Ferro-Titanit® - Influence of Chemical Composition and Heat Treatment on Microstructure and Mechanical Properties in Tensile Tests

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Abstract

FerroTitanit® is an extremely high alloyed PM material containing about 20 to 35 wt.% titanium based carbides. Such materials are designed to achieve a high wear resistance, but the high volume fraction of hard phases causes a comparable low ductility in case of tensile loading.
In the present study the mechanical properties of different Ferro-Titanit grades (variations in chemical composition and in heat treatment) were investigated by means of tensile tests. The mechanical properties and the fracture behaviour will be related to the chemical composition, the heat treatment and the microstructure.

Keywords : ferrotitanit, titanium carbide, tensile test, fracture behaviour, mechanical properties

1. Introduction

Ferro-Titanit is a high carbide containing PM processed material with extraordinary properties like extremely high wear resistance, high stiffness and good mechanical properties. Ferrotitanit is mainly used for tools, but its combination of properties makes this material also interesting for structural applications.

2. Experimental and Results

Five different grades with variations in the carbide content, the heat treatment conditions and in the matrix compositions were characterized with respect to their microstructure, their mechanical properties in tensile tests. Details about the chemical composition of the investigated Ferro-Titanit grades [1] are summarized in table 1. Scanning electron microscopy (SEM) was employed in order to characterize the fracture behaviour.

Microstructure

Ferro-Titanit grades typically consist of a metallic matrix with about 20 to 35 weight percent titanium carbide (TiC) particles. The high thermodynamic stability of TiC causes a very weak chemical interaction with the metallic matrix which is mainly iron or nickel based. The main grades exhibit matrices based on carbon steels, maraging steels, corrosion resistant austenitic steels. Grades with a carbon steel matrix can be heat treated to increase the hardness.

Figure 1 shows a typical SEM-micrograph of the microstructure of the Ferro-Titanit grade WFN with 33 wt.% TiC and a chromium rich martensitic matrix [1].

Table 1. TiC-contents and matrix compositions of investigated Ferro-Titanit grades [1].

grade	TiC-content	matrix composition					
		C	Cr	Mo	Co	Ni	Fe
	[wt.%]	[wt.%]					
WFN	33	0,75	13,5	3,0	---	---	bal.
WFN-21	21	0,75	13,5	3,0	---	---	bal.
WFN-23	23	0,75	13,5	3,0	---	---	bal.
Nikro128	23	---	13,5	5,0	9,0	4,0	bal.
U	34	---	18,0	2,0	---	12,0	bal.

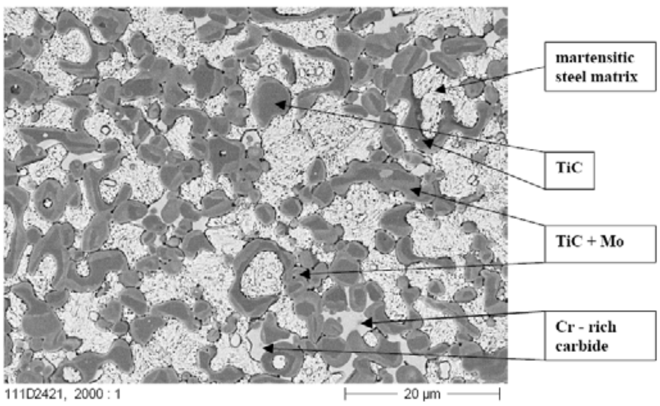

Fig. 1. SEM micrographs of microstructure of WFN [1].

Mechanical properties

Tensile tests using specially designed specimens were used to characterize the mechanical properties like yield strength, tensile strength and ductility [2].

Stress – strain curves of four investigated grades are exemplarily shown in figure 2. The results of the tensile tests are summarized in figure 3 for all investigated grades and heat treatment conditions.

The ultimate tensile strength values were in the range of 700 to 1350 MPa for the tested grades. The lower strength levels were found for grades with soft annealed carbon steel matrices, for austenitic steel matrices and for grades with higher carbide contents. The highest strength levels were found for grades with lower carbide content and hardened (quenched & tempered) carbon steel matrices.

Yield strength ($R_{p0,2}$) can be determined in grades with soft matrices like annealed carbon steels or austenitic steel. Typical yield strength levels are in the range of 600 to 900 MPa.

