IN-SITU NEUTRON DIFFRACTION STUDY ON THE CHANGE IN d_0 SPACING DURING SOLUTION HEAT TREATMENT OF 319 ALUMINUM ALLOY ENGINE BLOCKS

Anthony Lombardi[1], Dimitry Sediako[2], Comondore Ravindran[1], Robert MacKay[3]

[1]Mechanical & Industrial Engineering, Ryerson University, Toronto, ON, Canada M5B 2K3
[2] Canadian Neutron Beam Centre, Chalk River Laboratories, Chalk River, ON, Canada K0J 1J0
[3] Nemak of Canada Corporation, Windsor, Ontario, Canada, N9A 6X8

Aluminum alloy engine blocks have successfully replaced ferrous materials in order to maximize weight savings and improve vehicle fuel efficiency. However, the development of an optimal heat treatment process is required to improve engine block casting integrity and prevent potential problems such as in-service cylinder distortion. Optimization of heat treatment parameters requires an in-depth study to determine how residual stresses are relieved with time during solution heat treatment. In order to perform this analysis, however, in-situ neutron diffraction must first be carried out on stress-free samples of the same composition and processing history as the engine blocks to account for factors such as thermal expansion and changes in lattice parameter due to dissolution of secondary phases. In this study, stress free "match stick" samples were extracted from the top and bottom of the aluminum cylinder bridge of engine blocks in the as-cast condition. The match stick samples were then heated to 470, 500 and 530 °C in the CNBC quench furnace, allowing in-situ neutron diffraction to be carried out. This in-situ neutron diffraction experiment monitored the change in d_0 spacing with time at each solution heat treatment temperature. The results, shown in Figure 1(a), suggest that at the top of the cylinder prolonged exposure at the 470 and 500 °C resulted in a relatively small contraction in d_0 due to a small amount of Al_2Cu dissolution. At 530 °C, there was a larger amount of Al_2Cu dissolution, which allowed more Cu to be in solid solution, resulting in a larger contraction of d_0 with time. In contrast, at the bottom of the cylinder, the change in d0 was not significant with time for all solutionizing temperatures, which was likely due to the small Al_2Cu content in this section, which limited phase dissolution.

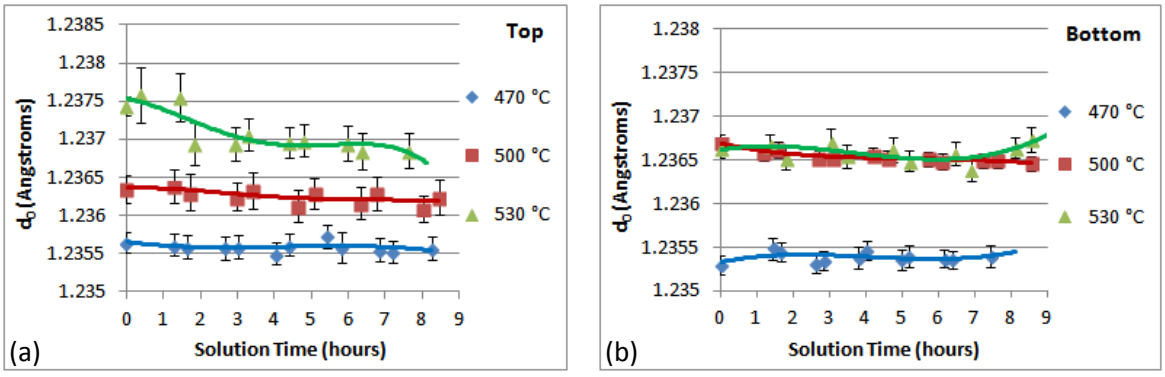

Figure 1: Variation in d_0 with time at each solutionizing temperature for (a) top, (b) bottom.