Feasibility study for the development of FeNbC cermets: effect of composition / C content

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Abstract

Cermets and cemented carbides use Ni and Co as the main constituent of the metallic matrix. Nowadays the trend is to replace them totally or partially with other elements like iron. There are some studies and even commercial materials using **TiC and Ti(C,N) particles bonded by a ferrous matrix**, but studies using **NbC are less common** due to its higher price. The interest on cermets reinforced with NbC comes from the characteristics of NbC and the known beneficial effects of NbC on cemented carbides. In this study, **the raw material is a composite powder** obtained by treatment extraction of the ore with Al and C. Every particle of the powder contains **NbC precipitates bonded by Fe**, as well as other intermediate phases, whose composition is influenced by the elements present in the raw material, such as Al or Ti. Al content is particularly important and novel in this type of materials and its influence on processing and properties will be studied. Samples were produced by **conventional powder metallu**rgy and by **Field Assisted Hot Pressing (FAHP)** to study the microstructure and properties of sintered materials. The raw material and the samples obtained were characterized using thermal analysis, particle size, density, hardness, XRD and SEM.

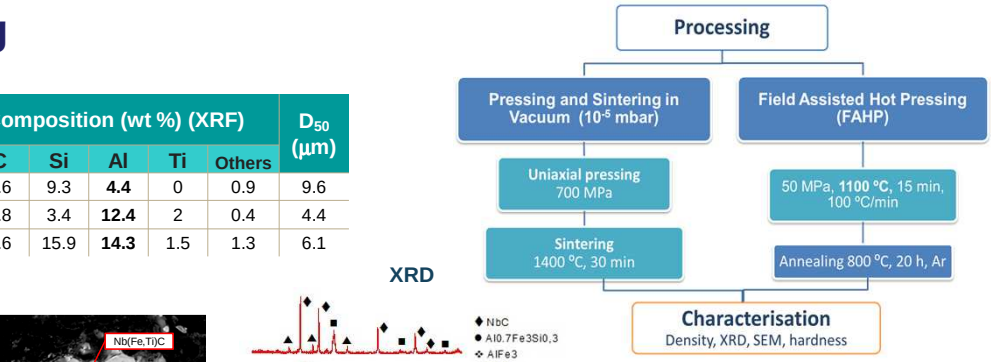
Objectives

- Develop FeNbC-based cermets.
- Using a novel raw material.
- Studying the processing conditions.
- Studying the influence of composition.

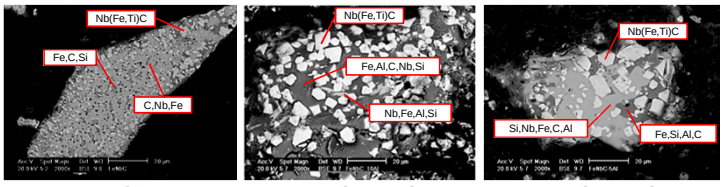
Materials and Processing

Characteristics of raw materials

Powder	Supplier	Density (g/cm^3)	Chemical Composition (wt %) (XRF)							D_{50} (µm)
			Nb	Fe	C	Si	Al	Ti	Others	
FeNbC	CBMM	6.7	56.4	21.3	7.6	9.3	**4.4**	0	0.9	9.6
FeNbC10Al	CBMM	6.2	40.9	36.1	4.8	3.4	**12.4**	2	0.4	4.4
FeNbC15Al	CBMM	6.6	30.8	31.5	4.6	15.9	**14.3**	1.5	1.3	6.1

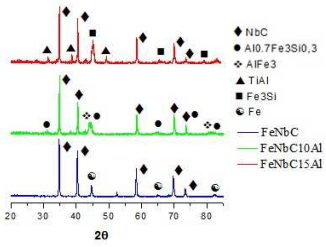


SEM microestructures of the starting powders



FeNbC FeNbC10Al FeNbC15Al

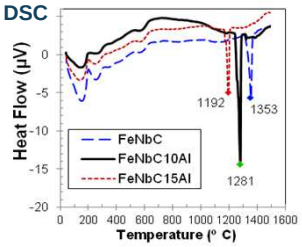
XRD



Starting powders are composite materials formed by NbC carbides dispersed in a two phase intermetallic matrix

