Title:

Research of a robotic Hybrid Additive Manufacturing process based on cold spray

Background & context:

Additive Manufacturing (AM) is a relative new technology family for forming/shaping. It has some other names, such as rapid prototyping, solid freeform forming/fabrication, layered manufacturing, direct CAD manufacturing, 3D manufacturing, material depositing modeling, etc. It is named due to its processing way, adding materials to build parts in a layer by layer sequence. According to its technical evolution, it has become a process to manufacture near or even functional parts in many production domains. However, using AM to produce metallic functional/end-use components is still quite difficult. Recently, Hybrid AM, which combine AM with traditional or non-traditional processing techs, e.g. subtractive or formative processing techs, is proposed to solve this problem.

As a surface treatment method, thermal spraying has become an indispensable process in the manufacturing industry for durable products in different fields, such as automobile, aircraft, aviation and shipping. The major advantage of thermal spray processes is the extremely wide variety of materials for coating deposition. Materials like metals, alloys, ceramic and even composite can be produced by different thermal spray methods. The second major advantage is the ability to fabricate thick coating up to several millimeters. Compared with the surface modification method like electroplating, physical or chemical vapor deposition, thermal spray technology can produce a coating in a large and/or irregular area at a high deposition rate. Thus, it has been considered as an effective additive manufacturing method. The third advantage is the ability to repair and restore worn or damaged component without changing its properties or dimension. Especially, the cold spray technology which appeared in the late 1980s as a branch of thermal spray has attracted more and more attention in the field of additive manufacturing.

As a fast-growing deposition method, Cold Spray (CS) principally used as a coating technology, is gaining considerable attention for direct production of freestanding components rather than deposition of surface coatings, due to its ability to create thick buildups, with no theoretical limit to the size and the thickness. CS as one of the additive manufacturing techniques offers great potential for producing components with complex 3D geometry that cannot be developed by other conventional methods due to its flexibility in the deposition of feedstock and high deposition rate. Against conventional thermal spraying that requires high-temperature gas spray, cold spraying uses low-temperature deposition so that the powders can retain their primary properties during deposition. These unique characteristics of CS imply the potential of manufacturing high value customized metallic or ceramic components with good performances, high production rate and low cost as well as less pollution and friendly working environment, which copes well with the trend of sustainable manufacturing.

Nowadays, CS has been used to fabricate components with relative simple shapes, like regular blocks, cylinders and axisymmetric bulk parts. For fabricating complex geometry components, a well-designed robot trajectory is indispensable, which should present the optimal deposition strategy and the compensation of coating growing up during the process. Although the use of robot can bring more degrees of deposition freedom, the shape accuracy of cold spray manufactured components is usually poor and cannot be directly used as functional components. This process can only build near net shape components with rough surfaces. To enable CS to produce functional components with acceptable surface accuracy and mechanical properties, other processing techs should be used in combination in or after the deposition process. Therefore, there is a need to investigate which process or processes could be used as compensation of CS for functional production. This derives the PhD research topic: development of a robot Hybrid Additive Manufacturing process via the combination of CS with compensation processing techs.

Research subject & objectives:

To fix the gap of manufacturing functional components, especially metallic components, in AM domain, this research will focus on both of the hardware aspect and software aspect to develop a totally new robotic HAM process based on CS. In the hardware aspect, an experimental HAM platform should be built; while in the software aspect, a set of process planning and decision-making tools for robotic control should be realized.

The objective of this proposed research is mainly to build up an experimental HAM platform and develop a set of decision making methods and tools with scientific originality for the HAM processing chain. Another intent is to prove the potential of this expected new HAM process for functional manufacturing in diverse manufacturing domains.

Background needed:

Mechanical engineering, material processing engineering; Additive Manufacturing/3D printing; CAX; Robotics, Electromechanics, Programming

Supervisors:

Sihao DENG (50%): System architecture, Robotics, Software developpement

Yicha ZHANG (50%): Additive Manufacturing, CAX, knowledge & AI-based decision making & optimization

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