Investigating oscillation techniques during collaborative robot-assisted wire arc additive manufacturing

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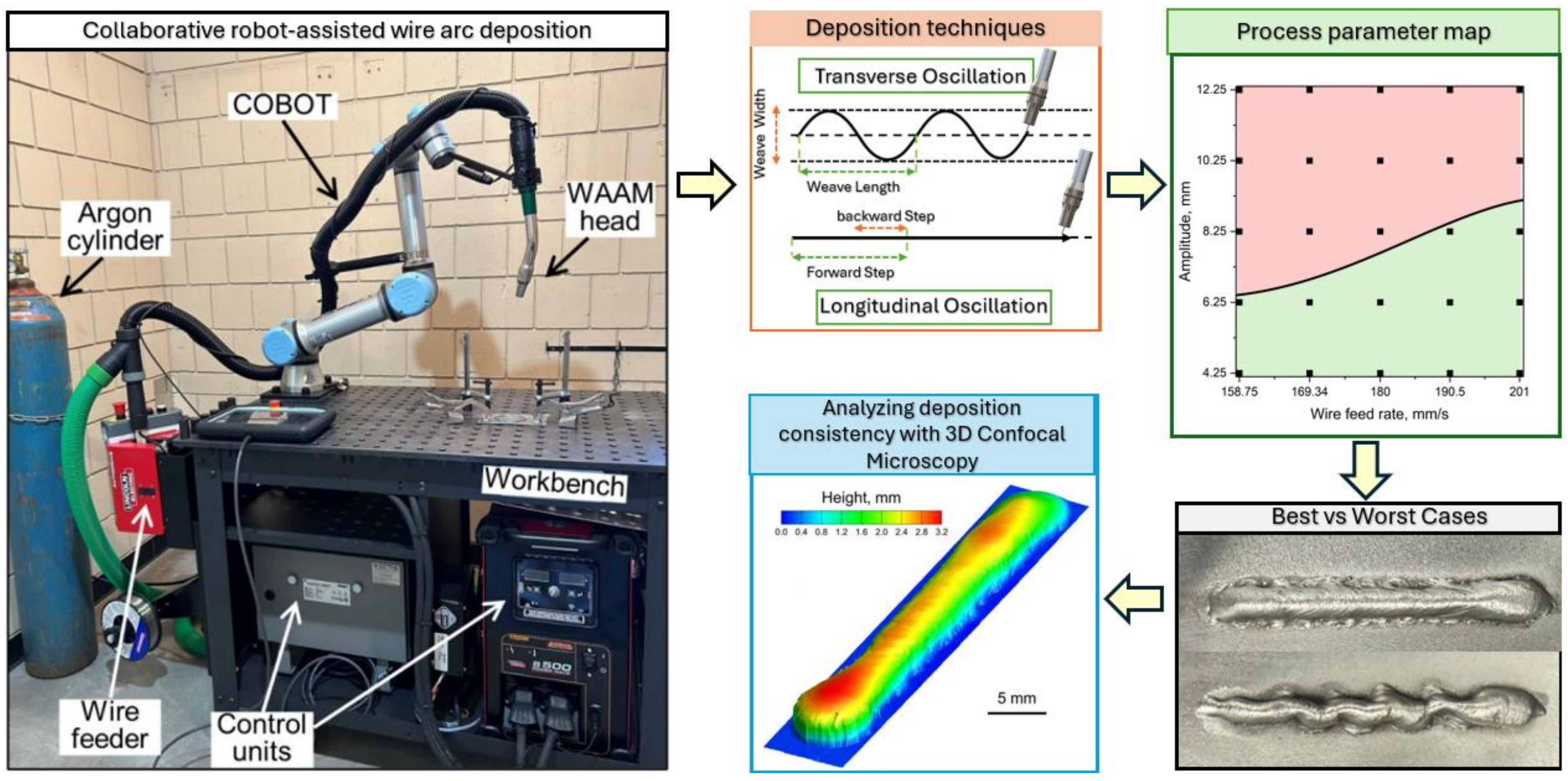

Figure 1: A schematic representation of the methodology used in this work.

Problem Statement and Objective

- This work utilizes oscillation techniques to enhance the deposition quality through collaborative robotics in the wire arc additive manufacturing (WAAM) process.
- The purpose of this study is to assess how various process parameters influence track integrity when oscillation techniques are employed to increase the productivity and viability of WAAM.

