Digital-Enabled Certification and Qualification in Additive Manufacturing: The DILAPRO Approach

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Introduction

Laser-based additive manufacturing (AM) has gained significant traction in producing high-performance parts with complex geometries. Nonetheless, the scalability of AM technology is often hindered by challenges in consistent quality assurance, regulatory compliance, and certification requirements. DILAPRO aims to address these limitations through an integrated digital framework that enhances both production efficiency and certification processes.

Certification remains a critical barrier to AM's widespread adoption, particularly in regulated industries that require thorough conformity documentation and rigorous adherence to standards. Pivotal to this innovation are two key software tools: DILAFACT and DILACERT, both of which use digital twins to refine production planning, quality control, and part certification. These tools form the strength of a robust approach that not only enhances efficiency but also aligns with global standards in additive manufacturing, setting a precedent for future practices. Thru integrating advanced software tools, DILAFACT and DILACERT, DILAPRO introduces a holistic approach to certification, enhancing compliance with international standards like ISO/ASTM and the International Additive Manufacturing Qualification System (IAMQS). This approach not only improves quality assurance processes but also promotes confidence in AM-produced components, enabling faster adoption across high-regulation sectors.

DILAFACT: Digital Laser Factory for Optimized Production

The DILAFACT platform embodies a "Digital Laser Factory," simulating laser-material interactions at both material and microstructural levels. Through precise modelling of additive, subtractive, and thermal processes, DILAFACT enables manufacturers to make data-driven decisions, optimizing parameters such as material properties, laser power, and environmental conditions. This granular level of planning reduces raw material waste by up to 64% and energy consumption by 27%, aligning production practices with sustainability targets while ensuring quality.

DILAFACT's simulation capabilities are particularly valuable for laser-based processes like Powder Bed Fusion-Laser Beam (PBF-LB) and Directed Energy Deposition-Laser Beam (DED-LB). By integrating multi-sensor arrays and real-time feedback, DILAFACT enhances in-situ monitoring, enabling immediate adjustments to process parameters to avoid defects. This continuous quality control significantly lowers scrap rates and rework, bolstering productivity and reliability [1,2].

DILACERT: Streamlined and Digital Certification for Laser-Based AM

DILACERT is designed to transform the certification of AM parts by providing a streamlined, semi-automated approach to compliance. Traditionally, AM part certification is a complex, manual process that demands extensive documentation and verification. DILACERT automates data collection and analysis, using digital twins to monitor parts in real-time and ensure they meet predefined quality criteria. This automated process enables faster certification cycles and reduces production costs, making it more feasible for manufacturers to achieve and maintain compliance with rigorous standards.

A key innovation of DILACERT is its alignment with IAMQS, which provides a structured approach to certifying both AM parts and the personnel involved in their production. DILACERT supports partial pre-certification by following established standards, such as DNV-BS-203, which outlines requirements for online monitoring in AM processes. By incorporating online monitoring data from DILAFACT, DILACERT provides early validation of part quality, reducing the risk of non-compliant parts advancing through the production line.

Certification Challenges and Regulatory Alignment

Certification in AM involves adhering to standards that are evolving to meet the specific needs of laser-based manufacturing. Within AM standardization communities, such as the ISO/TC 261 committee, standards for demonstrating process and part conformity have been developed. However, a significant challenge remains in the lack of standardized material property data for AM components. AM manufacturers often rely on proprietary material data sheets, which lack consistency across different systems and materials, limiting the reliability of certification processes.

DILAPRO addresses this challenge by promoting a harmonized approach to material property assessment. By establishing standardized material databases and performance metrics, DILACERT contributes to a unified certification framework that complies with codes such as ASME, API, and PED. This harmonization effort is essential for sectors like aerospace and medical devices, where failure to meet stringent quality standards can have serious consequences.

Integration of Digital Twins for Enhanced Certification

The digital twin technology underlying both DILAFACT and DILACERT allows for real-time, high-resolution monitoring of production processes, which is crucial for AM certification. DILACERT independently monitors production data and performs audits to maintain transparency and integrity in data analysis, distinguishing it from DILAFACT's production-oriented role.

The use of digital twins provides unprecedented insight into the thermal, mechanical, and chemical conditions experienced by each component during the build process. By enabling real-time adjustments based on data feedback, digital twins ensure that each part adheres to specified tolerances and standards. This capability is particularly valuable for industries with stringent regulatory requirements, as it facilitates consistent production quality and reliable certification outcomes.

Standardization Efforts and Industry Collaboration

DILAPRO is actively contributing to the development of new standards for AM certification by collaborating with organizations such as ISO, ASTM, DNV-GL, and TUV. Participation in international committees, such as ISO/TC 261 and industry groups like ESAFORM and EFFRA, allows DILAPRO to align its technologies with emerging policies and contribute to the creation of new guidelines for digital certification. This collaborative approach helps drive consistency across AM practices globally, promoting interoperability and compliance with established benchmarks.

Through ongoing collaboration with testing, inspection, and certification (TIC) bodies, DILACERT is designed to meet stringent compliance requirements across various industries. By engaging with standards organizations, DILAPRO is helping to shape the future regulatory landscape for AM, ensuring that digital certification processes remain relevant and applicable as the technology evolves.

Applications and Impact

DILAPRO's innovations are being validated through real use cases, demonstrating tangible economic and environmental benefits. For instance, resource efficiency improvements in PBF-LB and DED-LB techniques have resulted in reduced material and energy use, contributing to both cost savings and emissions reduction. These benefits highlight DILAPRO's potential for driving sustainable production practices in sectors that rely heavily on high-quality, certified AM components, such as aerospace, medical, and energy.

DILACERT's digital certification framework accelerates time-to-market for laser-manufactured parts by minimizing bottlenecks in certification workflows. As a result, manufacturers are better positioned to meet industry demands and regulatory requirements, facilitating broader adoption of AM technologies across sectors with rigorous certification needs.

Conclusion

The DILAPRO project presents a forward-thinking approach to laser-based additive manufacturing, particularly in the realms of quality control and certification. By integrating digital tools like DILAFACT and DILACERT, DILAPRO enables real-time process monitoring and automated certification, setting a new benchmark for quality assurance in AM. This approach not only supports compliance with international standards but also fosters a more sustainable, efficient production environment.

DILAPRO's commitment to certification innovation, aligned with ongoing standardization efforts, positions it as a leader in establishing a global framework for digital certification in AM. The project's contributions to certification practices, regulatory compliance, and sustainability underscore its significance in advancing additive manufacturing toward a future where digitally enabled, environmentally conscious production is the norm. As AM technology continues to evolve, DILAPRO's work will be pivotal in shaping the certification and regulatory practices that ensure safe, reliable, and high-quality AM products across industries.

Keywords: Additive Manufacturing, AM Qualification, AM Certification

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