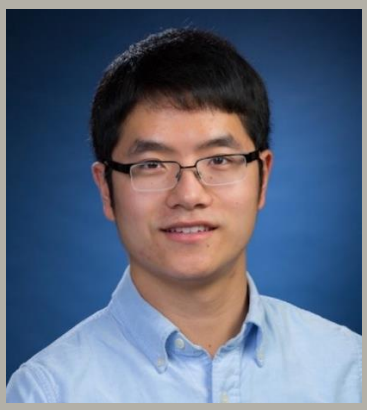
WPI MATERIALS SCIENCE & ENGINEERING

Haixuan Yu
PhD Dissertation



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An Integrated Systems Approach to Understanding Distortion and Residual Stress During Heat Treatment: Design for Heat Treating

Abstract

Heat treatment processes are used to develop the desired mechanical properties for steels. Unfortunately, heat treatment, especially quenching, can cause distortion. Failure to meet geometry specifications can result in extensive rework or rejection of the parts. A series of quenching simulations, using DANTE, have been conducted on an AISI 4140 steel Navy C-ring distortion coupon and a WPI designed plate with a hole to determine the effects of selected quenching process parameters on quenching induced distortion. Based on the simulation and experimental results, it was found that the two most import parameters are the part geometry and size (product design) and the temperature dependent heat transfer coefficients between the part and the quenchant (process design). The coupling of these product and process parameters is necessary to apply the systems analysis that must be accomplished to understand the interaction between the part design and process design parameters. This coupling can be accomplished by locally applying the well-known Biot number. The concept of a local Biot number is also introduced to quantify the local variations of part size, geometry and heat transfer coefficient. This local Biot number concept can be used in a systems approach to design a part and the quenching system. This systems approach can be designated as design for heat treating.