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Measurement of phase transformation kinetics in Austempered Ductile Iron

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1. Introduction

For the analysis of the austempering kinetics a dilatometric study can be used [1-4]. It represent relative sample expansion of the material subjected to investigation as a function of time and temperature. The exponential equation is used to describe the isothermal transformation processes:

$$f = exp\ (-1/nt) \tag{1}$$

where: f – volume fraction of the transformation product, n is curve shaped constant under a given transformation condition.

2. Experimental

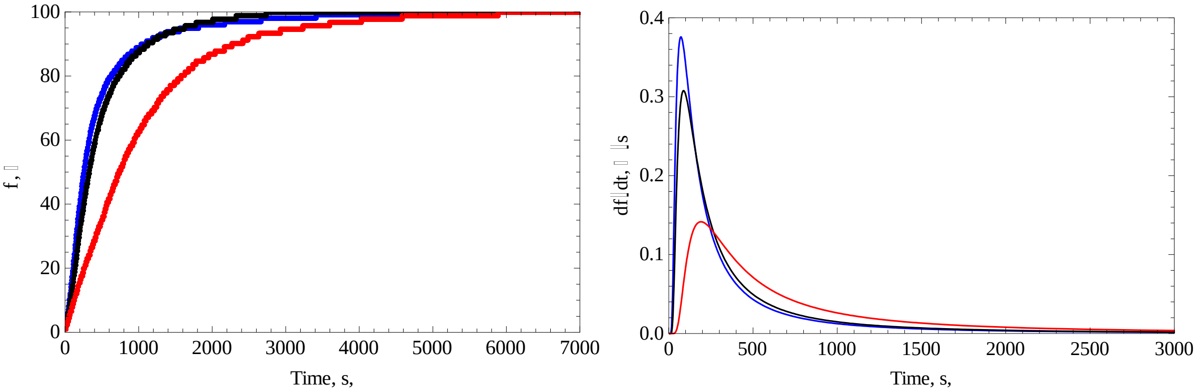
Alloy A (3.60C, 2.70Si), alloy B (3.65C, 2.65Si, 0.0.99Cu), alloy C (3.61C, 2.70Si, 1.1Cu, and 0.0.98Ni) were melted and cast in the form of Y-block test pieces. The complete ADI heat treatment were performed by the austenitsing as cast ductile iron samples for 30 minutes at 900 ^{o}C. followed by quenching to the austempering temperature 380 ^{o}C. The samples were isothermally austempered for 2 hour.

3. Results and discussion

Figure 1a shows dilatometry curves illustrating the degree of transformation (f) as a function of austempering time (t) of investigated alloys. Figure 1b shows the transformation rate during austempering expressed as the first derivative with respect to time of f(t). Quantitative parameters describing the transformation kinetics of austempering are summarized in Table 1. The corresponding microstructures (A, B and C alloys) formed in the austempering at t = 600 second are shown in Fig 2a, 2b and 2c, respectively.

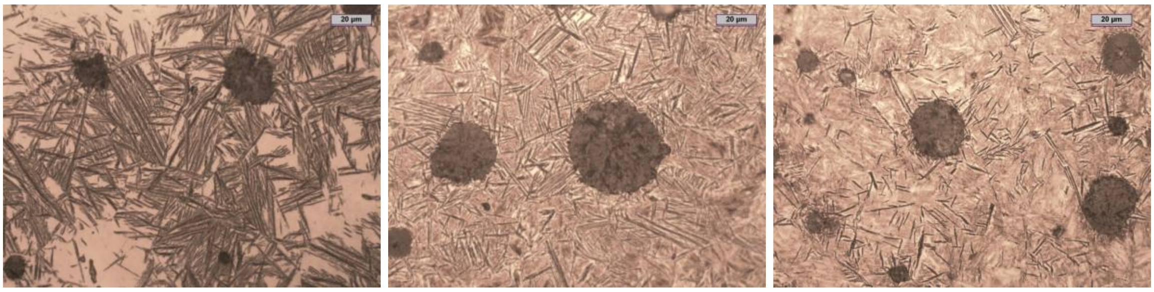
Table 1 Kinetics parameters of ausferritic transformation

No of Alloy	Incubation time, s	Austempering transformation time, s	Parameter n, $\times 10^3$ (eq. 1)	Max. transition rate, df/dt , %/s	Time of maximum. transition rate, s
A	41.5	5535	6.94	0.37	70
B	43.0	2780	5.68	0.31	88
C	110.0	6000	2.61	0.14	192



a) b)

Fig. 1. Austempering transformation kinetics: a) degree of transformation, b) rate of a transformation. Curve: blue-alloy A, black -alloy B, red – alloy C



a) b) c)

Fig. 2. Microstructures of investigated alloys A, B and C after austempering time t = 600 s

4. Conclusions

The dilatometric studies indicate that the addition of copper (alloy B) in contrast to the addition of copper and nickel (alloy C) does not significantly affect incubation time of austempering transformation. Austermpering process is characterized by different transformation rate in time (Fig. 1b). In the initial range the addition of copper, and even in a greater extent both copper and nickel reduces its rate and moves the maximum value of the right. Metallographic examination showed that the maximum transformation rate should be identified with the beginning of the ferrite plates growth (Fig. 2). In a second range of austempering (from about 50% of transformation) the additive of copper increases the transformation rate thus significantly reducing its duration time. In the case of the addition of both copper and nickel the longest time was achieved at which the greatest impact has the lowest transformation rate in its initial range.

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