INFLUENCE ALTERNATE AND STEADY MAGNETIC FIELD ON FLOW STRESS CURVES FROM THE TENSILE TEST FOR STEEL 12013

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VLIV STŘÍDAVÉHO A STEJNOSMĚRNÉHO MAGNETICKÉHO POLE NA KŘIVKY PŘETVÁRNÝCH ODPORŮ TAHOVÉ ZKOUŠKY PRO OCEL 12013

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Abstrakt

V tomto příspěvku je popisováno vliv střídavého a stejnosměrného magnetického pole na průběh křivek přetvárných odporů z tahové zkoušky pro ocel 12013. Rovněž byly provedeny experimenty kdy vzorek byl podroben působení stejnosměrného magnetického pole před zkouškou-magnetické zpracování a pak byl proveden test. Byly srovnávány dopady na tažnost, maximální homogenní deformaci, a na průběh křivek přetvárných odporů.

Abstract

This paper describes influences the alternate and the steady magnetic field on the evolutions of the flow stress curves. These curves were measured from the tensile test for steel 12013. The experiments were made too, when samples were magnetic treatment. After the magnetic treatment the samples were tested with the tensile test. The influences were compared on the flow stress curves, total strain at fracture, the value of the homogenous plastic strain.

Key words: Flow stress, strain, strain rate, steady magnetic field, alternate magnetic field, magnetic treatment, total strain at fracture.

Introduction

On our workplace - Department of Mechanical Engineering Technology we investigate possibilities of the application magnetic field in the technology of the metals treatment. At previous publications (e.g. [1]) we presented that the influence of the magnetic field on the flow stress is dependent on the strain rate and on the magnetic intensity. In this paper we made experiments only for one strain rate but for number of intensities of the magnetic field. We made experiments with the magnetic treatment for steady magnetic field 200 kA/m for the duration of 200s, and after tensile test.

The magnetic field caused the change of the plasticity. Changes in material behaviour during cold plastic deformation in magnetic field are caused by changes in types of energies related to changes in magnetic structure and processes occurring in the cation electron shell – change in electron spin states and in the cation core (core spin moments). Alternating magnetic field causes processes occurring in the electron gas as a reaction to changes magnetic flux in the time and oscillation is a product of magnetostriction in condition magnetic intensity as function time. Interaction of the process in the cation electron shell and cation core, together with processes occurring in the electron gas, also leads to changes in plasticity.

Experiment

Steel 12013 is ferritic steel with small quantity pearlite. The steel 12013 has guaranteed magnetic properties. Chemical composition of the studied steel 12013 is in Tab. 1.

Table 1 Chemical composition of steel 12013

element	C	Mn	Si	P	S	Cr	Ni	Cu	Al	V	Nb	Zr	N
weight %	0,028	0,415	0,037	0,020	0,020	0,007	0,037	0,064	0,002	0,014	0,015	0,030	0,050

The tensile tests were making for strain rate 0,005 s^{-1}. The sample was loaded in magnetic field - intensities for start the tensile test were for alternate magnetic field 50kA/m, 200kA/m, 470 kA/m and for steady magnetic field 1330kA/m. The magnetic treatment was made with the magnetic intensity 200 kA/m for the duration of 200s, after the magnetic treatment sample was loaded with tensile force until failure. The magnetic intensities were measured with transverse Hall probe. The measuring magnetic intensity was made with divided sample. The transverse Hall probe was inserted between the two parts of the sample (Fig.1.a). The tensile tests were making without magnetic field for confrontation too. Average flow stress curves as function logarithmic strain were determined for identical conditions of the experiment (magnetic intensity). Average total strain at fracture and the value of the homogenous plastic strains were determined for identical conditions of the experiment too. Then we compared influences magnetic fields with measurement errors.