Methods

- Two cases were developed to study oscillations impact on deposition quality and defect formation: (a) benchmark deposition, (b) increased travel speed.
- A qualitative process map was generated for the analysis of amplitude in comparison with:
  - Frequency of transverse oscillation.
  - Process parameters during longitudinal oscillation.
- Two cases were identified to highlight oscillations in mitigating defect formation:

(c) transverse oscillation, and (d) longitudinal oscillation.

- Cases (a)-(d) were analyzed through confocal microscopy and validated computationally

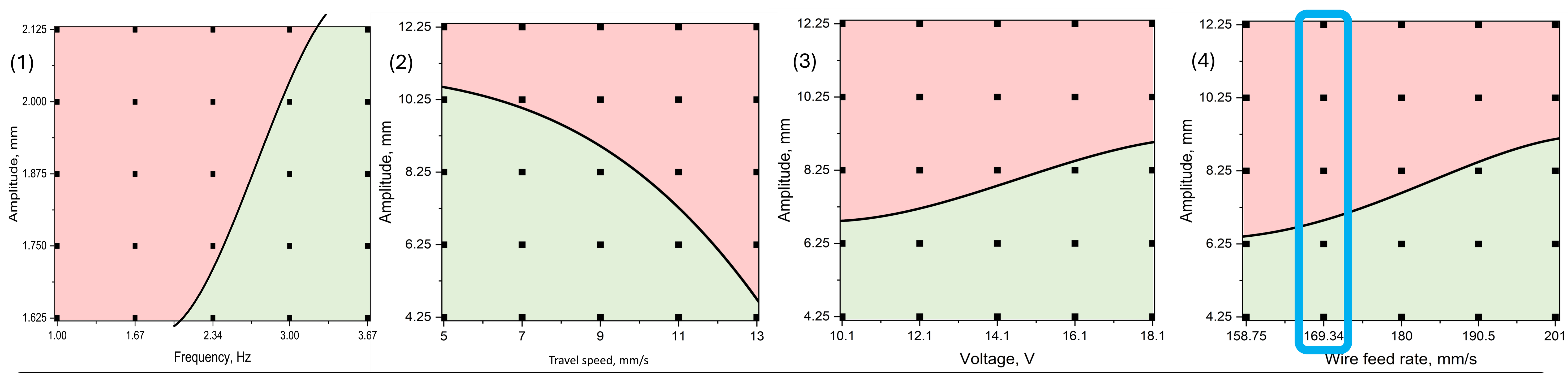

Figure 2: Graphs representing 25 tracks for comparison of humping formation. Graphs 1 represents transverse oscillation, while graphs 2-4 longitudinal.

