

THE ELABORATION AND CHARACTERIZATION OF SOME Cu-Ti FRICTION MATERIALS

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Abstract

Friction materials based on copper alloys are extensively used for high performance clutches and brakes. Copper –titanium powder system is a very interesting combination of friction materials, because of its high sintering activity and its good tribological behaviour. Several compositions were tested; the maximum concentration of titanium was 35%, with increments of 5%. Samples were compacted at 400 MPa and sintered in low vacuum ($4 \cdot 10^3$ Pa) at 850°C. They were studied by optical microscopy to observe structural transformations. The diffusion of copper provided formation of pores in the samples. The most affected samples were those containing 15% Ti. Increase in titanium content led to a decrease of compression strength and impact resistance. The hardness values varied as a function of the place where measurements were made; high values were in transitions areas and the lowest in the centres of the samples.

Keywords: *titanium powders, copper powders, Cu-Ti alloy, friction materials*

INTRODUCTION

Copper-Titanium alloys has been known since the 1930s [1], but because of the difficulties in sintering titanium they were abandoned. Today, sintering of copper-titanium powders is done in an inert atmosphere [2].

Friction materials based on copper alloys are extensively used for high performance clutches and brakes. Copper –titanium is a very interesting combination of friction materials, because of its high sintering activity and its good tribological behaviour [2].

The copper based powder materials with addition of up to 1.5% Ti are used to produce electrical contacts and electrodes for contact welding [3].

The purpose of this preliminary study is to investigate the mechanical properties of copper-titanium materials containing up to 35% Ti, obtained via powder metallurgy, in order to obtain friction materials.

MATERIALS AND METHODS

Titanium powder (0.01% Fe, 0.01% Al, 0.001% Si, 0.05% Mg, Ti balance) obtained through hydriding – milling – dehydriding with a grain size less than 100 μm and water atomized copper powder Pometon W150 with a grain size less than 150 μm were used.

Several compositions were tested; with increments of 5% up to the maximum concentration of titanium of 35%. After mixing by adding small fraction of titanium to the copper powder, the samples were uniaxially die-compacted at 400 MPa and sintered in vacuum ($4 \cdot 10^{-3}$ Pa) at 850°C for one hour. The heating and cooling rates were 10°C/min.

Cylindrical and Charpy impact test compacts were produced and tested.

Compression tests were performed on Galdabini Sun 5 universal testing machine, maximum force 50 kN, with a constant crosshead displacement of 1 mm/min.

The toughness was determined on unnotched Charpy specimens on a impact tester with a maximum energy of 300 J at ambient temperature.

The microstructure of sintered samples were studied by optical microscopy on an Olympus GX51 microscope. After grinding and polishing, samples were etched with a solution of $\text{CuCl}_4 + \text{NH}_3$.

The hardness was determined using Rockwell B apparatus. The measurements were made on cross-sectioned samples with the following parameters: ball of 1.588 mm, load of 100 kgF and duration of 15 seconds.

RESULTS AND DISSCUSION

Samples having maximum 25% Ti in composition were well sintered, the others presented a swell effect (Fig.1).



Fig.1. Sintered sample with 30% Ti.

The study of structure of the sintered compacts reveals diffusion of copper from the centre of the samples to the surface. Formation of some areas rich in copper and others rich in titanium (Fig.2) was observed. Because of the sintering temperature and vacuum atmosphere, it is possible that copper reached a liquid state. The phase transformation of titanium ($\alpha \rightarrow \beta$) occurred at a lower temperature than usual (883°C) determined by the presence of copper (which stabilize β phase of titanium) in the samples. The stresses produced by the phase transformation of titanium ($\alpha \rightarrow \beta$) caused the liquid phase copper to migrate to areas with a lower pressure, such as surfaces of the samples.



Fig.2. Macrostructure of sintered sample with 10% Ti.

Light microscopy revealed the formation of transition areas between rich areas in copper and those rich in titanium (Fig.3). The thickness of the transition area varied from sample to sample. Presence of big pores, especially in the centres of the samples, can be seen in Figs.2 and 3.

