densification and consequently the decrease of porosity. This same mechanism acting on the alloy with 25%Nb, however the formation of solid solutions is still low in order to reduce the porosity completely. The microstructure of metal matrix NEXT 100 presents practically no porosity, indicating the effectiveness of sintering in the last stages, with presence of Fe and ductile Cu, along with the solid solution CoFe homogeneously distributed in the matrix. While the alloy with 25%Nb shows a microstructure with particles rich in Fe and Nb, particles dispersed in Cu at random and heterogeneous and the presence of small spherical pores indicates the final stage and effectiveness of solid state sintering.

Topic: Metals Materials

Keyword: Next 100 alloy, Fe-Cu-Nb alloy, hot pressed

1. INTRODUCTION

The cutting tools for ornamental stones are characterized by presenting as the main part the cutting elements is its periphery, made of diamond composites, composed primarily of diamonds embedded in a matrix binder, usually metal. The link between diamonds and matrix should be strong enough for high performance. The adhesion between the matrix and the diamond is what determines the microstructural characteristics and performance of cutting tool to perform well. The impregnation of diamond in metal often shows a reaction between the diamond surface and the matrix. Besides the mechanical bond, a chemical relationship can also be formed (Yamaguchi et al., 1997).

The use of diamond cutting tools depends on the ability of the matrix to hold the diamonds, and thus their support for the cutting process. Thus, the choice of certain metals as binder results in high adhesion to the

crystals with diamond tools (Clark e Kamphuis, 2002; Del Villar et al., 2001; Oliveira and Filgueira, 2007; Oliveira et al., 2007; Yamaguchi et al., 1997).

The metal alloys used in diamond tools have a high content of cobalt which is undesirable, despite its high adhesion to the diamond, since it is highly toxic and uneconomical because of its scarcity in the world (Clark e Kamphuis, 2002; Oliveira, 2005). Over the years some alloys with reduced Co content processed such as Cobalite HDR, Cobalite CNF, KEEN and NEXT (Clark e Kamphuis, 2002; Del Villar et al., 2001; Eurotungstene, 2005; Kamphuis e Serneels, 2004; De Oliveira et al., 2009).

Therefore, the development of new alloys for the adhesion of diamonds, based on the introduction of niobium (Nb), to replace Co in ferrous alloys for direct use in cutting tools of stone industry and construction has been great importance.

This study aims to evaluate the properties and microstructure of metal matrix NEXT 100 (25.2wt%Fe-49.5wt%Cu-24.1wt%Co) and Fe-50wt%Cu-25wt%Nb, for later use in diamond tools, and information about their properties are very scarce in the literature.

2. MATERIALS AND METHODS

In this paper, was studied the commercial NEXT 10 and Fe-Cu-Nb alloys for use in diamond tools with the chemical composition (wt%):

- 25.2%Fe-49.5%Cu-24.1%Co
- 25%Fe-50%Cu-25%Nb

The sintering of metal powders were performed a industrial hot pressing by Pyramid, using the parameters: 35MPa/800°C during 3 minutes. The densification (bulk density - MEA) was determined using the Archimedes method, based on the buoyancy exercised on the sample during its immersion in a water container coupled to a balance. The calculation of the bulk density (MEA) builds on the value of dry mass (DM), immersed mass (IM) and the saturated mass (SM), as shown in Equation (1).

$$MEA = \frac{DM}{(SM - IM)} \quad \text{Eq. (1)}$$

The measure of hardness Rockwell B (HRB) was performed in a hardmeter Pantec, RBS model, applying a load of 62.5 kgf, and 5 indentations per sample.

The metallic matrix were examined by scanning electron microscopy (SEM), SHIMADZU model SSX-550, using secondary electrons and backscattered for microstructural analysis.

3. RESULTS AND DISCUSSION

The NEXT 100 alloy presented densification and hardness of 99.559% and 125.5 HBR, repectively. Regarding the matrix with 25%Nb the values obtained was 97.289% and 90.5 HRB respectively. The NEXT 100 had values above the alloy with 25%Nb, with results better than literature.

According to the research conducted with the NEXT 100 commercial alloy (Del Villar et al. 2001; De Oliveira et al., 2009), its structure is composed of two phases, ductile rich in Cu and solid solution rich in Fe(α). The presence of CoFe solid solution embedded in Cu matrix, improves the properties of the alloy.

It is known that the main phenomenon of mass transport for densification are basically limited by the phase rich in Cu. This densification process has two important contributions. First, during the compression stage,

where due to low stress field of the particles of Cu and the effect of stress concentration produced by the presence of the second hard phase CoFe, while Cu can achieve significant plastic deformation and consequently a relatively high density. Second, during high temperature pressing, plastic flow for these highly strained Cu particles is seen as an important role in the activation of mechanisms of material based on diffusion through agglomeration at grain boundaries (Del Villar et al. , 2001).

