ANALYSIS OF MATERIAL FOR FORMING DRILLS

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Tool material HSS is used for drills forming. The supplied material has enclosed from two separate batches the same certificate from the manufacturer. The material is in the standard CSN 419830. From one batch can be produced drills from the second cannot be produced. The article discusses the detailed analysis of the material. The differences are shown that are not listed in the attestation. Tests were performed for the customer available. Tests are not time consuming. Customer engaged in mass production usually does not have the possibility to detect differences. The customer usually does not have the necessary equipment. Made and recommended tests are based on metallographic knowledge, including hardness measurements, qualitative and quantitative chemical analysis. Data have graphical output. Elements are compared from the viewpoint of influence on hot formability. According to these collected data, the customer can assume the subsequent success of the production process.

KEYWORDS

HSS steel, forming drill, hardness test, carbide, chemical analysis.

1 INTRODUCTION

Moulded drills are made from HSS steel AISI M2 (equivalent according to CSN 419830 is steel 19830) [Fremunt 1994]. M2 is mouldable and does not do manufacturing problems [Dvorak 2013], [VSB-TU Ostrava 2016], [Altan 2004]. The standard prescribes its composition (Tab. 1).

Table 1. Data from the CSN 419830, max. weight %

C	Mn	Si	P	S	Cr	Mo	V	W	Co
0.93	0.32	0.23	0.027	0.0007	4.36	4.85	1.77	5.92	-

The problem is, however, a set of characteristics that affect the hot formability (Tab. 2) [3].

Table 2. Theoretical aspects of hot formability steel AISI M2

Medium size austenitic grain	$x \leq 6$ µm
the standard deviation of the size of the austenite grain	$s \leq 3$ µm
the number of carbides larger than 17 microns	$n \leq 9$ pieces.mm^{-1}
carbides form factor k_c (medial surface divided by the mean circuit) for carbides larger than 2 microns	$k_c \geq 0.85$
cobalt content	Co ≥ 0.5 %
vanadium content	V ≤ 1.73 %
sulphur content	S ≤ 0.01 %

Manufacturer issue the attests. Individual doses supplied material and may not be different, and the certificate is in order. When the customer knows credible information in advance, then problems may arise in the manufacturing process. This may have far-reaching consequences. To avoid such situations, it is good to know the structural properties of the delivered dose of the material. Not every customer has its own fully equipped laboratory. We can get good results even simple methods. Basic knowledge are available from the literature [Dvorak 2004], [Baca 2010], [Hosford 2011], [Vojtech 2010], [Forejt 2006], [Sedlak 2016], [Mouralova 2015]. The presence of carbides (frequency, size, layout, structure) focused the attention of authors. Influence of carbides was demonstrated on worse formability by hot at HSS M2 type.

2 ANALYSIS OF SAMPLES

Samples of materials are rod-shaped with dimensions of Ø 4.4 x 200 mm. For clarity, it is used for the material benefits of complying with the symbolic designation T (mouldable). Substandard batch is labelled N. Material of samples were prepared by conventional procedures for carrying out metallographic tests.

2.1 Method for chemical analysis

Two methods were used for etching in order to assess the difference in the structure (conventional etching and colour etching which is more difficult to prepare). Composition of etchants and etching conditions (Tab. 3). Colour etching was used to identify the carbides that remain in the image always white. This is necessary with regard to the further evaluation of carbides in the microstructure.

Table 3: Composition of etchant

	classic etching	colour etching
etchant	Nital 5 %	Klemm 1
nitric acid	5 ml	-
methylated	95 ml	-
saturated solution of sodium thiosulfate in H_2O	-	25 ml
potassium metabisulfite $K_2S_2O_5$	-	1 g
H_2O	-	25 ml
time etching	20 to 60 s	

Electron scanning microscope VEGA II XMU (TESCAN) in conjunction with X-ray.energy dispersive microanalyses QUANTAX 800 (Bruker) SDD detector type was used for the microanalysis of elemental composition. Measuring of elemental composition by EDS was performed at an acceleration voltage of 15 kV and a magnification 100x to the side of the samples.

