Sten Millot
Development Manager

WEARDENS® – introduction of a world novelty

The WEARDENS® material is a milestone in the development history of sintering technology. Its unique composition of Cr, W, Mo, V carbides and additives makes it possible to manufacture net-shape components with extremely high hardness and high density directly in a conventional sintering process. The material is particularly suitable for cutting tools and wear parts of hydraulic systems, forestry and agriculture.

WEARDENS® is a PM high-speed steel (HSS powder steel). It has been designed especially for cutting tools and components which require high wear resistance. It is possible to manufacture net shape or near net shape components with one possible grinding step as finish to obtain a sharp cutting edge or particularly fine tolerances.

The material is a high-alloy powder metallurgic high-speed steel with a good distribution of fine hard carbides, which ensure a homogenous mass with high wear resistance throughout the material. Components made of WEARDENS® will get high density and high hardnesses directly from the sintering process without subsequent heat treatment. This means that the process costs can be kept down compared to other known processes for high-speed steel, which results in considerable savings on the final product.

Relative density of more than 98%

The composition is a chromium/vanadium/tungsten/molybdenum steel with additives that enable high density and the formation of hard carbides during the sintering process. The relative density after the sintering process is higher than 98% with hardnesses of around 900 HV30, which corresponds to 66 HRC.

	%C	%Mo	%W	%Cr	%V	%Fe	%Other
Min	0.9	4.5	5.0	3.5	2.5	Bal.	0.4
Max	1.5	10.0	7.0	4.5	4.0	Bal.	1.3

Chemical composition WEARDENS®

WEARDENS® no.	Micro hardness [HV0.3]	Macro hardness [HV30]	Density [g/cm^3]
6500	887	866	7.98
6555	965	896	8.04

Hardnesses and density for two types of WEARDENS®

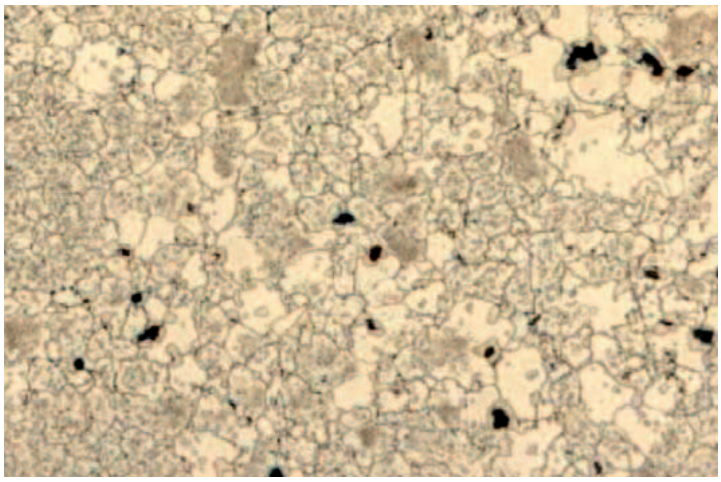
The high density and the extreme hardness of WEARDENS® means that the material can be used for many different purposes, where high wear resistance is required, e.g. for knives in the forestry or for wear parts in hydraulic systems.

Carbide formation

As it appears from the microstructure, the density is very high with small rounded porosities. The carbides are evenly distributed, which ensures good wear resistance.

SEM analysis (scanning electron microscopy) of the microstructure shows that the background material consists mostly of Fe/Cr carbides, whereas the carbides mostly contain Mo/W/V carbides. The peaks of the fj 266-pt5 graph show the contents of the elements at precise points where the concentration of vanadium, molybdenum and tungsten is high.

