Effects of gravity on track integrity during collaborative robot-assisted wire arc deposition

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Problem Statement and Objective

- Wire Arc Additive Manufacturing (WAAM) enables rapid deposition of large metallic components, but controlling track geometry and thermal history remains a key challenge.
- The objective of this research is to consider the impact of gravity on deposition consistency on non-horizontal and curved surfaces.

Methods

- The setup considers various substrate angles (30º, 60º, and 90º) and employs different deposition techniques, such as pulse and short circuit.
- The upward and downward direction of the weld torch is investigated by considering the impact of gravity on the molten pool behavior on curved geometry.
- The molten pool behavior is tracked by using a high-speed camera and waveform tracking as a real-time monitoring technique.
- The 3D confocal microscopy was used to measure the surface topography deposited with COBOT-assisted WAAM.

Results

1. Upward direction (against gravity):

Despite the increase impact of gravity at a 90-degree angle, the consistency of the deposition in pulse is much better than short circuit, and the bulge is the only defect that formed during the process.

2. Downward direction (along gravity):

For pulse, the deposition is continuous except for the bottom part; however, short circuit results in an uneven deposition and bulge formation at a 90-degree angle.

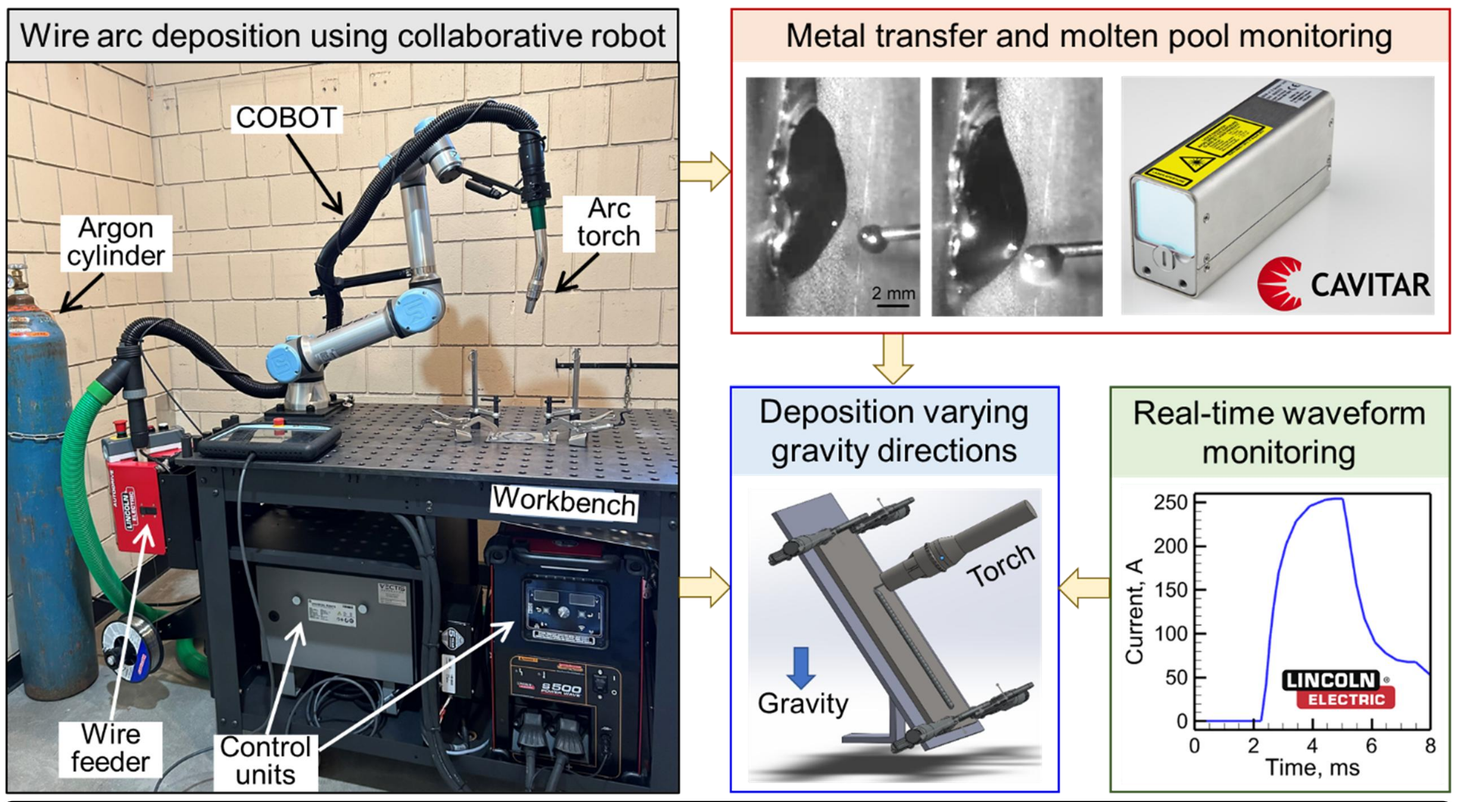

Figure 1: Schematic of COBOT wire arc deposition and process monitoring

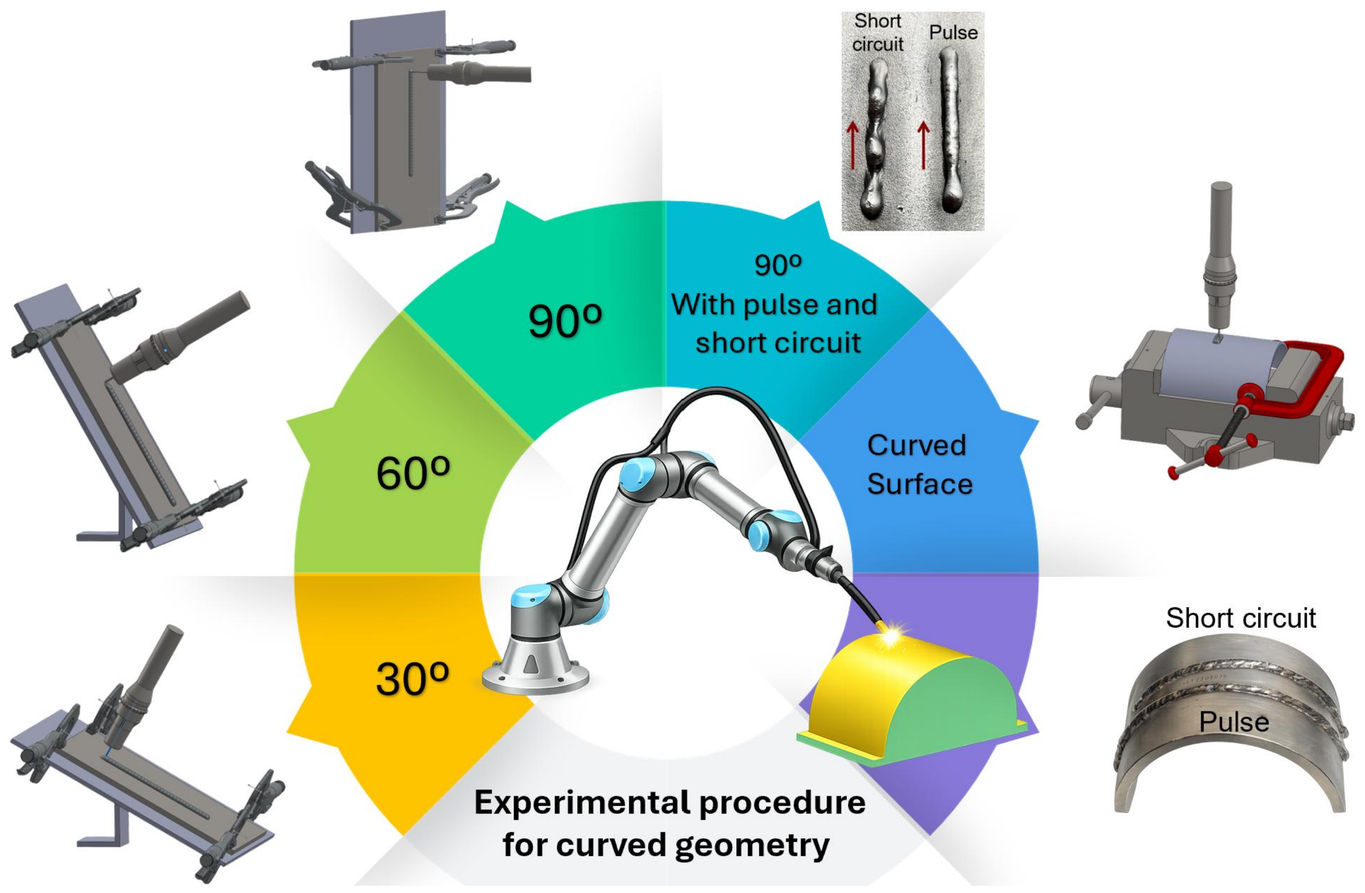

Figure 2: Geometric variation (30°, 60°, 90°) represents curved geometry and the effect of clamping condition and metal transfer modes on track integrity with the use of COBOT

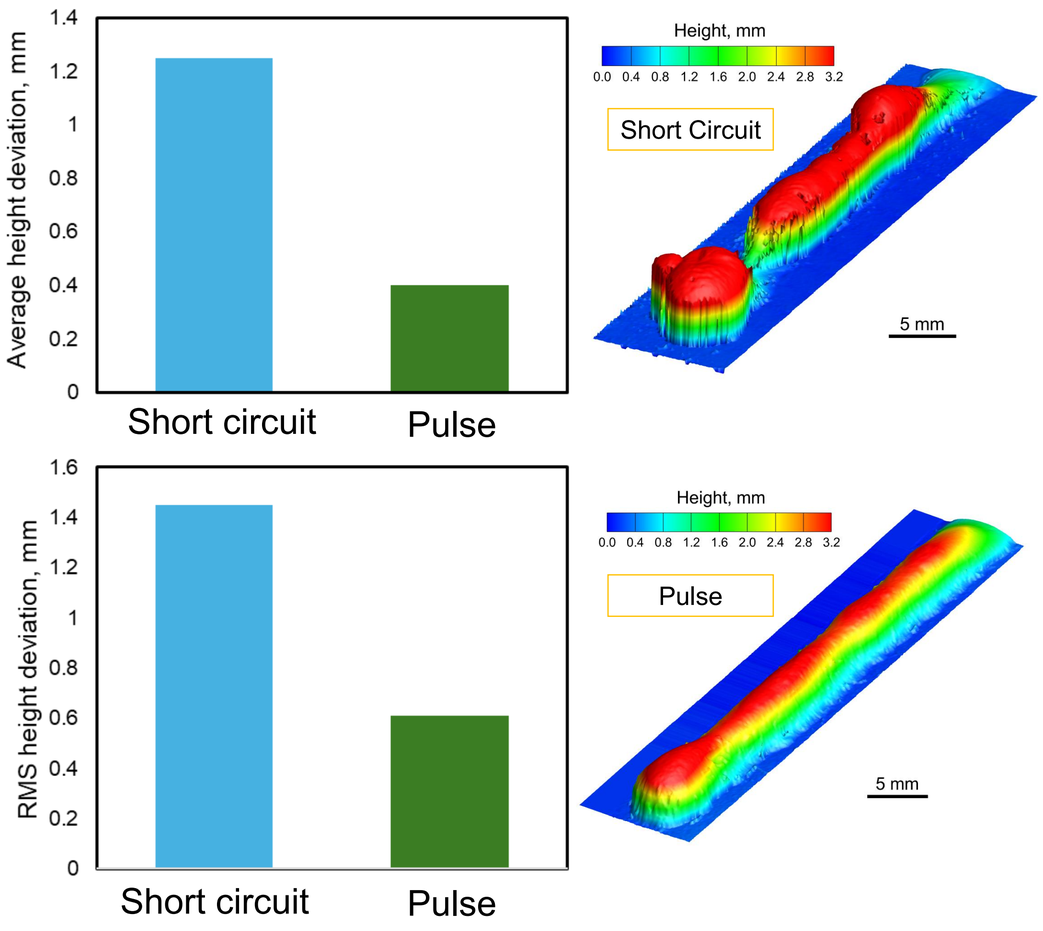

Figure 3: Average height deviation, RMS height deviation, and 3D confocal microscopy at 90° for short circuit and pulse