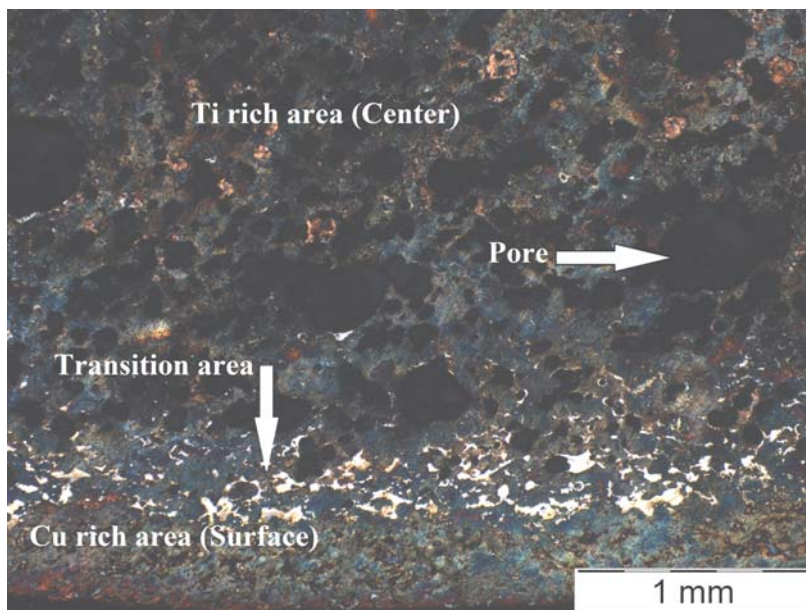


Fig.3. Microstructure of sintered sample with 10% Ti.

These pores are the result of copper migration to the surface area. Samples having 15% Ti presented the greatest porosity and also the biggest pores in the centre (Fig.4). Compression tests results are presented in Fig.5.

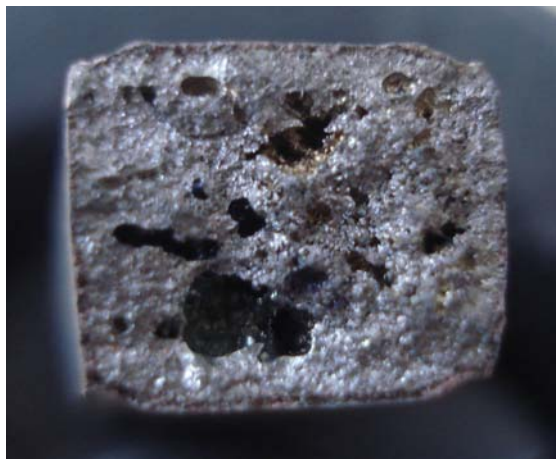


Fig.4. Macrostructure of sintered sample with 15% Ti.

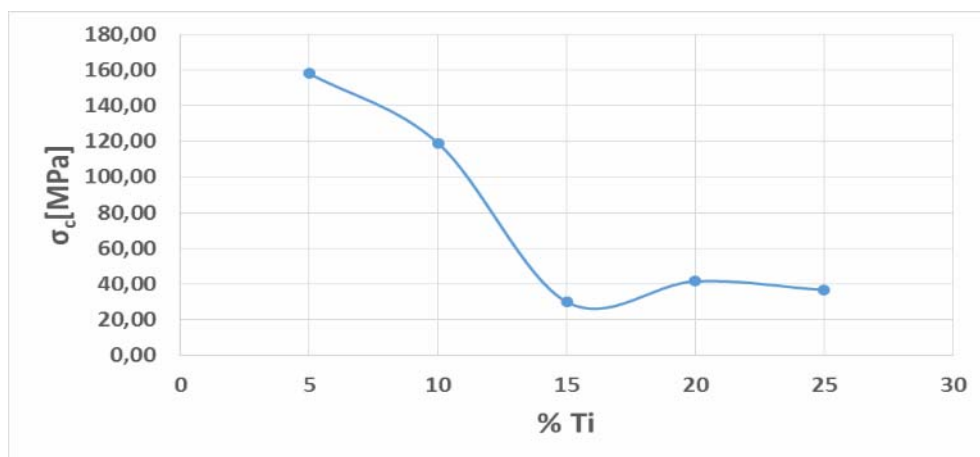


Fig.5. Compression strength curves of sintered Cu-Ti samples.

The highest values (~158 MPa) were obtained for samples with 5% Ti. Samples with 15% Ti had the lowest compression strength (~30 MPa), because of high porosity. As was expected, an increment of titanium content led to a lower compression strength. The graph showed a drastic decrease of compression strength at compositions having more than 10% Ti.