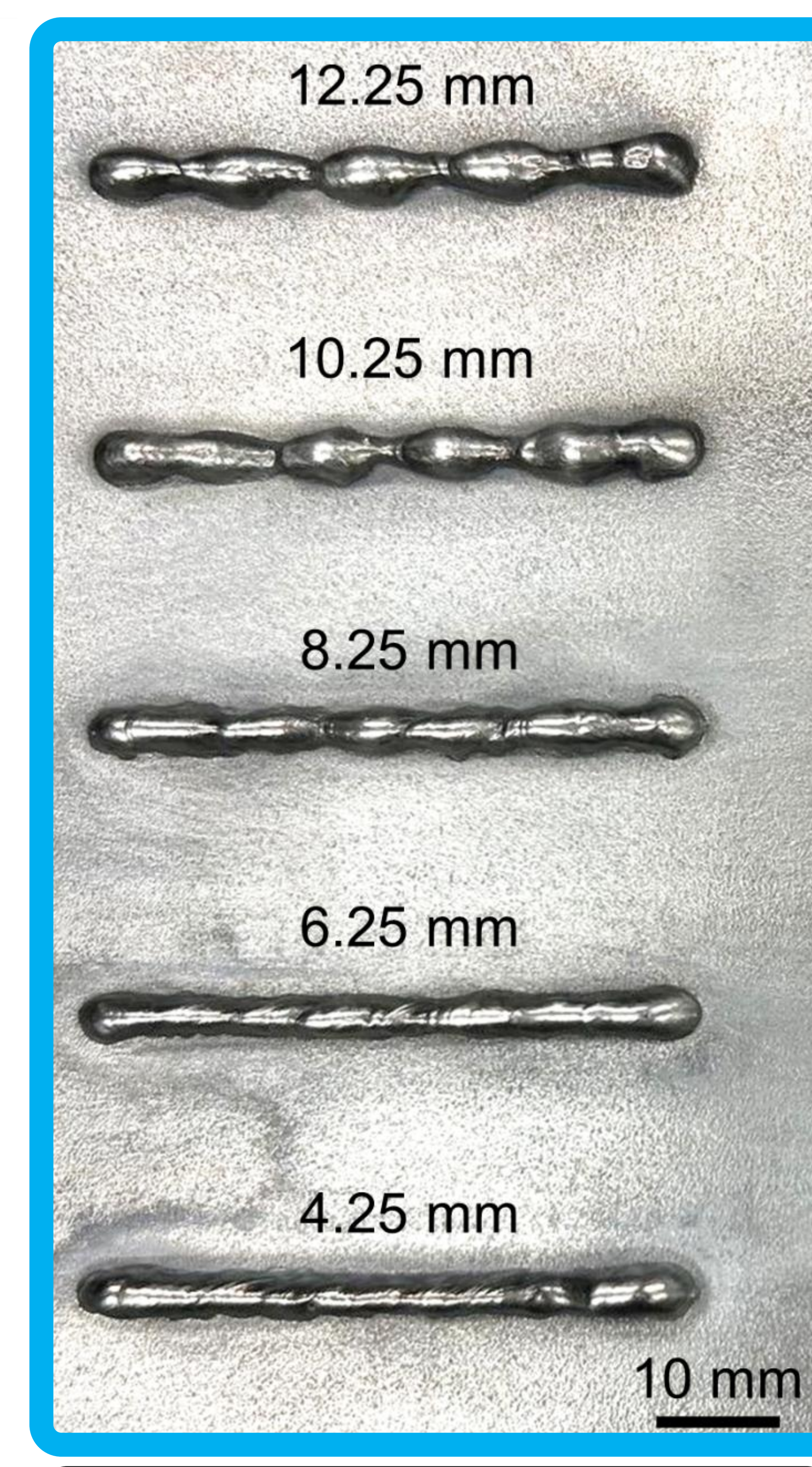

Figure 3: A demonstration of amplitudes affect on track integrity quantification for a wire feed rate of 169.34 mm/s.

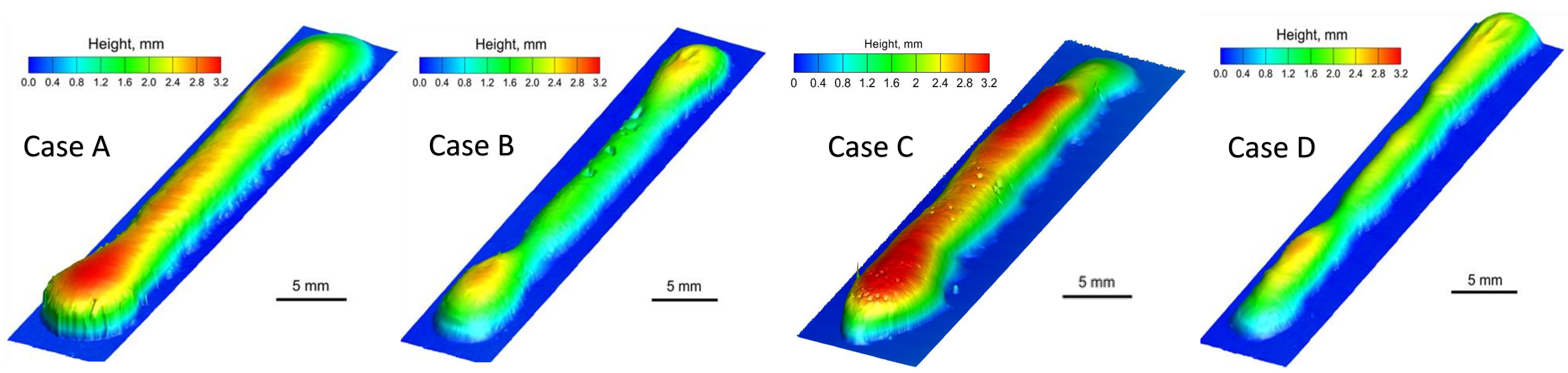

Figure 4: Height maps of different depositions for comparison between non-oscillatory and oscillatory movement, generated using confocal microscopy.

