Dataset of dimensionless operating conditions for welding and metal additive manufacturing

Published: 8 August 2022 | Version 2 |
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Description

The present dataset contains the dimensionless operating conditions obtained by processing a wide range of welding and metal Additive Manufacturing (AM) process parameters through a unified theoretical framework based on the Rosenthal solution [1]. The exploratory data analysis covered Arc and Beam Welding (AW and BW, respectively) on various materials, joint types, and bead sizes ranging from 0.5 to over 10 mm. As for AM, we considered Laser Metal Deposition (LMD) and Selective Laser Melting (SLM) on steel, Al, Ni, Ti, Cu, and Co-Cr alloys by limiting the research to the last five years of published literature.

Nomenclature:

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Cite this dataset

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U Velocity magnitude
P Power
p Welding power (AW and BW)
d Distance between adjacent scan lines (SLM)
s Nominal layer thickness (SLM)
T_0 Initial or preheating temperature
$\bar{R}$ Melt pool half-width
Ar Melt pool aspect ratio
$\tilde{U}$ Dimensionless velocity
$\tilde{P}$ Dimensionless power

Welding joint types are identified by the initials B, L, and T, standing for Butt, Lap, and T- joints, respectively.

[1] M. Moda, A. Chiocca, G. Macoretta, B.D. Monelli, L. Bertini, Technological implications of the Rosenthal solution for a moving point heat source in steady state on a semi-infinite solid, Mater. Des. (2022). https://doi.org/10.1016/j.matdes.2022.110991

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Files

AW.xlsx

BW.xlsx

LMD.xlsx

SLM.xlsx

Steps to reproduce

Material properties were retrieved from the literature considering the data points at the highest available temperature below the solidus.

Despite being also process-dependent, the energy absorptivity and efficiency were approximated with the average values available in the relevant literature: 0.7 for steel, Ni, Ti, and Co-Cr alloys, 0.5 and 0.4 for Al and Cu alloys, respectively.

The aspect ratio (Ar) and dimensionless operating conditions ($\tilde{U}$ and $\tilde{P}$) are defined in [1].

The half-width or penetration constraint $\bar{R}$ is defined based on the process type:
- for SLM and LMD processes [1]: $\bar{R}$ = sqrt(s^2+d^2/4)
- for AW and BW, we referred to the ISO standard 9692:2013 considering the recommended groove sizes. In addition, depending on the joint type and weld groove opening angle, the nominal P was derived by multiplying the welding power p by π/φ, where φ is the actual heat flow angle [2].

[1] M. Moda, A. Chiocca, G. Macoretta, B.D. Monelli, L. Bertini, Technological implications of the Rosenthal solution for a moving point heat source in steady state on a semi-infinite solid, Mater. Des. (2022). https://doi.org/10.1016/j.matdes.2022.110991

[2] Y. Wang, Y. Lu, P.F. Mendez, Scaling expressions of characteristic values for a moving point heat source in steady state on a semi-infinite solid, Int. J. Heat Mass Transf. 135 (2019) 1118–1129. https://doi.org/10.1016/j.ijheatmasstransfer.2019.02.042.

Institutions

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Categories

Welding, Stainless Steel, Steel, Aluminum Alloys, Titanium Alloys, Copper Alloys, Nickel Alloys, Cobalt Alloys, Nickel-Based Superalloys, Process Optimization, Direct Laser Metal Deposition, Laser Beam Welding, Analytic Solution, Exploratory Data Analysis, Chromium Alloys, Direct Metal Laser Sintering, Arc Welding, Electric Resistance Welding, Automatic Welding, Selective Laser Melting, Directed Energy Deposition, Inconel, Design for Additive Manufacture, Powder Bed Fusion, Laser Powder Bed Fusion, Electron Beam Powder Bed Fusion

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