Considering the stage of compaction and its influence in pressing the high temperature, an interesting question arises regarding the effect of stress concentration of hard particles CoFe into ductile phase Cu for the NEXT 100 alloy. The amounts present in solid particles of CoFe induce a high deformation that act by increasing the driving force for densification. Therefore, the concentration of Cu in the alloys has a stronger effect on densification kinetics than in its state of deformation, confirmed by the high value of densification to NEXT 100 and Fe-Cu-Nb alloys. This may be due to the parameters of sintering and solid solution formation CoFe, responsible for the hardness of the material.

According to literature, Cobalite HDR (Clark and Kamphuis, 2002) presented a densification of 98% for sintering temperatures between 750 and 850°C. The cobalt alternatives alloys, called DIABASE (Fe-Co-Cu-Sn) (Weber and Weiss, 2005) sintered in a temperature range between 780 and 900°C has a density of about 98.5%. While the NEXT 100 alloy (Del Villar et al., 2001) showed a density of 97% using sintering temperature of 720°C.

The best densification, Next 100 alloy, is related to the amounts present in solid particles that induce a high strain in Cu which act by increasing the driving force for densification and consequently the decrease of porosity. This same mechanism acting on the alloy with 25%Nb, however the formation of solid solutions is still low in order to reduce the porosity completely.

The density obtained by the NEXT 100 and Fe-Cu-Nb alloys is associated with the mechanism of mass transport during pressing at high temperature. Where the quantities present in solid particles of CoFe induce a high strain in Cu which act by increasing the driving force for densification and consequently the decrease of porosity and increased hardness.

The NEXT 100 alloy presented solid solution formation CoFe, responsible for the hardness of the material. The best densification is related to the amounts present in solid particles that induce a high strain in Cu which act by increasing the driving force for densification and consequently the decrease of porosity. This same mechanism acting on the with 25%Nb, however the formation of solid solutions is still low in order to reduce the porosity completely.

This can be seen in Figure 1 and 2, where the microstructure of metal matrix NEXT 100 presents practically no porosity, indicating the effectiveness of sintering in the last stages, with presence of Fe and ductile Cu, along with the solid solution CoFe homogeneously distributed in the matrix. While the array with 25%Nb shows a microstructure with regions rich in Fe and Nb, particles dispersed in Cu at random and heterogeneous and the presence of small spherical pores indicates the final stage and effectiveness of solid state sintering.

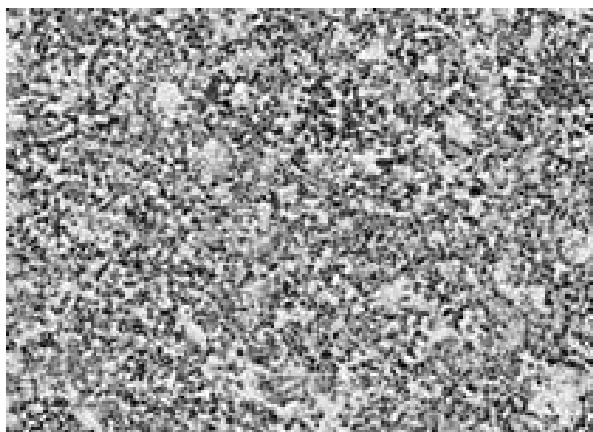


Figura 1. NEXT 100 matrix observed in BSE, 2000x.

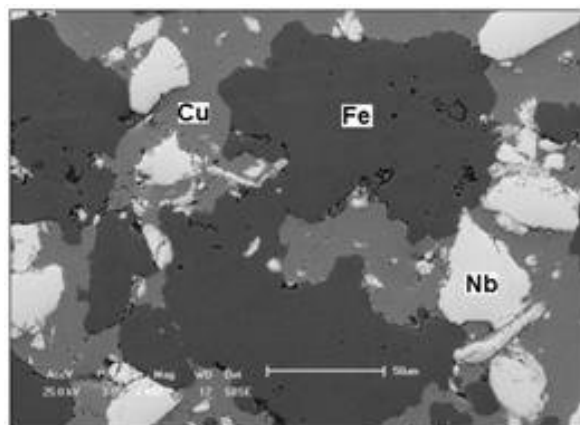


Figura 2. Fe-Cu-25%Nb matrix observed in BSE, 400x.

4. CONCLUSIONS

NEXT 100 alloy obtained in this work, sintered at 800°C, had a score of densification and hardness than the Fe-Cu-Nb alloys that is intended to replace, sometimes mentioned above.

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