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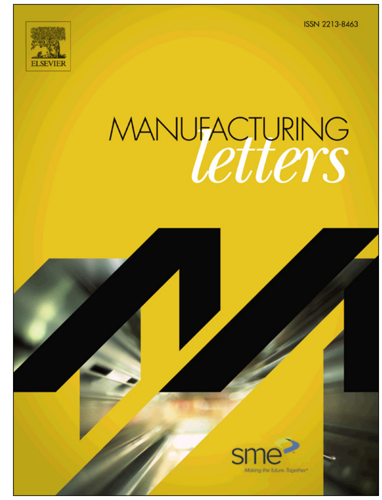


Letters

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# Modal Analysis of Metal Additive Manufactured Parts

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*Abstract:* The validation of metal Additively Manufactured (AM) parts is difficult and expensive because the overall morphology and microstructure are interdependent and are subject to process parameters. This paper investigates the use of modal analysis to quantify the mechanical properties of tensile test specimens built using selective laser melting. The relationships between process parameters, material properties, and the modal response is studied experimentally. This shows that the yield strength correlates directly to the part natural frequency to a better extent than density does. This provides the basis to develop a modal analysis screening method for determining metal AM part quality.

Keywords: Metal Additive Manufacturing, Powder Bed Fusion, Modal Analysis, Validation, Non-Destructive Evaluation



## 1. Introduction

Metal Additive Manufacturing (AM) is seeing increased use in the aerospace and biomedical industries due to the ability to produce parts with comparable properties that are not able to be manufactured with traditional methods [1-2]. The certification for these parts poses a significant challenge to the continued expansion of metal AM. Due to the nature of metal-based powder fusion technology, variations in part geometry and process parameters modify the thermal history, which influences the crystallization of the liquid metal, including the resulting phases, grain size, and porosity [3]. These changes in microstructure can cause significant changes in the part mechanical properties [4]. The unique relationship between material properties, geometry, and process parameters, coupled with the fact that AM parts are typically fabricated in small lot sizes, introduces unique challenges for traditional lot-acceptance methods.

Sub-surface defects, such as unmelted powder, hollow voids, and delamination, can be detected using Computerized Tomography (CT) scanning [5]. However, this process is slow and costly. Acoustic testing, which relies on striking a part and listening for audible changes in the frequency response, has been applied to traditionally manufactured parts and offers a low-cost, though less precise, alternative. Modal analysis, which involves identifying resonant mode shapes and frequencies and is often applied for structural health monitoring [6-8], strikes the necessary balance between cost and precision.

This paper examines the sensitivity of modal analysis with respect to changes in engineering properties

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