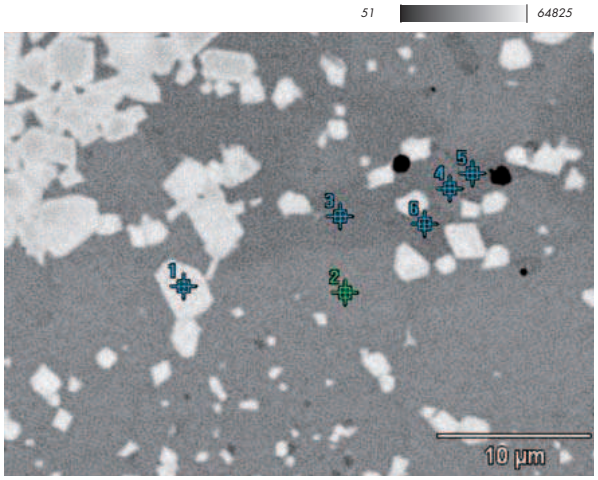
The fj 266(2) graph is a scan of one particle in the direction



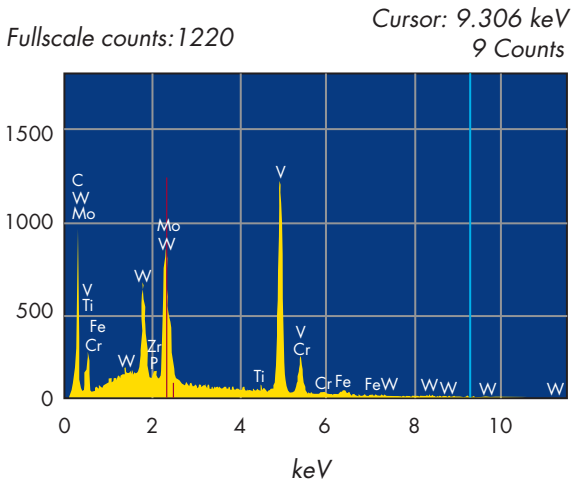
Microstructure of WEARDENS® x200 etched

of the arrow, which shows a high concentration of molybdenum carbide, vanadium carbide and tungsten carbide. The matrix also has a high content of iron carbide. The hardnesses of the carbides vary from approx. 1,500 HV to 3,000 HV, and the material is therefore very suitable for high-wear applications or applications where good cutting properties are required.

