Research project

Name and Surname: Davide Palumbo

Title: Development of new procedures and data analysis for non-destructively characterizing AM components

Reference Labs:

- Advanced Structural Diagnostic Laboratory (Prof. Davide Palumbo)
- Structural Health Monitoring and Thermal Methods for Experimental Mechanics (Prof. Umberto Galietti)

Description:

In a multidisciplinary approach, the research project aims at the monitoring of additive manufacturing (AM) processes by means of non-destructive inspections. During AM, several parameters determine the properties of the final component, both in terms of quality, namely the possible presence of defects, and mechanical specifications, such as hardness, tensile strength, elastic modulus, and fatigue limit. The assessment of these parameters can significantly reduce production scraps and, thus, increase overall sustainability.
Non-destructive inspections can reduce the typical problems related to this process in a non-destructive way since they are a powerful tool both for online and offline inspection, very fast and cheaper with respect to destructive techniques.
The experimental analysis produces unstructured data in the form of sequences, maps and data evolving over time. The correlation between input parameters and output properties and quality cannot be inferred directly by expert operators and then, processing methodologies are essential to discover from the data the best features to describe the thermal behaviour of the process. New AI-based approaches will be developed to model AM process by deeply analysing data captured from actual coupons and, in this regard, other research institutes will be involved in the project.
The acquired thermal and mechanical data will be statistically analysed to develop models able to describe the process and the mechanical behaviour via thermal methods. The performance results for each model will be statistically analysed, evaluated, and compared in terms of predictive performance, processing time, and outlier sensibility to obtain robust models. Considering the same models and features, the acquired data will be analysed to find localized defects and anomalies, directly during the process.
Offline non-destructive tests (with micro-computed tomography, ultrasounds, eddy current and thermographic techniques) will be carried out to evaluate the presence of defects and the material thermophysical properties in order to obtain a correlation with the mechanical properties.
The expected results are: i) the development of robust AI-based approaches to correlate process parameters and material/mechanical properties of manufactured goods; ii) the definition of an experimental pipeline for the remote thermal inspection of coupons during manufacturing and offline; iii) the validation of AI-based classifiers for offline quantification of defects from thermographic data; iv) the optimization of the process parameters for the improvement of AM sustainability.
The research project will be articulated in four WPs and several subtasks here summarized:
WP1 Assessing the manufacturing of different coupons produced by AM processes by non-destructive analyses.

Definition of a Design of Experiments (DOE), also considering the production of coupons with AM typical defects. Setting the setup and parameters to monitor the process by IR and optical sensors.
1.1 Definition of the experimental plan, material, and sample geometry (DOE with nominal process parameters such as laser power, powder flow rate, and scanning speed).
1.2 Preliminary assessment of the most suitable setup and acquisition parameters.
1.3 First experimental campaign and data acquisition.
1.4 Preliminary analysis of the acquired data and extraction of the most suitable thermal/optical features.
1.5 Definition of the final setup for process monitoring.
1.6 Acquisition of the sequences and first qualitative analyses.

WP2 Correlation among acquired data, process parameters, and the resulting material/mechanical properties via AI-based models.
The resulting material and mechanical properties (WP3) and extracted thermal features will train AI architectures for regression to model input-output relationships. Online defect identification and comparison with non-destructive results.

2.1 Development of (Deep Learning) DL network to correlate process parameters and thermal features.
2.2 Training, testing, and validation of the models.
2.3 Correlation analysis via the developed models between features and mechanical properties (hardness, tensile strength, fatigue limit).
2.4 Anomaly detection and characterization considering the same features and comparing the results with destructive tests to evaluate the effective presence of defects in the final microstructure (analyses performed by third parties).

WP3 Ex situ characterization of built parts
Extraction of customized parts to assess the material/mechanical properties via destructive tests and evaluate the presence of defects, tensile strengths, hardness, and fatigue limits.

3.1 Destructive tests to evaluate the presence of defects in the microstructure.
3.2 Tensile strength assessment of built parts.
3.3 Hardness assessment of the built parts.
3.4 Fatigue assessment of the built parts.
3.5 Generation of ground truth data set from the ex-situ characterization for the AI models.

Candidates should provide detailed CV

Contacts

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