# Distortion in Aluminum A319 Engine Blocks

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The replacement of nodular cast iron with 319 type aluminum (Al) alloys in gasoline engine blocks is an example of the shift towards the use of lighter alloys in the automotive industry. However, excessive residual stress along the cylinder bore may lead to bore distortion, significantly reducing engine operating efficiency. In the present study, residual stresses were evaluated from top to bottom along the cylinder bridge of engine blocks following thermal sand reclamation (TSR), T7 heat treatment and service testing of the casting. Neutron diffraction was effectively used to quantify the residual stress along the Al cylinder bridge in the hoop, radial, and axial orientations with respect to the cylinder axis. The results, shown in Figure 1, suggest that highly tensile residual stresses were present along the cylinder bridge in the as-cast engine block. This stress was also found to approach the yield strength for the 319 Al alloy. Following T7 heat treatment, the residual stresses were significantly relieved at the top of the cylinder. The residual stresses did not relieve as effectively at the bottom of the cylinder as for the top.

The observed variation in residual stress from top to bottom along the cylinder was likely the result of the mould geometry and cooling rate discrepancies during casting. Extensive metallography indicated a significant refinement in microstructure at the bottom of the cylinder relative to the top, which occurred due to increased cooling rate at the bottom of the cylinder. In turn, this suggested an increase in alloy yield strength at the bottom of the cylinder relative to the top. This increased yield strength at the bottom of the cylinder likely reduced the susceptibility of the cylinder to rapid relief of residual stress at elevated temperature. In contrast, the coarse microstructure at the top of the cylinder likely resulted in a lower yield strength which allowed the residual stresses to exceed this yield strength at elevated temperature. For this reason, stress relief was likely triggered more effectively at the top of the cylinder during elevated temperature exposure. In addition, relief of residual stress is accompanied by plastic deformation, indicating that the top of the cylinder is most prone to permanent dimensional distortion.

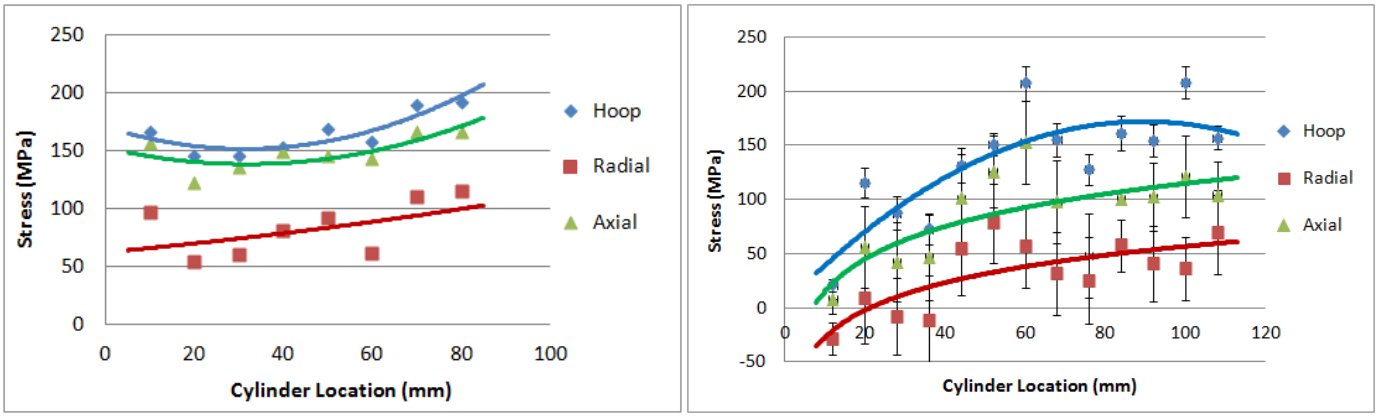


**Fig. 1** Residual stress profiles along the aluminum cylinder bridge of engine blocks in: (a) as-cast condition, (b) T7 heat treated condition.