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BENDING BEHAVIOR ASSESMENT OF NdFeB MAGNET BASED SAMPLES

Ph.D. Stud. Eng. Melania Tămaş[1], Prof .Univ. Emerit. Ph.D. Eng.Constantin D. Stănescu[2], Ph.D. Stud.Eng. Doina Ene[3]
[1] Ion Neculce" National College, Bucharest, ROMANIA, melaniat2@yahoo.com
[2] Polytechnic University, Bucharest, ROMANIA, prof_cstanescu@yahoo.com
[3] I. Socolescu" Technical Architecture College, Bucharest, ROMANIA, doinaene@ymail.com

Abstract: *The technological advancements impose new solutions for growing adding value. In this context, this paper presents some experimental researches concerning the bending behavior of steels magnets, NdFeB based. Neodymium magnet samples of different density and hardness values. Mechanical processing for cold plastic deformation by bending of technological samples is characterized by technical difficulties at bending low angle technological tests. The size and shape of the geometric deformations of materials depends on the size, type and mode of application of the stresses to which they were subjected and their properties. For technological samples with small thickness (up to 8 mm), present fractures, in the case of free bending test.*
Keywords: *NdFeB magnets, bending behavior, thermal characteristics, electrical characteristics*

1. INTRODUCTION

The upward level of requirements and demands, constantly growing, regarding the performance of human activities, led to unprecedented development and continuous improvement of science and engineering technology [1,4].
Theoretical and experimental research undertaken in Romania and abroad, in the field of composite materials technology is an interdisciplinary field in which materials engineering, mechanical engineering and chemical technology contributes to achieving the final project: "the composite" [5-9].
Today, composite materials are used in all areas where technological progress requires a combination of properties that cannot be provided by conventional materials.
The article deals with possibilities and behavior of materials used to produce permanent magnets, NdFeB based (see figure 1), on machining of cold plastic deformation by bending [10, 11].

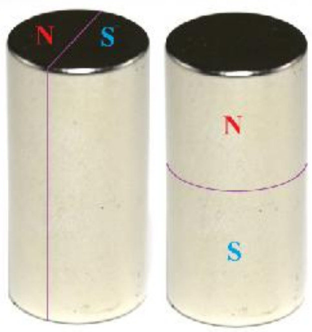

Figure 1: Rare earth magnets, NdFeB based

The size and shape of the geometric deformations of materials depends on the size, type and mode of application of the stresses to which they were subjected and their properties [12].

2. CHEMICAL COMPOSITION AND TECHNICAL FEATURES OF TECHNOLOGICAL TESTING SAMPLES

In the framework of experimental researches, encompassing plastic deformation mechanical processing, they were used eight types of samples, with diffrent densities and hardness with carbon steel 0,5% based matrix of composite material, and neodymium alloy, which incorporates complementary material composed of boron ferrite (FeB) short fibers, evenly spaced, with guided distribution.
The samples, acquired from the company Arca Hobber Chemicool SRL, have been designed and molded with the following dimensions (see Figure 2) [4-7]
- Length: 80 - 100 mm;
- Width: 30 - 40 mm;
- Thickness: 5 - 10 mm;

Figure 2: Geometrical configuration of the test samples used for experimental research by plastic bending deformation

Table 1 shows the chemical composition of experimental saples, based on NdFeB.

Table 1: Chemical composition of experimental semples based on NdFeB

Name	Chemical element components, %						
	C	Fe	B	Nd	Al	Nb	Dy
NdFeB	0,5	64,2-68,5	1-1,2	2,9-3,2	0,2-0,4	0,5-1	0,8-1,2

Where: Nb-niobiu, Dy-disprosiu;

Table 2 presents the mechanical characteristics of experimental samples, based on NdFeB.

Table 2: Main Mechanical characteristics of experimental samples

Sample	Density g/cm^3	Hardness			Resistance Nm/mm^2		Force		Young module	Rigidity N/m^2	Compresibility 10^{-12} mm^2/N	Poison ratio
		HB	HRC	HV			F_i	F_f				
W4	4.4-5.5	40-45	551	570	1980	780	8	9.8	1.6	0.64	9.8	0.24
W6	5.3-5.8	40-45	551	570	1980	780	8	9.8	1.6	0.64	9.8	0.24
W8	5.6-6.0	35-38	551	570	1980	780	8	9.8	1.6	0.64	9.8	0.24
W8H	5.6-6.0	35-38	551	570	1980	780	8	9.8	1.6	0.64	9.8	0.24
W10	5.8-6.1	35-38	551	570	1980	780	8	9.8	1.6	0.64	9.8	0.24
W10H	6.0-6.2	35-38	551	597	1980	780	8	9.8	1.6	0.64	9.8	0.24
W12	6.2-6.6	35-38	551	597	1980	780	8	9.8	1.6	0.64	9.8	0.24
W12D	6.2-6.6	35-38	551	597	1980	780	8	9.8	1.6	0.64	9.8	0.24

Where: Fi is tensile force;
Ff –flexural force (10^{-12} m^2/N).