2.2 *Results of quantitative and qualitative chemical analysis*

Results of the analyses are documented by X-ray.spectrum (Fig. 1, Fig. 2) and quantitative the concentration including the statistical processing (Tab. 4). The samples were measured 3 times. The concentration of light elements (C, O) were not counted. In both samples were consistently identified elements C, V, Cr, Fe, Mo and W. The elements Si (Si peak partly overlaps with the peak W) and Mn (Mn peaks are partly coincide with a peak Cr and Fe) were also entered to calculate concentrations . Standard values according to CSN 419830 are shown in Tab. 1. Tab. 4 contains the measured values and their differences to the nominal values in Tab. 1.

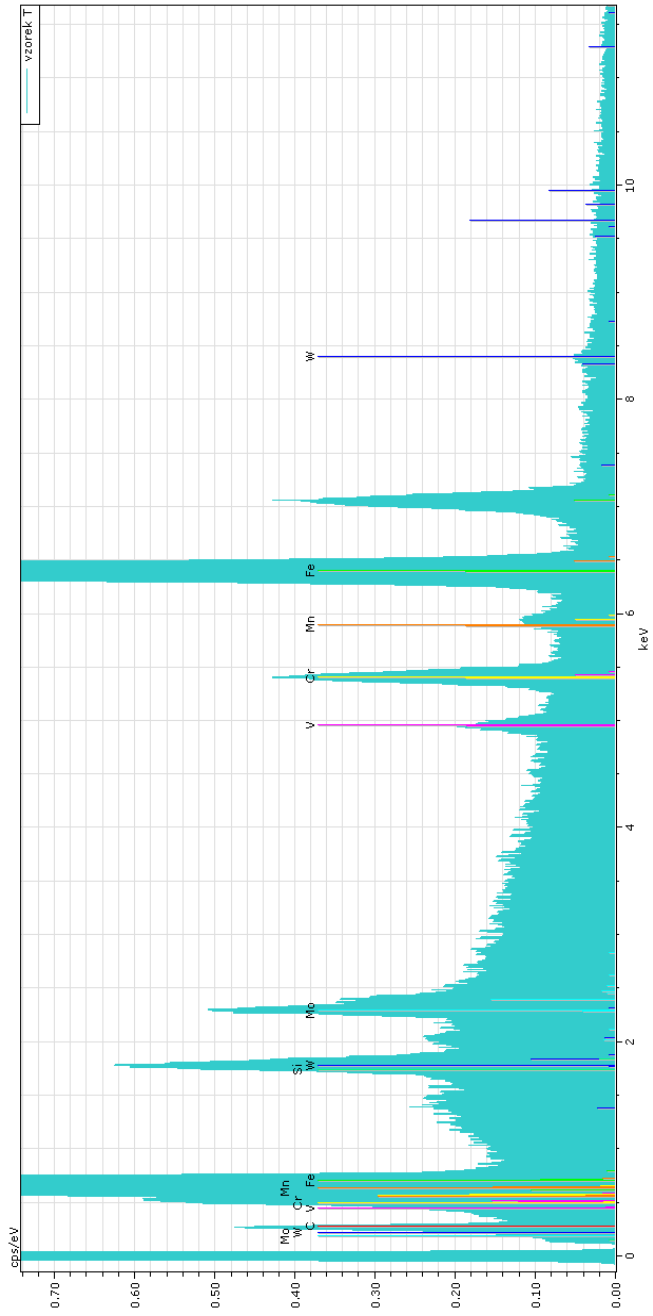

Figure 1. 1329 X-ray spectrum of one sample T

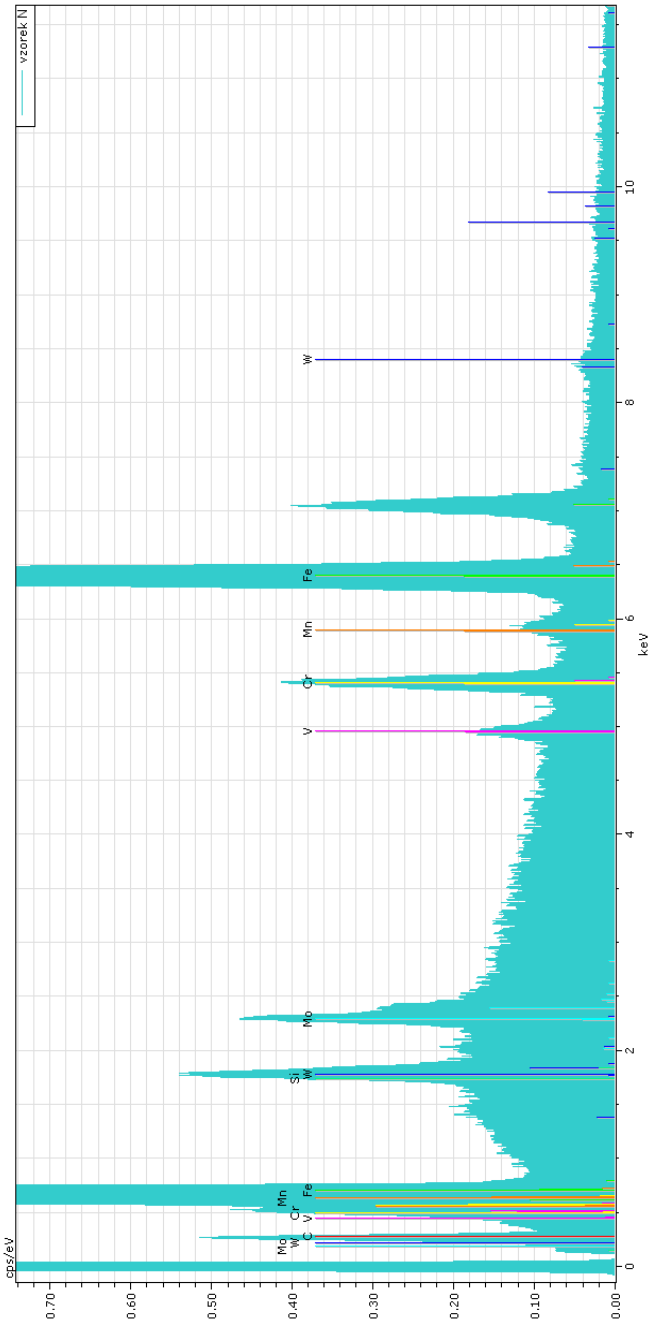

