Doctoral Dissertation
Doctoral Program in Energy Engineering (30th Cycle)

Industrialisation of Additive Manufacturing – A Holistic approach: From design to production

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Summary

The scope of the present research is to introduce a holistic approach on the production and industrialisation of metal-based AM, presenting a new concept of Design for AM, demonstrating the technical advantages of AM with the development of real industrial applications and identifying the main technological upgrades for the future machinery and the industrial uptake of AM. Furthermore, the dissertation evaluates the profitability of the applications in production aiming to demonstrate the technology's maturity for adoption by small, medium and large companies.

Existing methods on how the companies and the engineers approach the design for AM have been studied. The next step was the identification of existing design approaches and rules/guidelines for Additive Manufacturing, followed by defining the terms of design aspects and design considerations. Design guidelines and specific thresholds per process type were summarised, along with a proposed method to determine these thresholds for a specific process-material combination. Based on this study and the gaps identified, a novel concept for DFAM has been developed and presented considering the process know-how and the design freedom. The merge of these aspects as well as the need to combine different assembly components into one were applied in two motorsport cases exploiting the advantages of AM and paving the road for further implementation of metal AM in the design of new products.

Furthermore, an extensive study on the current production of metallic AM products has been performed. This, along with the current innovations and automation in machinery level have been used in order to present 3 real industrial applications from the most AM oriented industrial sectors. The development of these cases has demonstrated the technical maturity and advantages of implementing AM as valid alternative manufacturing process. Moreover, the end-users' requirements and specifications contributed to the technological upgrades realised in machinery level in order to facilitate the building and the repairing of various components such as dental parts, turbine blades and aerospace nozzles.

Subsequently, an analysis of the costs and the economic benefits of the integration of AM in the production has been also performed. For each case the production costs were calculated, and the profitability was quantified providing an estimation of how an investment in AM can be absorbed over the years and provide important technical advantages consolidating it as the main manufacturing process.

The dissertation outcomes are expected towards lowering the cost of transitioning to Additive Manufacturing, which is also linked to AM experts, proposing new business and technological approaches on how to increase AM industrial uptake and increasing the knowledge base in an easy-to-use way oriented towards SMEs (small-medium enterprises) and big OEMs.