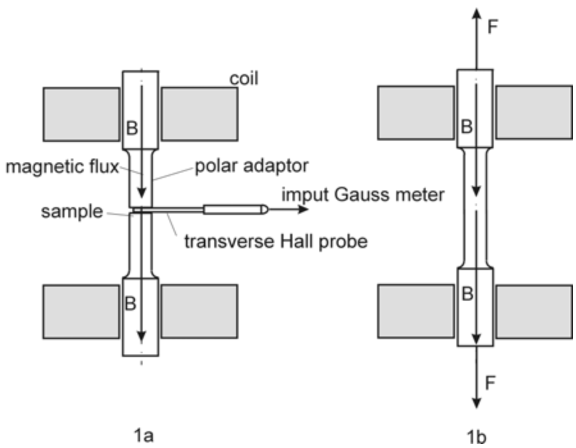

Fig.1 a) Measuring magnetic intensity, b) Tensile test

The equipment for product of the magnetic field is composed from two coils, power amplifier and function generator and serial tuning capacitor (Fig. 2.). The coils are in parallel connection by reason of decline winding inductance.

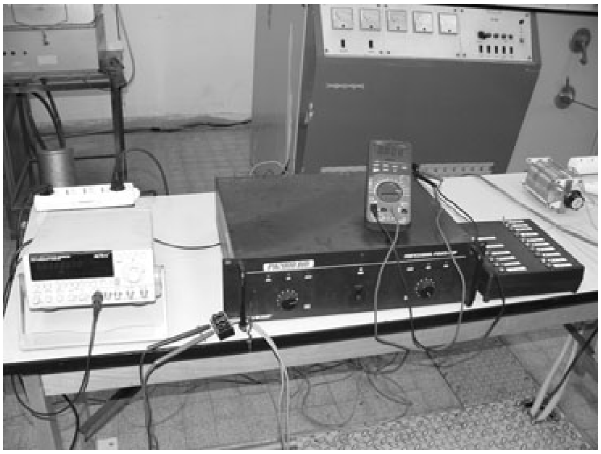

Fig.2 Equipment for product of the magnetic field

Results

The outputs from our experiments were:

- Confrontations influence of the alternate magnetic field or steady magnetic or magnetic treatment on the flow stress curves vs. measurement error (Fig. 3. –Fig.7.).
- Confrontations influence of the alternate magnetic field or steady magnetic or magnetic treatment on the total strain at fracture vs. measurement error (Tab. 2.)
- Confrontations influence of the alternate magnetic field or steady magnetic or magnetic treatment on the homogenous plastic strains vs. measurement error (Tab. 2.)

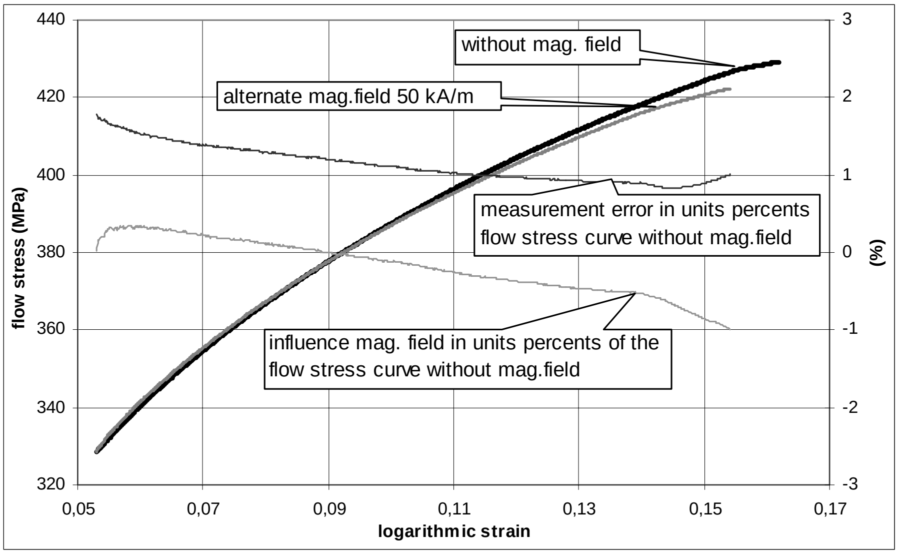

Fig.3 Confrontation influence of the alternate magnetic field 50 kA/m on the flow stress curves vs. measurement error