Figure 2. 1329 X-ray spectrum of one sample N

Table 4. Elemental analysis of samples (weight %)

spectrum	Si	V	Cr	Mn	Mo	W
	mean of three measurements of samples					
sample T	0.2	1.6	5.1	0.6	3.4	6.5
difference from CSN (Tab. 1)	0.03	0.17	-0.74	-0.28	1.45	-0.58
sample N	0.3	1.5	5.1	0.7	3.7	7.1
difference from CSN (Tab. 1)	-0.07	0.27	-0.74	-0.38	1.75	-1.11
statistical evaluation of samples T and N between themselves						
average value	0.2	1.5	5.1	0.7	3.6	6.8
standard deviation	0.1	0.1	0.0	0.1	0.2	0.4

2.3 *Hardness measurement*

Conditions of measurement samples (Fig. 3) are shown in (Tab. 5) [11] and the results (Tab. 6). The samples were measured 3 times.

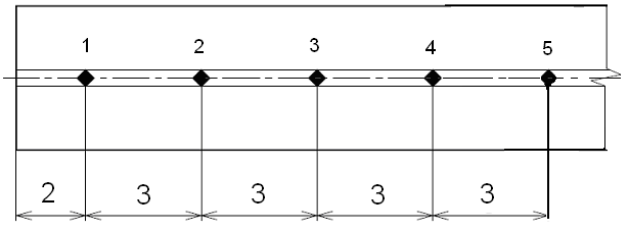

Figure 3. Locations no. 1-5 HV10 hardness measurements on samples, length dimensions are in mm

