EXAMINATION OF IRON-BEARING CONTENT IN COLD WORKED AISI 304 STEEL BY MÖSSBAUER SPECTROSCOPY

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1. Introduction

The austenitic steels are one of the key candidate structural materials for Gen-IV reactor systems. In general, stainless steels have superior oxidation and corrosion resistance in many media, but they are not immune to severe degradation in some common environments [1].

This work is focused to study the iron-bearing phase composition of cold-worked AISI-304 stainless steel by Mössbauer spectroscopy.

2. Experimental details

The AISI-304 stainless steel has been cold-worked at the levels 20, 30, 40 and 45% (CW), respectively with the purpose to increasehardness and yield strength [1], chemical composition of the steel is given in table 1.

Tab. 1.Chemical composition of the AISI-304 type stainless steel [1]

Element	C	Cr	Ni	Mn	Cu	Si	S	P
wt.%	≤ 0.04	19.0-20.0	9.0-10	≤ 2.0	≤ 1.0	≤ 1.0	≤ 0.03	≤ 0.04

The samples for mössbauer experiments were measured at room temperature using constant-acceleration Wisselmössbauer spectrometer with the ^{57}Co(Rh) source in backscattering geometry. The isomer shifts were determined relative to natural iron. Hyperfine parameters of the spectra including spectral area (A_{rel}), isomer shift (IS), quadrupole shift/splitting (QS), line width (Γ), as well as hyperfine magnetic field (B_{hf}), were refined using the CONFIT fitting software [2], the accuracy in their determination are of ±1 % for relative area, ±0.02 mm/s for isomer shift, quadrupole shift/splitting, and line width, ±0.5 T for hyperfine field correspondingly.

3. Results

AISI 304 stainless steels are normally austenitic (face centered cubic). But, when the surface of these materials is plastically deformed, a thin layer of martensite (body centered cubic) is formed on the austenite base [3].

From qualitative point of view all of the Mössbauer spectra ofthe AISI-304 stainless steel 20-45%CWcontain dominant paramagnetic singlet with line width Γ = 0.36-40 mm/s which represents fcc austenitic phase of iron atoms. On the other hand, magnetic part of the spectra can be described by sextet with hyperfine field distribution with mean hyperfine field value B_{hf}= 24.6-25.7 T, which can be assigned to bcc martensitic phase of iron atoms. The analysis of the hyperfine field distribution in the martensite reported in this paper is complicated by the presence of the three major substitutional elements, chromium, nickel and manganese, as each of these elements have different extend of influences on hyperfine field [4]. Isomer shifts of the austenitic phase close to IS = -0.13 mm/s and close to zero for bcc fraction for all samples (tab. 2.), these IS values are similar to ideal bcc and fcc iron structures. Quadrupole splitting is very close to zero value for all relevant components.

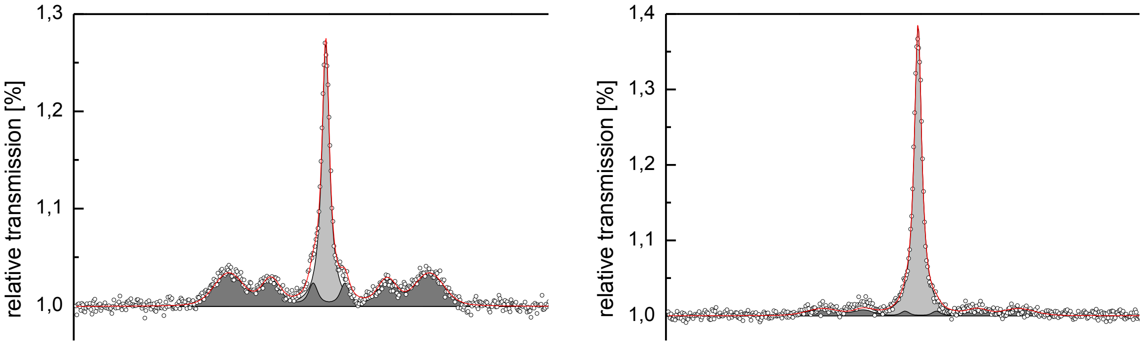

Fig.1. *MS spectrum of AISI 304 (a) 20% CW and (b) 30% CW. Dark grey component represents martensitic bcc Fe, light grey component represents austenitic fcc Fe.*