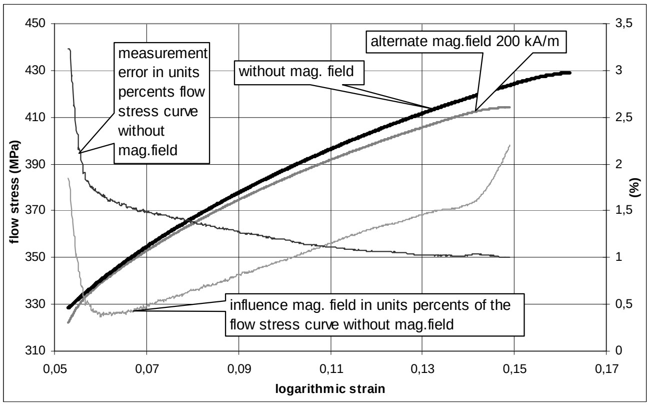

Fig.4 Confrontation influence of the alternate magnetic field 200 kA/m on the flow stress curves vs. measurement error

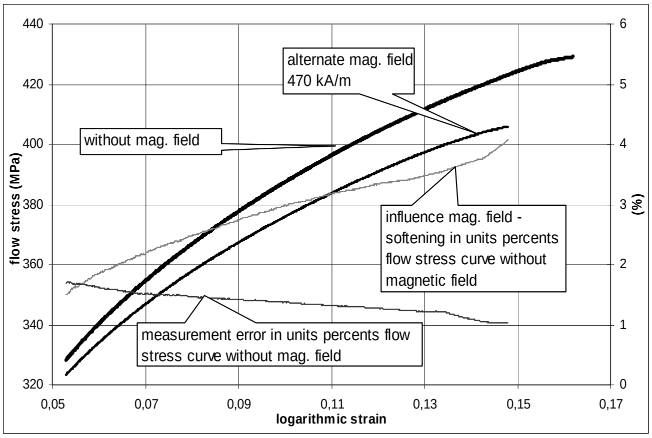

Fig.5 Confrontation influence of the alternate magnetic field 470 kA/m on the flow stress curves vs. measurement error

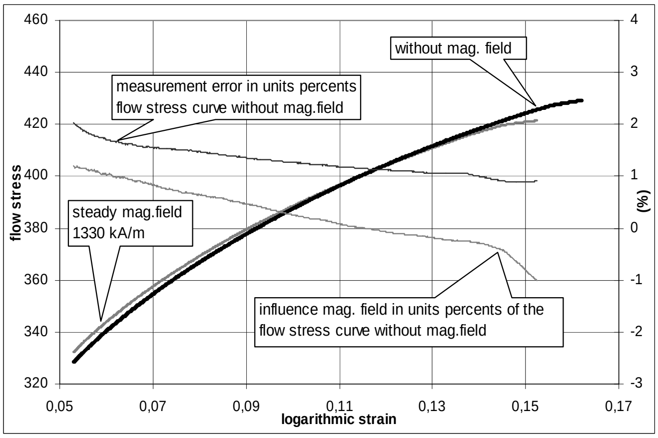

Fig. 6 Confrontation influence of the steady magnetic field 1330 kA/m on the flow stress curves vs. measurement error

