Improved Analytical Equation for Calculating Nickel-based Alloys Density

Oleg Milder[1], Dmitry TARASOV[1], and Andrei Tiagunov[1]

[1]Ural Federal University named after the first President of Russia B N Yeltsin

April 16, 2024

Abstract

The density of metallic materials, along with strength and corrosion-resistance, is one of the main physical characteristics. This property is critical for nickel alloys, which are widely used in space and aeronautics, where it is extremely important to minimize the mass of each part. When developing new types of the alloys, it is essential to have a reliable and accurate method for estimating density. Unfortunately, no unified method for calculating the density has yet been proposed, except several regression models that give more or less accurate results. In this paper, we analyze and critically evaluate the available approaches, and provide a group of advanced analytical equations that accurately calculate the density of a nickel alloy based on its chemical composition. The method takes into account the spatial fcc structure of the alloys, the molar mass and molar volume of the alloying elements, as well as, the behavior of light ligands. We verify the accuracy of the equation based on real density and chemistry data for 69 nickel alloys. Using all equations, we calculate the density and compare the calculated data with real values. Comparison of the results shows that the proposed method provides the best accuracy of all those considered. The RMSE between the calculated values and the real ones is about 0.07. The error of the regression methods is 0.5 at best. Thus, the proposed approach increases the accuracy of calculating the density of nickel alloys by about an order of magnitude, while significantly simplifying it.

Hosted file

`Tarasov_Dens.docx` available at https://authorea.com/users/360083/articles/712974-improved-analytical-equation-for-calculating-nickel-based-alloys-density