Sintered materials

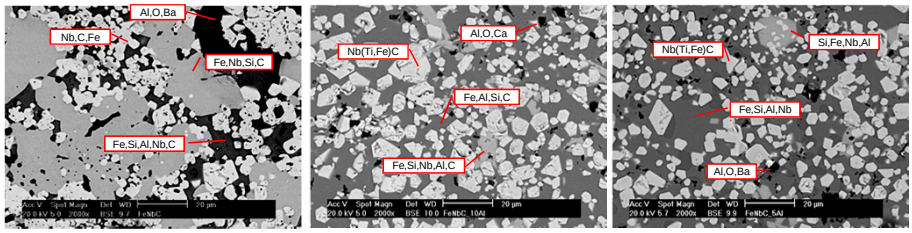
DSC



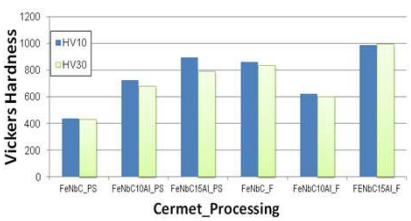
DSC→liquid phase appears al lower temperature when increasing Al content.

SEM-EDS→ PS cermet contains three main phases **NbC and two intermetallic phases.** The black phase was impurities (Al_2O_3). The cermet FeNbC presented coarse and heterogeneous microstructure , in particular when processed by FAHP. Cermets with aluminium, processed by PS and FAHP had more similar microstructure, containing NbC, two intermetallic phases and an impurity black phase.

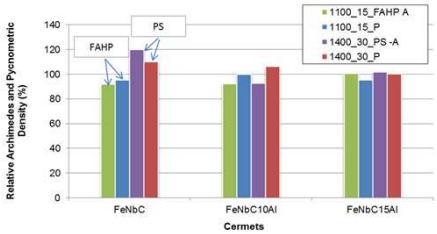
SEM microestructures of samples produced by Pressing and Sintering at 1400ºC



FeNbC FeNbC10Al FeNbC15Al

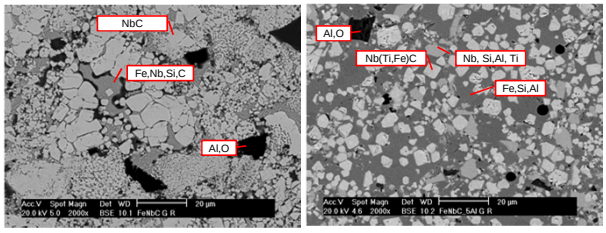


Harness increases with Al content..



Relative density of cermets, (legend shows: sintering temperature_ time_ A: Archimedes or P:pycnometry)

SEM Microestructures of samples produced by FAHP at 1100ºC



FeNbC FeNbC15Al

Conclusions

Cermets were produced by PS and FAHP using a novel raw composite powder from niobium ore treated with Al and C. The cermets presented properties and characteristics of great interest. Cermets consisted mainly of: (1) NbC, (2) a matrix phase constituted of Fe, $Al_{0,7}Fe_3Si_{0,3}$ or Fe_3Si depending on the stating powder and (3) an intermetallic phase. Al_2O_3 impurities were also observed in some cases.

Processing by PS produced samples with higher densities than those produced by FAHP; this is probably due to the formation of larger amount of liquid phase and more time for diffusion than processing by FAHP.

The cermet FeNbC processed by FAHP presented microstructure with very heterogeneous distribution due to the short processing time, but the other cermets presented microstructure similar to those produced by PS. Processing by FAHP was very satisfactory in producing materials with high density and good hardness. The material that presented higher hardness was the cermet FeNbC15Al processed by FAHP with hardness about 1000 HV

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