Thermo-mechanical analysis of a metal 3D printing using coupled numerical and experimental framework

Harsh Vardhan Singh Chauhan
Research Guide: Dr.Koushik Viswanathan
Dept. of Mechanical Engineering, IISc, Bangalore

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1 Introduction

Metal 3D printing, also referred to as additive manufacturing (AM), has emerged as a revolutionary technology, enabling the creation of complex geometries with unparalleled design freedom. It is widely utilized in industries such as aerospace, automotive, and biomedical engineering due to its capability to fabricate high-strength and lightweight components with intricate internal features. Among various metal 3D printing methods, techniques like Selective Laser Melting (SLM) or Direct energy deposition(DED). This project is about solving problems arises in metal 3D printed part. A specific problem observed in metal 3D printing is the accumulation of layer waviness, which manifests as geometric inaccuracies. For instance, in the case of a cylindrical component with a straight internal channel, the waviness from each layer can distort the intended straight path, resulting in a non-uniform and distorted geometry. Such defects are detrimental in applications where high precision and surface integrity are essential. This study seeks to address these issues by employing a coupled numerical and experimental framework for thermo-mechanical analysis. By integrating simulations with experimental validation, this research aims to provide a deeper understanding of the interplay between thermal and mechanical behaviors during the metal 3D printing process. The ultimate goal is to mitigate layer waviness, enhance geometric accuracy, and ensure the structural integrity of printed components.

2 Methodology

Thermal analysis of experimented 3D printed part using IR image camera and compare it with simulation thermal data obtained from Comsol multiphysics and Ansys(DED module),After getting both actual and simulation data use convolution neural network that is profoundly known for managing data in the form of picture or grid,which extract features that cause potential defect in actual printed part.

3 Future work

In future work, I plan to utilize the ANSYS DED module to simulate the actual additive manufacturing process. In addition, I will explore the application of Convolutional Neural Networks (CNN) within this project. With the data gathered from both experiments and simulations, I aim to train a CNN model to extract meaningful features such as temperature gradients, cooling rates, and material properties. These features can then be used for predictive modeling to improve process optimization, defect detection, and performance prediction. By leveraging CNNs, I also intend to analyze complex patterns in the temperature field and geometry interactions, which might be difficult to capture through traditional methods. This approach could lead to better understanding and control of the additive manufacturing process