Table 2 presents the thermal characteristics of experimental samples, based on NdFeB [13, 16].

Table 3: Thermal characteristics of experimental samples

Sample/ characteristic	Symbol	U.M	W4	W6	W8	W8H	W10	W10H	W12	W12D
Thermal conductibility	K	kcal/mh ^{0}C	7.7	7.7	7.7	7.7	7.5	7.5	7.5	7.5
Specific heat capacity	C	kcal/mh ^{0}C	0.12	0.12	0.12	0.12	0.1	0.1	0.11	0.11
Melting point	T/C	^{0}C/K	1016/ 1289	1016/ 1289	1016/ 1289	1016/ 1289	1016/ 1289	1017/ 1290	1017/ 1290	1017/ 1290
Boiling point	Tf	^{0}C/K	3070/ 3343	3070/ 3343	3070/ 3343	3070/ 3343	3070/ 3343	3060/ 3340	3060/ 3340	3060/ 3340
Coefficient of thermal expansion	c	10^{-4}0C	3.4	3.4	3.4	3.5	3.5	3.5	3.5	3.5
Temperature resistivity coefficient	a	10^{-4}0C	2	2	2	2	2	2.1	2.1	2.1
Curie temperature	Tc	^{0}C	310	310	310	316	316	316	316	316
The heat of vaporization	cv	mΩ/cm	283.68	283.68	263.68	263.68	263.68	263.68	263.68	263.68

Table 4 presents the electrical characteristics of exterimental samples based on NdFeB.

Table 4: Electrical characteristics of experimental samples

Sample/ characteristic	Symbol	U.M	W4	W6	W8	W8H	W10	W10H	W12	W12D
Electrical conductibility	σ	10^6S/m	0,667	0,667	0,667	0,667	0,670	0,671	0,720	0,720
Electrical resistance	ρ	kcal/mh0C	150	150	150	152	153	158	158	158

The analysis of HV and HRC values of experimental specimens show that the materials used in these samples gives a very high hardness, mechanical strength and good tear.

3. THE ASSESSMENT OF MECHANICAL PROCESSING BEHAVIOR TO BENDING PLASTIC DEFORMATION OF EXPERIMENTAL SAMPLES

In order to produce of experiments, the technological samples has been demagnetized at a temperature of 110^{0}C, within an oven, model Nabertherm having the possibility of variation of the temperature in the range of 30-3000^{0}C. The laboratory equipment belongs to SIMAR INDUSTRIAL SA company from Bucharest (figure 3).

Figure 3: The oven for heating to demagnetize of technologic samples, model Nabertherm and temperature range 30-3000^{0}C

In order to acheive the mechanical test, has been used two diffrent experimental equipments, a mechanical driven one and a hydraulic driven another one.
The equipment belong to Laboratory of Plastic Deformation from TMS Department, and these are:

- AbKant apparatus, model 850, for free bending tests;
- Hydraulic universal machine, model WE60 (Hydraulic universal material testing machine) for mold bending.

The figure 4 presents free bending tests using the Abkant 850 apparatus.

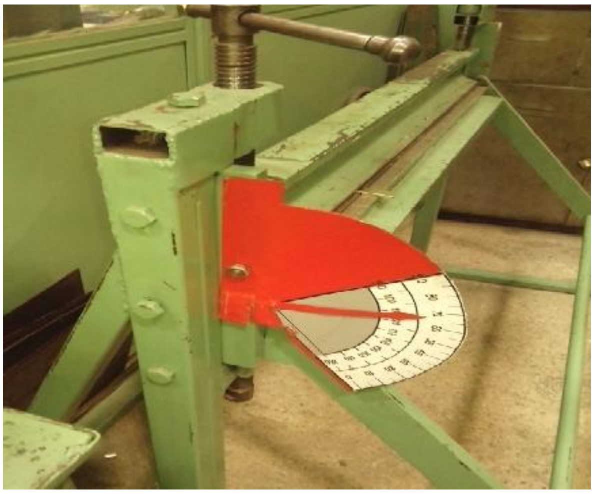

Figure 4: Free bending tests of technological samples using the AbKant 850 apparatus

The bending tests has been acheived at two bending angle values: $\alpha=170^0$ şi $\alpha=90^0$. The experimental results has presented it Table 5.

Table 5: Experimental results of bent test samples, using AbKant 850 apparatus

Simbol of test sample	LxHxW (mm)	Bending angle (grade)	Recover angle (grade)	Assessment
W4	100x40x5	160-130	-	cracked
W6	100x40x5	160-130	-	cracked
W8	100x40x5	160-130	-	cracked
W8H	100x40x5	140-120	0.3	fissures and creases
W10	100x40x5	160-120	0.2	fissures and creases
W10H	100x40x5	140-110	0.2	accepted
W12	100x40x5	120-110	0.1	accepted
W12D	100x40x5	120-90	0.1	accepted

3. CONCLUSION

In the case of free bending technology, the mechanical processing of cold plastic deformation of test samples with small thickness (up to 8 mm) presents difficulties at bending low angles, resulting creases, fissures and cracks.

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