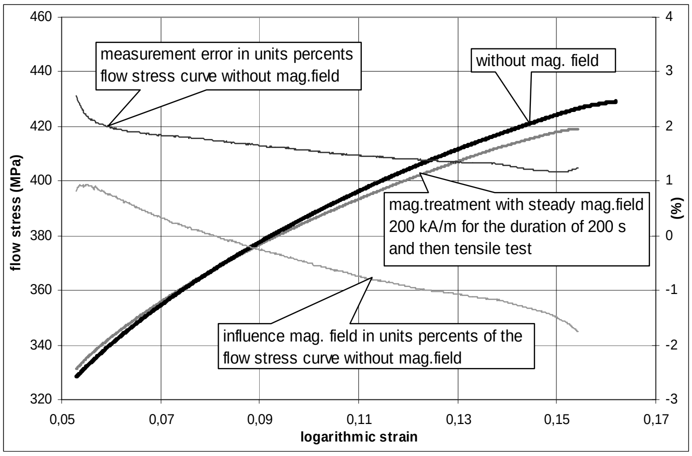

Fig.7 Confrontation influence of the magnetic treatment with steady magnetic field 200 kA/m for the duration of 200s on the flow stress curves vs. measurement error

Table 2 Confrontations influence of the alternate magnetic field or steady magnetic or magnetic treatment on the total strain at fracture ε_f vs. measurement error, confrontations influence of the alternate magnetic field or steady magnetic or magnetic treatment on the homogenous plastic strains ε_{hom} vs. measurement error

	alternate mag. field 50 kA/m	without mag. field	influence mag. field	measurement error
ε_f	0,3929	0,3928	0,0001	0,0219
ε_{hom}	0,1542	0,1620	-0,0078	0,0114
	alternate mag. field 200 kA/m	without mag. field	influence mag. field	measurement error
ε_f	0,3852	0,3928	-0,0076	0,0232
ε_{hom}	0,1490	0,1620	-0,0129	0,0127
	alternate mag. field 470 kA/m	without mag. field	influence mag. field	measurement error
ε_f	0,3630	0,3928	-0,0298	0,0223
ε_{hom}	0,1480	0,1620	-0,0139	0,0109
	steady mag. field 1330 kA/m	without mag. field	influence mag. field	measurement error
ε_f	0,3907	0,3928	-0,0021	0,0206
ε_{hom}	0,1526	0,1620	-0,0094	0,0126
	Magnetic treatment	without mag. field	influence mag. field	measurement error
ε_f	0,3855	0,3928	-0,0073	0,0225
ε_{hom}	0,1545	0,1620	-0,0075	0,0121

Conclusion

The alternate magnetic field 50 kA/m has the smaller influence then measurement error. When we make confrontation flow stress curves with alternate magnetic field 200kA/m vs. without magnetic field, then we can say magnetic field caused softening. Until 0,101 of the logarithmic strain the influence magnetic field is smaller then measurement error (Fig.4). The alternate magnetic field with magnetic intensity 470 kA/m evidently caused shift of the flow stress curve to less values of the mechanical stress. Influence magnetic field is over measurement error (Fig.5). The influence of the steady magnetic field 1330 kA/m is under measurement error (Fig. 6.). The magnetic treatment with steady magnetic field 200 kA/m for the duration of 200 s, has not effect on next tensile test (Fig. 7.). We can say steady magnetic field for these used values of the magnetic intensities do not influence on the flow stress curve of the steel 12013. The alternate magnetic fields 200 kA/m and 470 kA/m influence the evolution of the flow stress curves during tensile test.

Now we make confrontation influences magnetic fields on total strain at fracture ε_f and the homogenous plastic strains ε_{hom} vs. measurement error (tab- 2.). The alternate magnetic field 50kA/m, the steady magnetic field 1330 kA/m and the magnetic treatment with steady magnetic field 200 kA/m for the duration of 200 s did not have effect on total strain at fracture ε_f and the homogenous plastic strains ε_{hom}. Their effects are smaller then measurement errors. The alternate magnetic fields 200kA/m and 470 kA/m caused decrease the homogenous plastic strains ε_{hom}. The alternate magnetic field 470 kA/m caused decrease total strain at fracture ε_f too.

Acknowledgement

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Literature

[1] Tomčík P., Švrčková R., Hrubý J.: Comparison flow stress curve of the tension test of the steel 12013 in magnetic field, In: 12. mezinárodní vědecké konference CO-MAT-TECH 2004 Zborník abstraktov. Bratislava: STU, 2004, s. 209. ISBN 80-227-2121-2