Table 5. Conditions for hardness testing

conditions	item	remark
hardness tester	ZWICK No. 3212	Laboratory Institute of Engineering Technology
optical settings	20 : 1	influence on the size the indentation
time indentation	10 s	-
room temperature	21 °C	Laboratory Institute of Engineering Technology
measurement point	No. 1 to 5	Fig. 3
sensing camera	CS8420C-02 (Made in Japan)	
program	TestXpert the hardness tester Zwick No. 3212	

Table 6. Measured values of hardness HV10

	sample T	sample N
spot metering	HV10	HV10
1	303	304
2	300	307
3	306	305
4	304	306
5	306	306
average value	303.8 (30.3 HRC)	305.6 (30.5 HRC)
standard deviation	2.2	1.0
coefficient of variation	0.0072	0.0033

2.4 *Analysis of sample marked T*

The microstructure after conventional etching is shown (Fig. 4). The microstructure after colour etching the presence of carbides (carbides appear white) is displayed (Fig. 5).

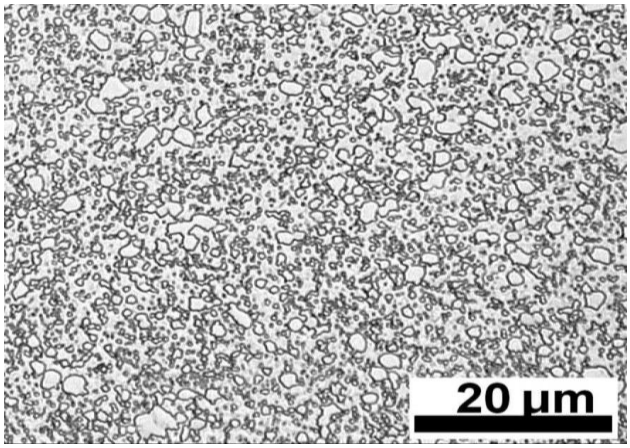

Figure 4. Detail of microstructure sample T (conventional etching)

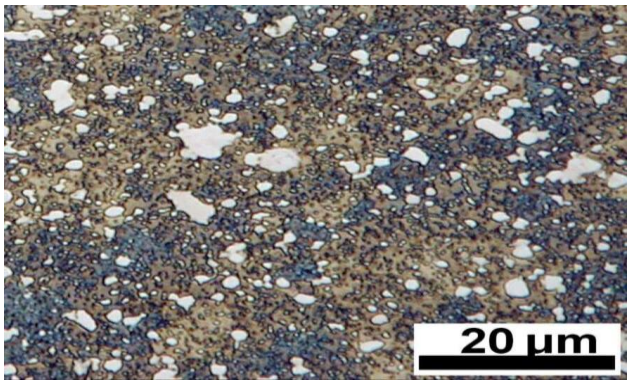

Figure 5. Detail of microstructure sample T (colour etching, carbides appears white)

2.5 *Analysis of sample marked N*

The microstructure after Conventional etching is shown (Fig. 6). The microstructure after colour etching the presence of carbides (carbides appear white) is displayed (Fig. 7).

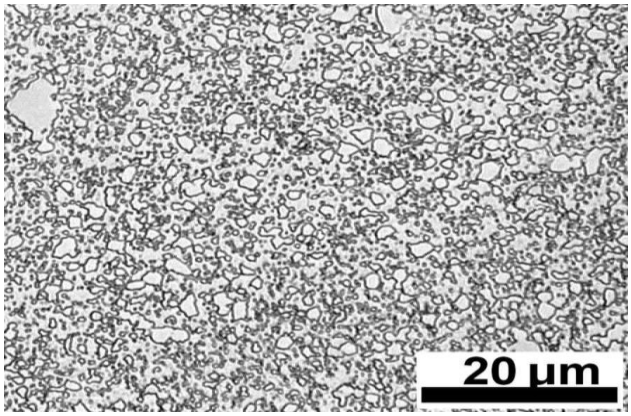

Figure 6. Detail of microstructure sample N (conventional etching)