Frequency Calculations

Here, $Length$ is the linear distance traveled by the weld head during one cycle. For Longitudinal Oscillation, this is the sum of the Forward and Back step distances. For Transverse Oscillation, $Length$ is equivalent to the wavelength.

$$Frequency = \frac{Travel\ Speed}{Length}$$

Track Integrity

Here, N denotes the total number of height measurements taken along the length, Z is the deposited track's height at the track's mid-width, and Zm is the mean height. Therefore, the height deviation indices indicate the deviation of track height from the mean height along the track.

$$h_A = \frac{\sum_N |Z - Z_m|}{N} \qquad h_{RMS} = \sqrt{\frac{\sum_N (Z - Z_m)^2}{N}}$$

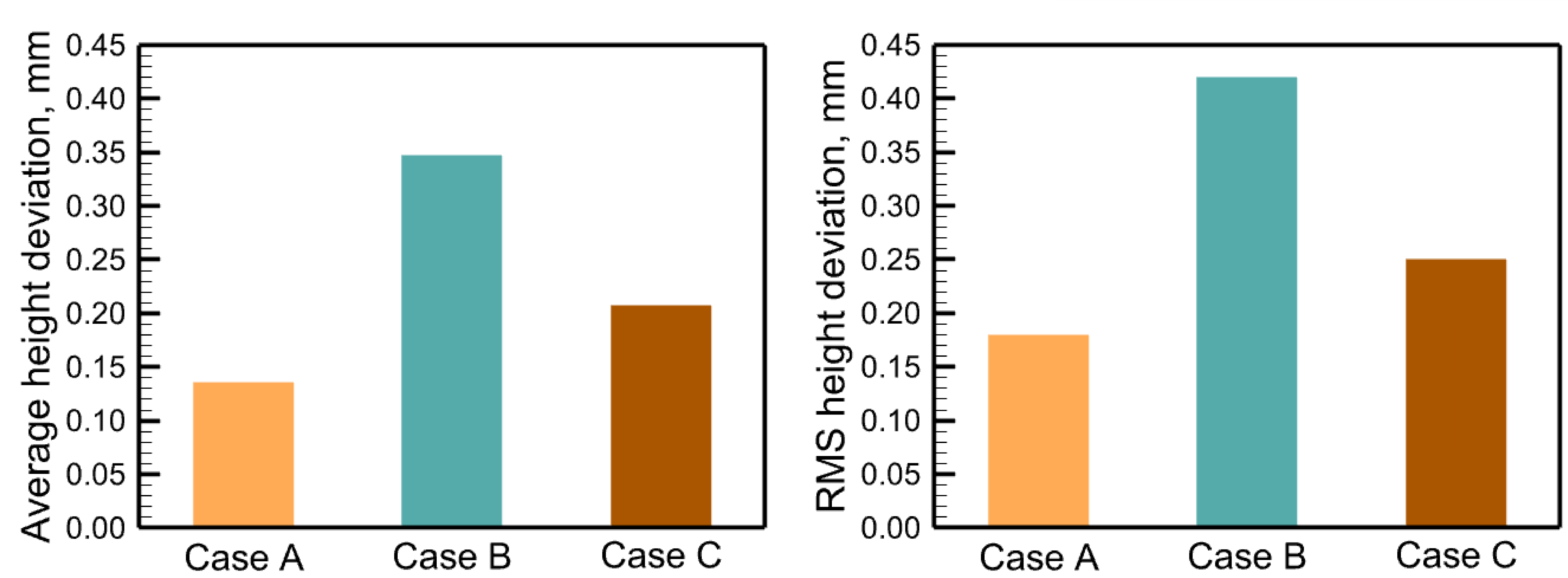

Figure 5: Graphs showcasing average height deviation and RMS, which support increased deposition integrity

Discussion

- Specific waveform parameters- such as oscillation direction- influence bead formation at varying travel speeds.
- Increased track width can be strategically leveraged to reduce overall build time in multi-track deposition processes.

Results

- Observations of **longitudinal oscillation** and its effect on track integrity showed improved deposition quality when compared to tracks with no oscillatory movement at similar travel speeds.
- Observations of **transverse oscillation** and its effect on track integrity showed enhanced productivity while maintaining weld quality found in non-oscillatory welds at same travel speeds.

Conclusions

- Longitudinal oscillation was found to enhance track integrity, especially at high travel speeds.
- Transverse oscillation increased the width of the track, suggesting improved deposition productivity.

Acknowledgments

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