Heating of 3D Printed Tooling with Circuits Printed In-situ through EDAM

Embedded heating circuits printed directly into polymer-based tools enable uniform temperature control for composite manufacturing, reducing thermal gradients and energy consumption.

During the last decade, Additive Manufacturing (AM) techniques have evolved from rapid prototyping methods to a potential manufacturing method for in-service parts and tooling. Extrusion Deposition Additive Manufacturing (EDAM) is one of the most matured and commonly used AM techniques for polymeric materials, allowing for production of short runs of intricate shapes with lower cost, lower material waste, and at higher rates than traditional subtractive methods. Nevertheless, feedstock materials conventionally used in EDAM, namely acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA), which are both thermoplastics, lack the mechanical properties required in end-use parts. Such limitations have fostered the adoption of fiber-reinforced polymers for 3D printing.

The low Thermal Conductivity (TC) of the fiber-reinforced polymeric materials used in EDAM limits the effectiveness of traditional cartridge heaters, heating mats, or heating fluids to achieve the temperature uniformity. These traditional techniques combined with the low TC of the printing materials introduce large temperature gradients on the tooling surface. There is an unmet need for methods and an apparatus for additive manufacturing of tools or molds capable of operating at temperatures up to 180 degrees Celsius without undesirable thermal gradients within the printed tool.

Purdue University researchers have developed the use of heating elements embedded as circuits inside printed tools. Heating circuits can be printed in-situ by coextruding the heating elements together with the printing material, by inserting an electrical circuit between two adjacent layers, or using an automatic element dispenser. This technology allows the use of 3D printed tools in composite manufacturing processes at temperatures up to 180 degrees Celsius. Nevertheless, temperature gradients on the tooling surface can be reduced using heating circuits near the surface. Heating circuits can

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deliver the same heating power of traditional heating elements, such as cartridge heaters or fluids, but at lower heat fluxes, thereby averting melting the material around the heating element. Further, heating circuits can be located by zones in order to have different temperature control schemes depending on heating requirements. Placing heating circuits near the tooling surface can potentially reduce the energy required for heating the tool.

Advantages:

-Unique flexibility to design heating zones in a tool

-Reduced temperature gradients

-Use of higher heating power without melting the polymer

-Reduces energy use

Potential Applications:

-Additive manufacturing

-3D printing

-Composites tool making industry

-End-use parts

TRL: 4

Intellectual Property:

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