Design Optimization for a Metal Additive Manufacturing Pilot Line

J. Kruis, H. Saudan, G. Perruchoud, O. Sereda, M. Dadras, E. Onillon

Metal additive manufacturing (AM) allows, by enabling use of advanced design, production of high added value components, at levels that cannot be reached with conventional manufacturing techniques. Still, the AM-based manufacturing sequence implies large amounts of critical steps – design for AM, AM fabrication, post processing, etc. – compared to conventional production sequences. Presently, the key competencies related to these steps are either not fully implemented at industrial level (process quality monitoring) or dispersed geographically with poor connection between different steps. Relying on two major AM technologies (LPBF: Laser Powder Bed Fusion and EBM: Electron Beam Melting), the H2020 research project MANUELA aims at deploying an open-access pilot line facility, covering the whole production sequence, to show full potential of metal AM for industrial AM production.

The H2020 research project MANUELA will deploy, with the collaboration of 20 EU partners, an open access pilot line addressing limitations of metal additive manufacturing (AM) process, namely limited speed, limited capability of right first-time production, limited number of qualified materials, limited of further data analytics. It is mainly composed of a hardware and dashboard layer as depicted in Figure 1.

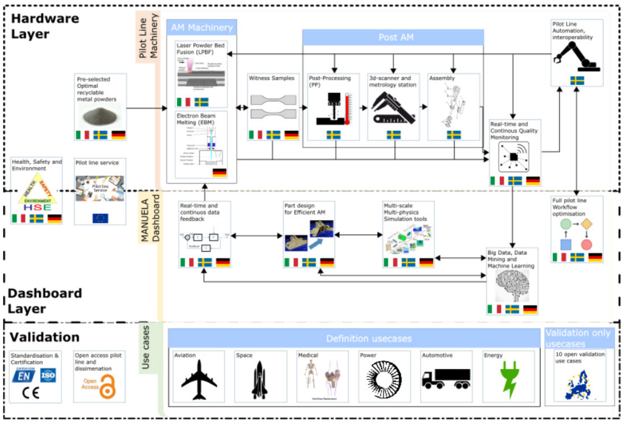

Figure 1: MANUELA pilot line deployment overview.

The pilot line hardware layer covers two main metal-AM technologies, Laser Powder Bed Fusion (LPBF) and Electron Beam Melting (EBM), as well as the post-treatment and which is essential to complete the whole part production sequence, including control and shipping. From a geographical point of view, the LPBF and EBM branches of the pilot line will not be located in the same place, LPBF being deployed in Sweden and Italy, and EBM in Germany. However, the parts production flow generated by each branch will essentially converge to a unique location when it comes to post AM treatments in Gothenburg, Sweden. Machines will be additionally equipped with the state-of-the-art monitoring systems.

The dashboard is comprehensive, with a graphical user interface enabling easy access to the pilot lines software capabilities. A machine learning approach, relying on collected big data and data mining will enable adaptive process parameters and suggests design corrections taking into account the entire pilot-line performance over its lifetime. In parallel, a set of multi scale and multi-physics simulation tools will enable the deployment of a pilot line digital twin. CSEM is playing a pivotal role within the MANUELA consortia re (i) the part design for efficient AM, (ii) the workflow optimization, and (iii) the quality control:

- The part design for efficient AM provides all relevant information enabling users to judge the feasibility and economic advantages of changing the manufacturing of a part or assembly of parts to an AM equivalent. The user just provides a CAD file of their part, answers a short questionnaire, adds assembly interfaces to their part and provides application specific constraints.
- The design tool interfaces with the simulation environment, the data as well as the data mining & machine learning and workflow optimization framework. It offers a manufacturability analysis, part specific process flow selection, suggested part optimisation (minimizing geometric distortions and weight, support structures where needed). It also provides the relevant process and part parameters with the design to the pilot line. As a consequence, less defects and distortions will propagate to the post-AM stage.
- In parallel, the line workflow will be continuously optimized.

The pilot line workflow optimization consists of three levels: part level, lot level, pilot line level. On the part level the inputs from the part design for efficient AM are used to select the optimal workflow for a specific part. On the lot level, the number of components per lot will be maximized by efficient stacking and combining of products with similar materials and workflows. On the pilot line level, usage will be parallelized to maximize workshop usage and reduce waiting times between parts.

The pilot line will be validated by the following 6 use cases from various industrial domains:

- Avionics use case (QIOPTIQ), design and pilot manufacturing of Helmet mounted displays (HMDs) components intended for aerospace applications.
- Space use case (RUAG), design and pilot manufacturing of novel slip rings allowing energy and signal transfers for rotating actuators.
- Medical use case (CBE), design and pilot manufacturing of custom-made cranial implants created by the usage of titanium alloy.
- Power use case (ENEL), design and pilot manufacturing of power plant machinery components subjected to high thermo-mechanical stresses.
- Automotive use case (OEB), design and pilot manufacturing of rocker for motorsport competition.
- Energy use case (SIEMENS), design and pilot manufacturing of gas turbine heat shields.

The project is financed partly by the European Commission under the H2020 program, grant number 880774, as well as the Swiss Secretariat for Education, Research and Innovation (SERI) and for which we would like to thank for their support.