The results from hardness measurements, using the Rockwell B method because of the porosity of the samples, are plotted in Fig.6. The centres of the samples are less hard than the transition area. The higher values of hardness in the transition areas were obtained as a result probably of formation of mainly TiCu_4 [1, 4] and the phase transformation of titanium which may occur ($\alpha \rightarrow \beta$); β titanium is characterized by a higher hardness than α titanium.

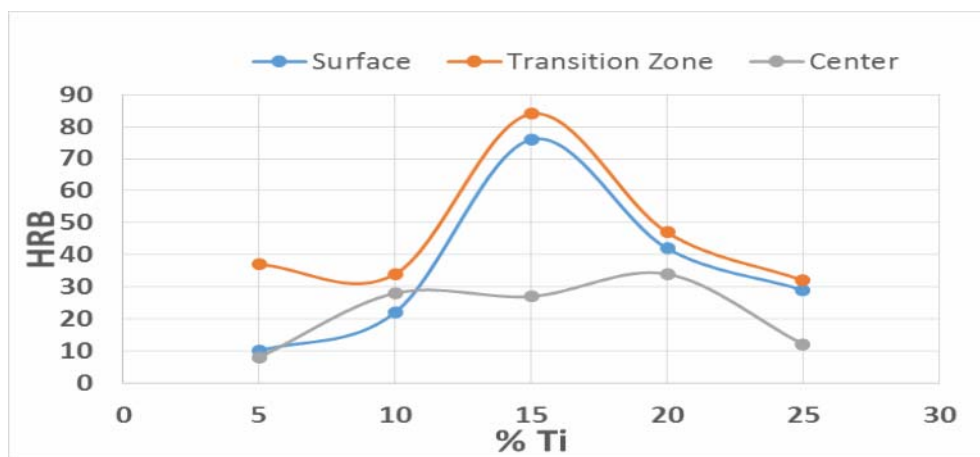


Fig.6. HRB hardness of sintered Cu-Ti samples.

As it was observed in previous tests, samples with 15%Ti were more affected by porosity resulting from copper diffusion; they presented the lowest values of impact energy, as can be seen in Fig.7. A higher content of titanium led to the formation of a structure that decreased the impact resistance. Also, the results were affected by the porosity of samples.

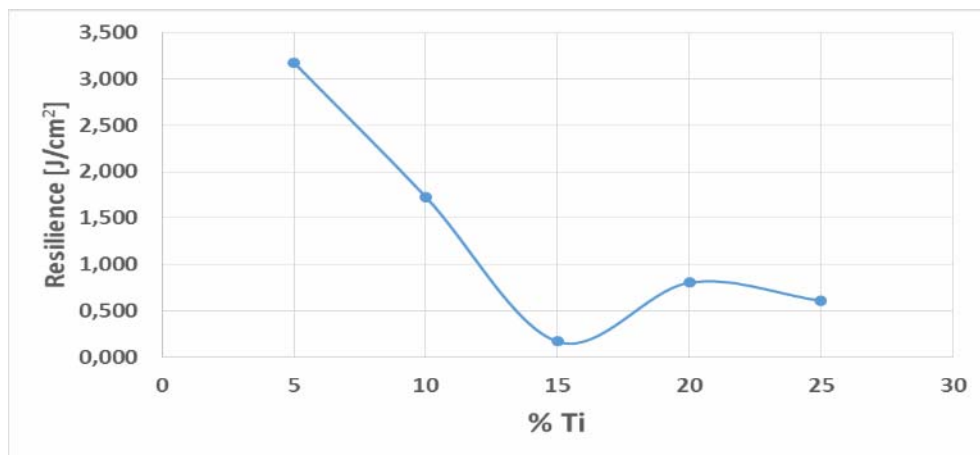


Fig.7. Charpy impact test results of sintered Cu-Ti samples.

CONCLUSIONS

Pressed and sintered samples made from copper-titanium powders with up to 35% Ti were produced and tested. Sintering in a low vacuum at 850°C led to diffusion of copper from centres to the surfaces of the samples and resulted the formation of pores. The most affected samples were those containing 15% Ti. Increasing the titanium content led to a decrease of compression strength and impact resistance. The hardness values varied with the place where measurements were made; high values were in the transitions areas and the lowest were found in the centres of the samples. Further studies are necessary to develop the copper-titanium materials with up to 35% Ti obtained via powder metallurgy.

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