Modified Inherent Strain Method for Simulating Part-Scale Residual Stress in Parts Processed by Laser Powder Bed Fusion

Xuan Liang*, Qian Chen*, Devlin Hayduke†, and Albert C. To*

* Department of Mechanical Engineering and Materials Science
University of Pittsburgh
Pittsburgh, Pennsylvania, U.S.A
e-mail: albertto@pitt.edu, web page: http://www.pitt.edu/~albertto

† Materials Sciences Corporation
Horsham, Pennsylvania, U.S.A.

ABSTRACT

Residual deformation is one of the most critical issues in metal additive manufacturing (AM) techniques that melt the feedstock material during processing. It is a challenge to predict the residual deformation in the part-scale by performing detailed process simulation for the entire part, which is prohibitively expensive and hence impractical. In this work, the modified inherent strain theory is proposed to enable efficient yet accurate prediction of residual deformation of large components produced by the laser powder bed fusion (l-pdf) process. The proposed theory allows for the calculation of inherent strain accurately based on a small-scale process simulation of a small representative volume out of a large component. The extracted mean inherent strain vector will be applied to a part-scale model layer-by-layer in order to simulate accumulation of the residual deformation by static finite element analysis. To verify the accuracy of the proposed method, the residual stresses at various locations of a printed double cantilever beam and L-bracket are investigated, and the predicted residual stress matches well with the experimental results while the computational efficiency is also shown. Moreover, the influence of the number of lumped physical layers on the accuracy of the proposed method is also studied in order to determine the proper number of equivalent layers in the layer-by-layer simulation.