# Zirconium saturation with nitrogen during high-temperature nitridation

*A. S. Chernyavskii[1], I. A. Kovalev[1], V. Yu. Zufman[1], A. I. Ogarkov[1], S. V. Shevtsov[1], S. V. Kannykin[2], A. V. Shokodko[1], A. A. Konovalov[1], D. V. Prosvirnin[1], E. A. Shokodko[3], V. M. Ievlev[2,4], K. A. Solntsev[1,4]*

[1]*Baikov Institute of Metallurgy and Materials Science, Russian Academy of Sciences, Moscow, Russia*

[2]*Voronezh State University, Voronezh, Russia*

[3]*Moscow State University of Civil Engineering (National Research University), Moscow, Russia*

[4]*Lomonosov Moscow State University, Moscow, Russia*

*imet@imet.ac.ru*

The purpose of this work is to understand general trends of the variation in the amount of nitrogen absorbed by zirconium during high-temperature nitridation. The kinetics of zirconium saturation with nitrogen were experimentally evaluated from the weight gain of the samples over a period of 60 min. Figure 1 shows plots of the sample weight gain against nitridation time at different temperatures. Our results demonstrate that zirconium saturation with nitrogen involves two stages: the first stage can be described by an exponential rate law and the second stage is well represented by a linear rate law. The transition from the exponential to linear behavior depends on synthesis temperature and occurs after heating for 40, 35, 30, and 18 min at 1500, 1800, 1965, and 2400°C, respectively. At the transition from the exponential to linear behavior, the fraction of absorbed nitrogen with respect to the stoichiometric composition of ZrN is 0.24, 0.36, 0.39, and 0.63 at temperatures of 1500, 1800, 1965, and 2400°C, respectively.

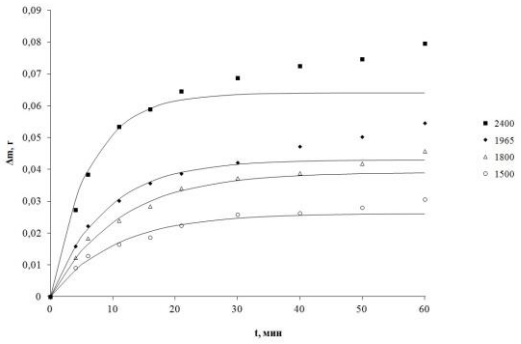


*Fig. 1. Weight gain against nitridation time at different temperatures. The solid lines represent calculation results and the points represent the experimental data.*

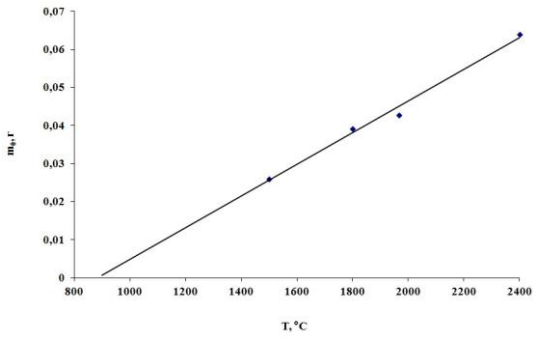


*Fig. 2. Maximum weight gain as a function of nitridation temperature for the exponential stage of the process.*

From the slope of Arrhenius plots, the effective activation energy was determined to be 22.8 kJ/mol in the exponential stage and 37.4 kJ/mol in the linear stage. Figure 2 shows the maximum weight gain (m0) as a function of nitridation temperature for the exponential stage of the process. The maximum amount of absorbed nitrogen (m0) was found to increase with increasing temperature. A least squares extrapolation to the abscissa yields the lowest temperature (~ 900°C) above which zirconium saturation with nitrogen can be described by an exponential rate law.

This work was supported by the Russian Science Foundation, project no. 14-13-00925 (federal state budget funded science institution Baikov Institute of Metallurgy and Materials Science, Russian Academy of Sciences).