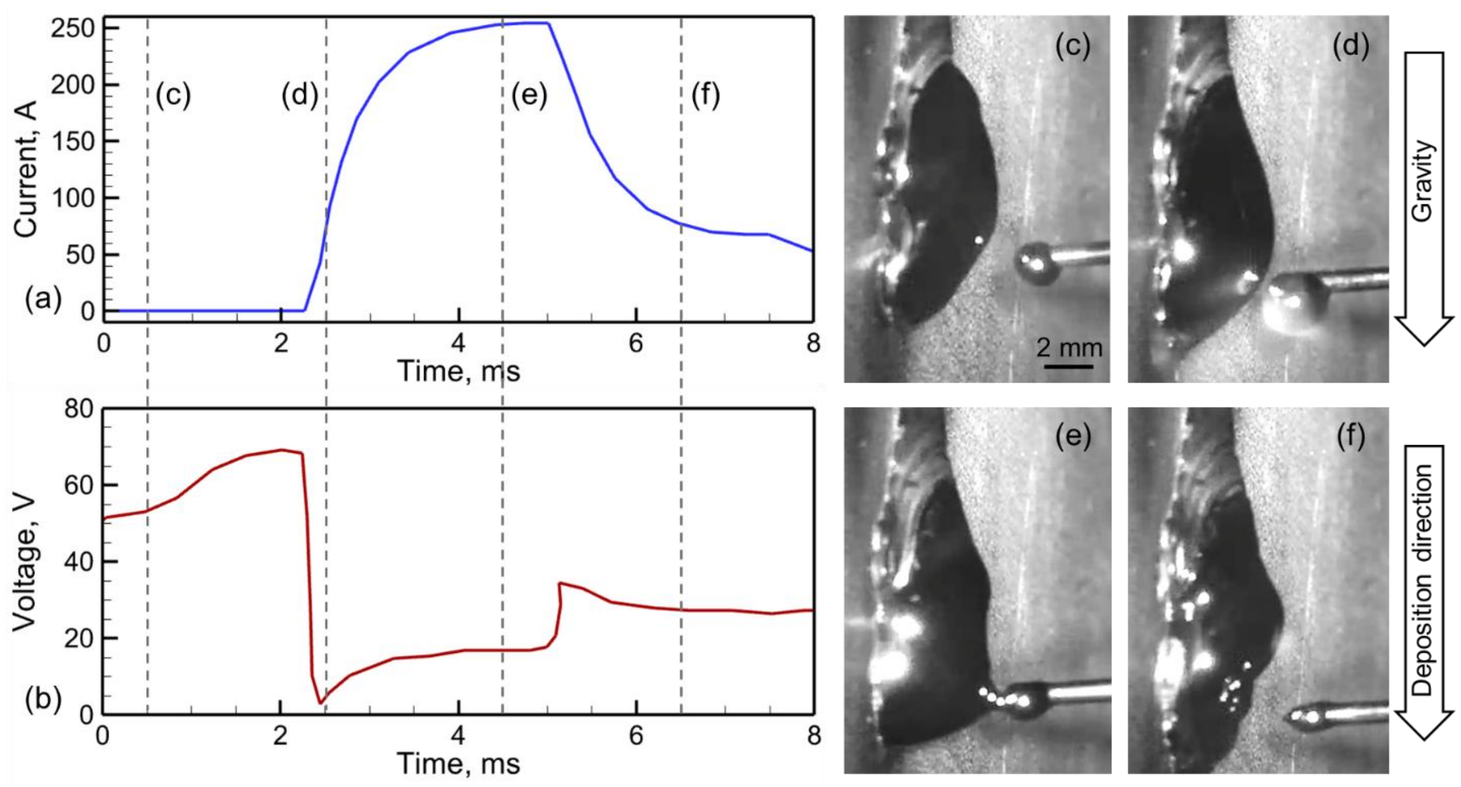

Figure 4: Waveform graph for short circuit during wire arc deposition at a 90-degree angle with real-time imaging of droplet formation against gravity

Discussion

- The waveform is monitored using the system's in-built waveform analyzer, providing real-time voltage and current signal data with a precise time resolution.
- Pulse mode provides better control over deposition behavior, leading to improved overall track integrity, while the short-circuit mode can lead to irregular bead shapes due to the fluctuation in metal transfer.

Conclusions

- Tracks made at a 90º angle exhibit more discontinuity than those made at a 30º angle because of the molten pool instability at higher deposition angles.
- Deposition on curved surfaces is a unique combination of both upward and downward scanning at various deposition angles.

Acknowledgments

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