Molten Metal Deposition (MMD): A Novel Additive Manufacturing (AM) Technology that brings Aluminum AM towards Industry

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Abstract

3D printing or Additive Manufacturing (AM) is a quite novel production technology from 1980's and metal AM is around since 1990's. The technology offers multiple advantages such as more design freedom for complex geometries, topology optimization for light-weighting, parts integration, and more. Barriers are found in cost, production speed and low automation along the manufacturing chain.

However, AM has a very difficult relation with aluminum. Although aluminum is world-wide the second most used metal, in the world of AM, aluminum is a minority. Main reason is found in the processing of aluminum. The most common AM technologies rely on laser light as a source of energy to melt the material. Aluminum is ~90% reflective meaning that only 10% of the applied energy is useful for the process. Laser light heats up the aluminum towards 2000°C causing evaporation of lighter alloying element and rapid cooldown of 103 – 106K/s causes hot cracking.

ValCUN developed a technology focused on aluminum AM with resistive heating as energy source. The energy transfer of the heater to the aluminum is highly efficient. The aluminum is heated above liquidus temperature and deposited through a nozzle. The maximum operating temperature remains below 1000°C avoiding evaporation of alloying elements. Cooldown rates vary between 10 – 50K/s, similar to casting, avoiding hot cracking.

The technology can be used in different configurations. The traditional approach is to use the printhead on a 3-axis gantry system to manufacture parts. Second, the printhead can be installed on a robotic arm to expand the degrees of freedom and increase the part complexity. Lastly, hybrid manufacturing opens a new world of possibilities. Printing on top of a semi-finished product like a sheet, extrusion, cast or other enables parts with an unprecedented complexity at a pricing leaning towards traditional techniques rather than AM.

As an application example, power electronics in Electrical Vehicles or ICT infrastructure need high performant heat exchangers to dissipate all the heat generated on small areas. Aluminum as a high thermal conductive material is well suited for heat exchangers. In combination with the part complexity that AM allows, this leads to high performance heat exchangers.