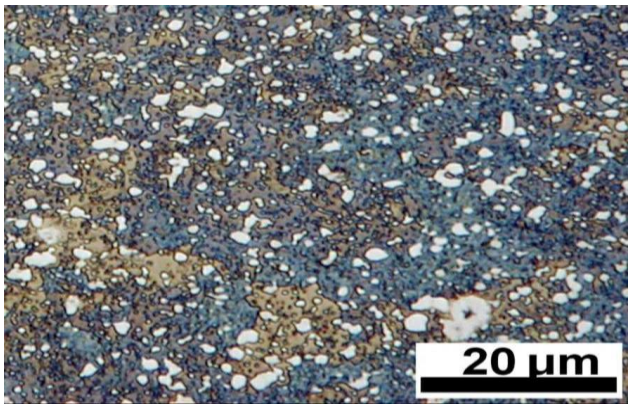

Figure 7. Detail of microstructure sample N (colour etching, carbides appears white)

2.6 *Comparison of sample analyses T and N content of carbides*

Section X-X and Y-Y are inserted into the original complete frame for comparing the content of carbides in the samples (Fig. 8, Fig. 9). The number of grains of carbides is determined subsequently at each section (Tab. 7).

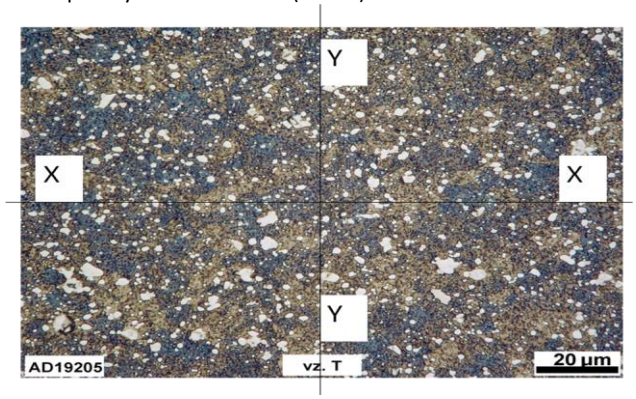

Figure. 8. The original photo of the microstructure of the sample T with embedded sections

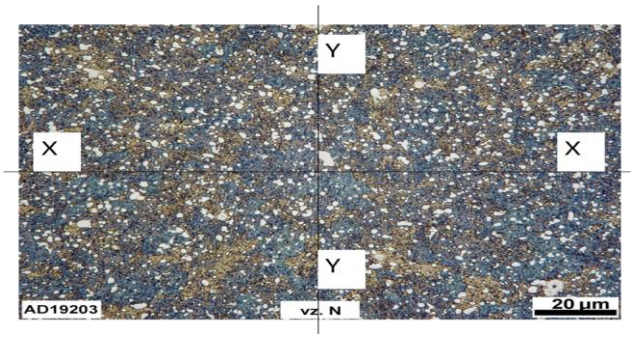

Figure 9. The original photo of the microstructure of the sample N with embedded sections

Table 7. Number and size of grain carbides

carbides	sample T		sample N	
	X-X	Y-Y	X-X	Y-Y
the number of grains	26	16	33	24
grain size [microns]	2.6		1.5	

3 CONCLUSION

Laboratory tests and measurements proved that it can be stated:

- Hardness samples T and N differ slightly, about 0.6 %. The hardness of the sample T is 303.8 HV10 (30.3 HRC) hardness of sample N is 305.6 HV10 (30.5 HRC).
- The content of elements in weight. % differs. Sample N has a higher value (stated relative to Sample T), molybdenum (Mo) 9 % tungsten (W) by 17 %, manganese (Mn), 9 %, silicon (Si) 50 %. Factors affecting the inferior hot formability HSS. Especially Si.
- The proposed methodology for assessing the number and size of carbide grains in images gives an unambiguous result. Sample N has a higher value (stated relative to Sample T) section X-X 27 % , section Y-Y 50 %. Additionally, a sample N has significantly finer grain 1.5 microns (sample T has 2.6 microns).

Testing of samples supplied confirmed operational experience. Sample T is formable. Sample N causes trouble from the viewpoint of hot formability. There are cracks. The final product (moulded twist drill) is therefore unsatisfactory. The same attest is with each batch material. But the doses are different. Customer detects this up in production. This situation is disadvantageous for the customer.

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