Water Vapor Effect on the Lattice Parameters of the Thermally Grown Oxides on Hot Work Tool Steels

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Hot work tool steels containing about 5wt% chromium are commonly used in forging processes. They may suffer chemical damage during service since the oxide films formed on their surface are not protective [1]. Although some data on the oxidation of Fe-Cr alloys with a low chromium content in oxygen or air are available in the literature [2-3], these results rarely mention the effect of the water vapor on the oxidation mechanisms [4].

The purpose of this work is to determine the lattice parameter evolution for different Fe_2O_3-Cr_2O_3 solid solutions developed in either an oxygen containing media or in an 'O_2+H_2O' containing one. The investigated temperatures are 600°C and 700°C for exposure times of 90 hours. X-Ray diffraction is used in the Grazing Incidence configuration to characterize the thermally grown oxides. The diffracted response (figure 1) exhibits peaks shifted from the theoretical position of pure α-Fe_2O and pure Cr_2O_3. This is particularly interesting since this typical peak shift can be correlated to the lattice parameters of the oxide expressed as $Fe_{2-x}Cr_xO_3$.

For the evaluation of parameter x, the M_2O_3 oxides parameters are taken in the hexagonal system and the position of the (h k l) diffraction peak is measured on the experimental pattern. Our results will focus on the (3 0 0) peak as the d_{hkl} expression in the hexagonal system can be simplified this way. Pure α-Fe_2O_3 and Cr_2O_3 are considered to be the limits of our system and correspond respectively to x = 0 and x = 2. Their lattice parameters are given in table 1. A first assumption is that the evolution of parameter 'a_H' is linear from pure hematite to pure chromite lattice. This seems to be in good agreement with the results reported by Di Cerbo *et al.* [5] and by Wretblad [6] expressed in function of the amount of Cr_2O_3 in the solid solution (figure 2).

Finally, the evolution of the lattice parameter 'a_H' at 600°C when for example 11 vol% of H_2O are added to the 'O_2' atmosphere shows an increase from 5.0299 (x=0.12) to 5.0337 (x=0.04) respectively. The corresponding amounts of diluted chromite are 6wt% and 2 wt%.

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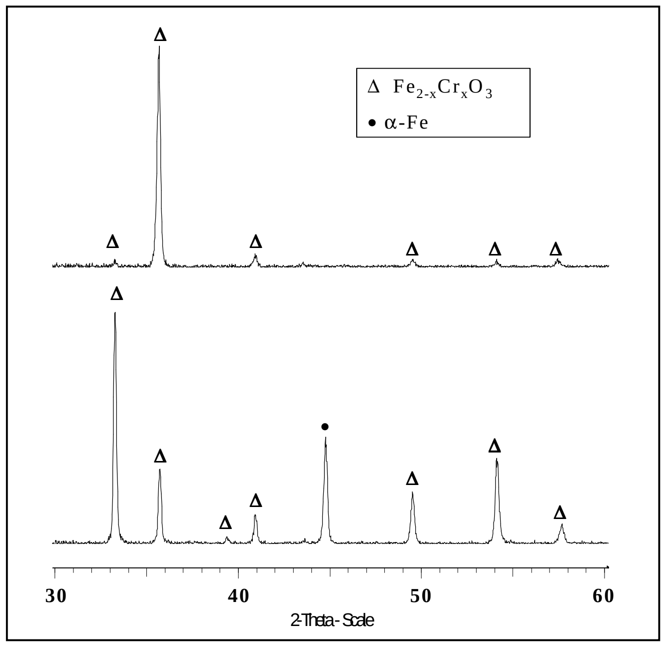

Figure 1 : XRD patterns for the grazing angle 5° after 90 hours exposure at 600°C (a) in the O_2 containing atmosphere, (b) in the ' O_2 + 11 vol%H_2O ' gas mixture.

Table 1 : Lattice parameters of α-Fe_2O_3 and Cr_2O_3 in the hexagonal system taken from the JCPDS cards number 33-664 and 84-313 respectively, and from reference [5].

	Fe_2O_3	Cr_2O_3
a_H (a.u.)	5.0356	4.9372
c_H (a.u.)	13.7489	13.53
a_H (a.u.) *from ref. [5]*	5.0343	4.9591
c_H (a.u.) *from ref. [5]*	13.749	13.599

Figure 2 : Evolution of the lattice parameter 'a_H' in the solid solutions $Fe_{2-x}Cr_xO_3$.