International Conference on Advanced Research in Engineering, CARE 2022
Doctoral School "Acad. Radu Voinea" - Faculty of Mechanics, University of Craiova, Romania
October 28, 2022

The "dark side of the moon" when researching: the case of pyrometrical measurements in WAAM

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Abstract

Some people see "the dark side of the moon" as something mysterious. However, others perceive "the dark side of the moon" as a side that we do not see by standard means (but it exists). Both ways of interpreting the dark side of the moon are found amongst researchers. We sometimes cannot see "the dark side of the moon" in a scientific investigation (for example, a thesis). This occurs not because it is mysterious and untouchable. But only because we are not able to see immediately from the other side what is happening. Therefore, if you find a way to go round to see the other side, good surprises can come out.

In this talk, I will use a case to show how the discovery of the dark side can be feasible and exciting in research. My students and I wanted to explore further the use of pyrometers to keep the wall geometry and microstructure as constant as possible while building up a thin wall by Wire Arc Additive Manufacture (WAAM). The importance of applying control to accomplish these objectives is widely recognized. A control based on the interlayer temperature (IT) is likely the more straightforward and feasible way. Thus, from the “visible side of the moon”, we were already able to predict as a setback an uneven thermal profile in the wall and a temperature gradient along the layer length after a thin wall layer deposition. These thermal profile-related characteristics themselves questioned the effectiveness of IT and its measuring approaches.

Because on the side of knowledge that we could see, we planned experiments to compare two measurement strategies to use infrared pyrometers. The initial target was to elucidate their advantages and limitations for both open and closed-loop control. The proposed Upper and Sideward Pyrometer strategies were assessed at different distances from the heat source. A calibration procedure was proposed. The results confirmed the existence of a natural temperature gradient along the wall.

However, from the side of knowledge that we could not see (the dark side of the moon), we were surprised to see how differently the arc heat affects the measured points (in intensity and steadiness) according to the strategy. Another unexpected result was a temperature maximum point close to one edge of the wall. Explanations for those findings, based on simulation and experiments, were found. After that, we were able to define for our purpose that interlayer temperature measured at a specific point in WAAM should be taken as a reference and not an absolute value; the absolute value changes accordingly to the measuring approach, sensor positioning and calibration. Using as a temperature reference, both strategies can be used in open-loop control to reach repeatability (geometrical and metallurgical) between layers. But the Sideward Pyrometer strategy is more recommended for feedback control of production, despite being less flexible.