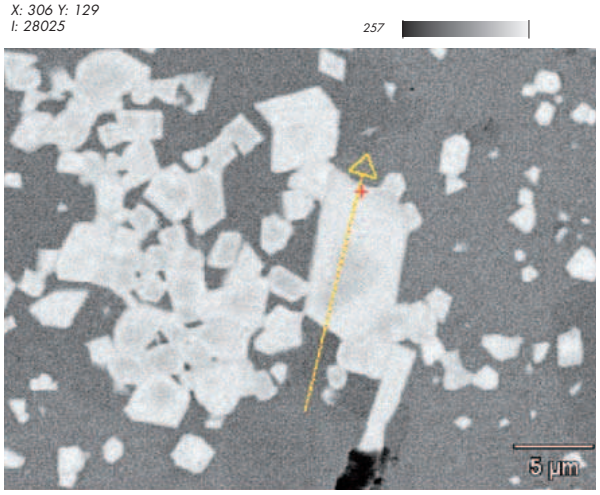
266(1)-pt1



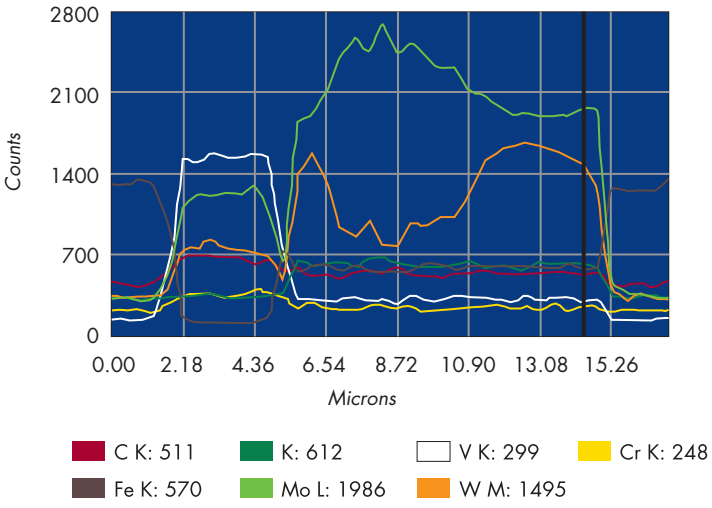
fj 266-pt5



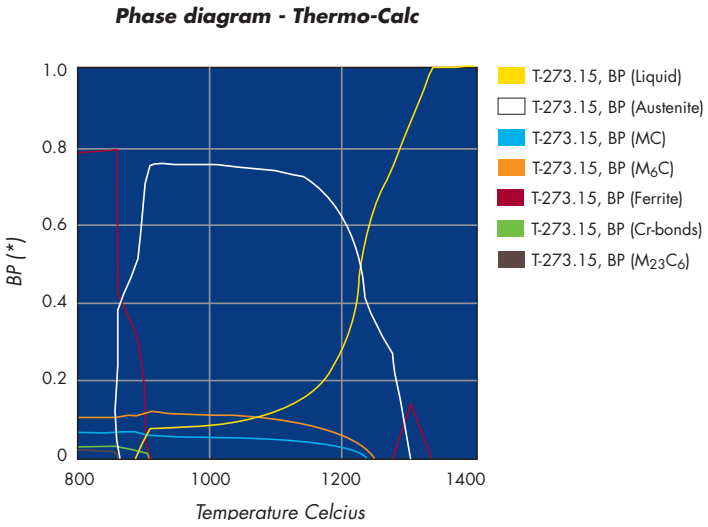
fj 266(2)



fj 266(2)



To ensure high density and carbide formation, increased sintering activity is required. This phenomenon has been studied by means of Thermo-Calc, which calculates the phase diagram for the concerned material. At the sintering temperature, approx. 18% of the material is in the liquid phase, where there is a high solubility of Cr, Mo and W of 8.60%, 4.76% and 2.22% respectively, which precipitate to carbides during cooling. Furthermore, the carbides ($M_{23}C_6$ and MC carbides) have a high vanadium carbide content of 49.13%, and 39.60% tungsten carbides and 22.71% molybdenum carbides respectively in M_6C carbides.



The figure shows the calculated mass share as a function of the temperature – the calculation has been performed with Thermo-Calc.

	Weight%	%C	%Mo	%W	%Cr	%V	%Other	%Fe
Liquid phase	17.89	1.15	4.76	2.22	8.60	0.85	4.69	77.73
Austenite	70.12	0.51	2.33	2.58	2.99	0.91	0.23	90.44
Carbides	3.91	12.98	17.35	15.12	4.29	49.13	0.00	1.11
M_6C	8.08	2.20	22.71	39.60	2.45	3.51	0.00	29.52

The phase distribution during sintering calculated with Thermo-Calc.

WEARDENS® increases tensile strength of cutting tools

In some cases, it is a good idea to stick to a well-known concept, which has over the years worked well for a company. A Swedish supplier of machines for the forestry, however, decided to think untraditionally and explore the advantages of powder metallurgy for the production of tool parts.

This has, among other things, resulted in a debarking tool made of sinter metal, and now FJ Sintermetal's patent pending WEARDENS® material creates even more interesting possibilities for further use of sinter metal.

The high density and strength of WEARDENS® makes the powder highly suitable for cutting tools in e.g. forestry. It is hard as wrought high-speed steel and has a number of other advantages. As the cutting tool has not been rolled but sintered, the final component has isotopic material properties – i.e. full tensile strength in all directions of the steel. The risk of breach of the material has therefore been reduced considerably, as the vertical cutting direction of the component does not collide with inverse rolling grooves.

Furthermore, there is a financial incentive for the customer, as the process has been shortened considerably compared to a conventional production method. The powder is pressed and sintered to a finished component without milling or hardening heat treatment. The cutting tool thus gets its dimensions and shape directly from the sintering process.