The ductility (plastic strain to fracture) is in the range of 0,1 to 0,5%. The higher ducitility values are observed for the grades with the lower carbide contents. The grades with hardened matrix fracture without macroscopic plastic strain.

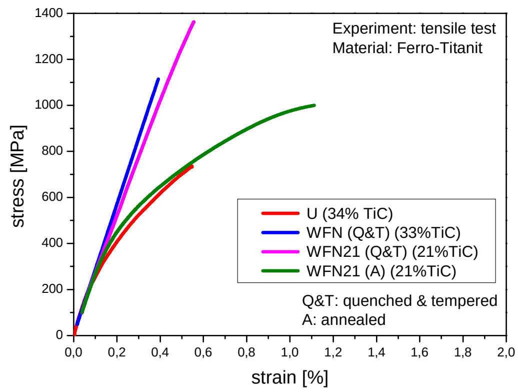

Fig. 2. Typical stress-strain curves of various Ferro-titanit grades.

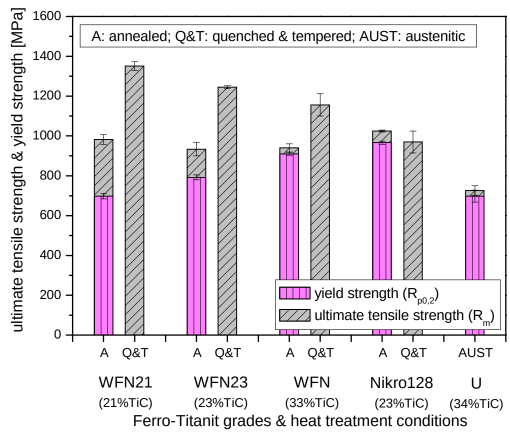

Fig. 3: Yield strength and ultimate tensile strength of the investigated Ferrotitanit grades.

Fractography

Fractographic inspection revealed ductile matrix fracture mode in case of austenitic and soft annealed matrices (Figure 4) and brittle matrix fracture in case of hardened matrices (Figure 5).

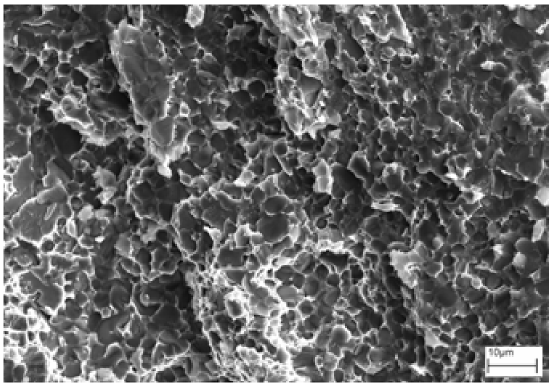

Fig. 4. SEM micrographs of the fracture surface of WFN-21 in the annealed condition.

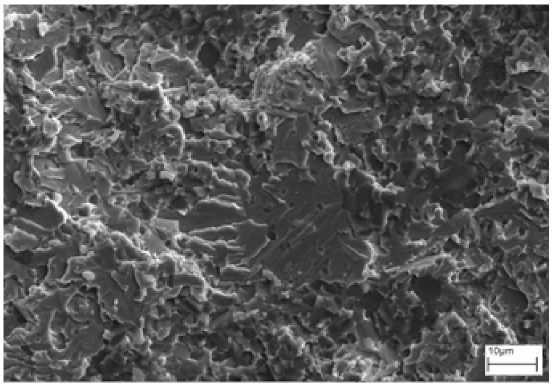

Fig. 5. SEM micrograph of the fracture surface of Nikro 128 (23% TiC) in the hardened condition.

3. Conclusion

The strength and ductility levels of the investigated materials indicate that some of the studied Ferro-Titanit grades have not only a potential for wear applications but also for use in case of high loaded mechanical engineering components, but special rules for design with low ductility materials have to be taken into account.

4. References

1. M. Foller and H. Meyer, A new investigation on mechanical properties of Ferro-Titanit®, Proc. of the 6th Intern. Conf. on Tooling, Vol.1, Karlstad (2002).
2. S. Marsoner, R. Ebner, R. Minichmayr and F. Jeglitsch, Material behaviour of powder-metallurgically processed tool steels in tensile and bending tests, Proc. of the 6th Intern. Conf. on Tooling, Vol.1, Karlstad (2002).