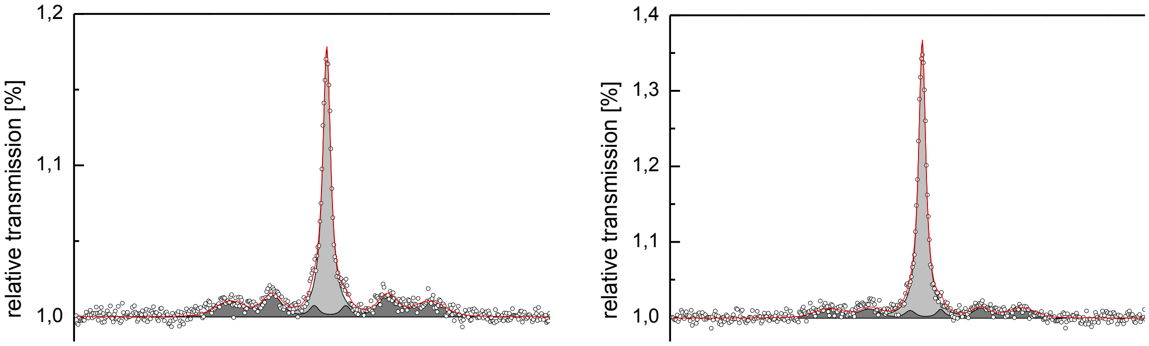

Fig.2. *MS spectrum of AISI 304 (a) 40% CW and (b) 45% CW. Dark grey component represents martensitic bcc Fe, light grey component represents austenitic fcc Fe.*

Tab. 2. *MS spectral parameters of The AISI-304 stainless steel cold-worked at the levels 20, 30, 40 and 45%.*

	austenitic fraction (fcc)			martensitic fraction (bcc)					
CW [%]	A_{rel}[%]	IS [mm/s]	Γ [mm/s]	A_{rel}[%]	IS [mm/s]	QS [mm/s]	B_{hf}[T]	B_{dist} [T]	Γ [mm/s]
20	45	-0.14	0.38	55	-0.01	-0.01	25.7	7.5	0.37
30	81	-0.11	0.38	19	0.01	0.01	25.2	8.5	0.37
40	60	-0.13	0,40	40	-0.01	-0.01	25.5	7.8	0,36
45	72	-0.13	0.36	28	0.00	0.00	24.6	7.4	0.38

From quantitative point of view all of the relative areas of identified components are ranging inconsistently in comparison to the intensity of the cold working process. As mentioned before, one should keep in mind that when the surface of these materials is plastically deformed, a thin layer of martensite (body centered cubic) is formed on the austenite base [3], therefore relative areas of the bcc fraction may be artificially influenced during sample preparation (by unintended plastic deformation). Therefore, quantitative determination of bcc to fcc ratio can be for this reason questioned.

4. Conclusion

The analysis of experimental results from ^{57}Fe Mössbauer spectroscopy confirmed the phase presence of austenite (fcc) and strain induced martensite (bcc), previously identified in [1].However, described phase transformation processes are not in correlation with MS results, which can be explained by possible artificial influences in measured relative areas of the bcc and fcc fraction. From qualitative point of view all of the Mössbauer spectra of the AISI-304 stainless steel 20-45% CW contain dominant paramagnetic singlet with line width $\Gamma = 0.36$-40 mm/s which represents fcc austenitic phase of iron atoms. Magnetic part of the spectra can be described by sextet with hyperfine field distribution with mean hyperfine field value Bhf = 24.6-25.7 T, which can be assigned to bcc martensitic phase of iron atoms.

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