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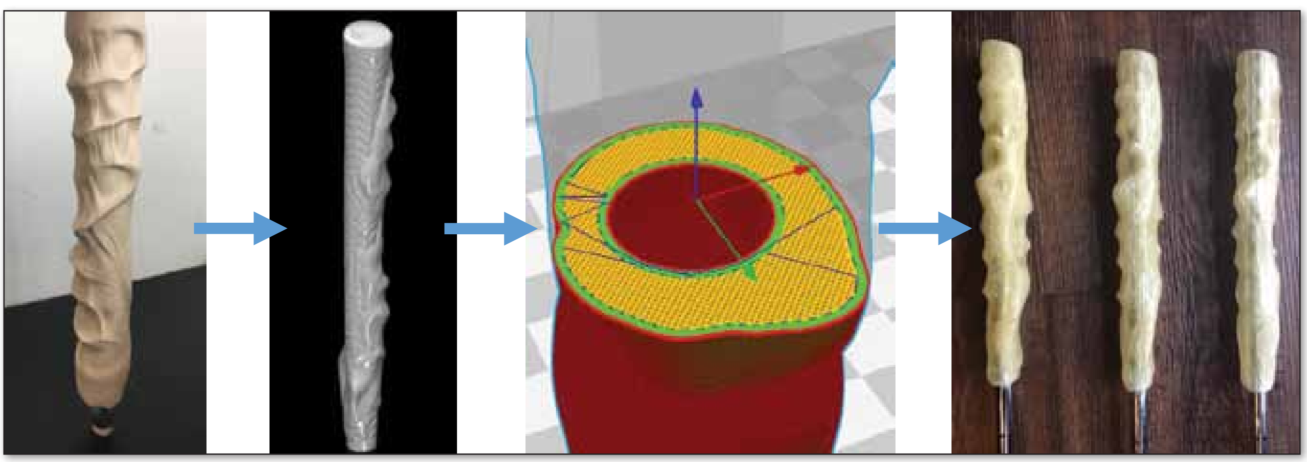
SME SPEAKS
GUEST EDITORIAL

Digital Manufacturing Challenge Gives Students Glimpse into AM's Evolution

Design something impossible. That was the homework assignment given to my Introduction to Mechanical Design class by Professor Carl Crane when he first uncrated a Stratasys FDM 1600 at the University of Florida in the summer of 1998. This three-word homework assignment is the reason I first fell in love with what was then referred to as "rapid prototyping," and instilled in me a passion for the technology to which I have since dedicated my career. This assignment is now the first homework I give to the students enrolled in my additive manufacturing (AM) course at Virginia Tech as it perfectly captures the possibilities afforded by a layer-by-layer fabrication process. It opens students' eyes to the constraints imposed by traditional manufacturing technologies and, simultaneously, to the design freedom offered by additive manufacturing. It also makes them keenly aware that the bottleneck in product design is no longer imposed by manufacturing technologies; it is instead imposed by their skill with CAD tools (and perhaps even the tools themselves).

The opportunity to selectively place material in only the locations needed—whether for product customization, design optimization or aesthetic purposes—is a key value proposition of AM technologies. However, it is often the most challenging aspect to leverage, simply because it requires a whole new way of thinking about product design. In effect, one must forget previous training in traditional design for manufacturing principles, which are heavily focused on a series of constraints with geometries that cannot be fabricated. In the 2014 National Science Foundation (NSF; Arlington, VA) workshop, "Educational Needs & Opportunities in Additive Manufacturing" (co-organized by Tim Simpson, PhD, Penn State, and myself), Design for Additive Manufacturing (DfAM) knowledge—including computational tools and frameworks for process selection, costing and idea generation—was the most frequently requested skills of the next-generation AM workforce by industry participants.

Student design competitions, such as SME's Digital Manufacturing Challenge, are an excellent way to engage the



Process summary. From left to right: a clay mold is made, an STL is created from the scanned mold, a cavity is added for the shaft and a set of grips are printed.

next-generation workforce in developing the ability to design products that leverage the design freedoms offered by additive manufacturing processes. Sponsored by the Direct Digital Manufacturing Tech Group, which is part of SME's Additive Manufacturing Community and chaired by SME member Carl Dekker, president of Met-L-Flo Inc. (Sugar Grove, IL), this competition invites high school and university-level students to showcase their technical and commercial talents by demonstrating new and creative ways AM can add value. This competition provides both a context and an incentive for students to engage in DfAM, and has resulted in a number of novel uses of additive manufacturing, from a printable drone that is able to inspect bridges to a prosthetic limb for dogs.

The 2017 Digital Manufacturing Challenge centered around a theme of "mobility." The competition challenged students to design products that could restore, enhance or fundamentally alter physical mobility and/or performance in the areas of personal transportation, sporting goods or medical appliances/physical therapy devices. This year's university-winning team was an interdisciplinary group from Virginia Tech composed of both undergraduate (Andy Cohen, mechanical engineering) and graduate students (Camden Chatham and Jake Fallon, macromolecular science and engineering, and Eric Gilmer, chemical engineering).

The team designed a "customized golf grip trainer" that aimed to allow players to practice with a proper grip without the need for a professional's constant supervision. In their concept, the grips are first custom-fit to the player by an onsite golf professional using clay. The clay impression is then 3D scanned, converted to an STL file, 3D printed with a thermoplastic urethane (TPU) resin and delivered to the customer. The printed grips provide the "perfect grip" during practice so that the player can commit it to muscle memory for a future game.

Through their design, the team leveraged the design freedom offered by additive manufacturing by providing a customized geometry and user interface. In addition to customizing the external surface, the team also customized the hardness of the printed grip by altering the printed infill pattern (and thus internal structure) of the part. What perhaps impressed me most was that the team did not limit themselves to commercially available material extrusion filament; instead they selected a specific TPU resin (Texin RxT70A) for this application due to its FDA approval for prolonged tissue contact, its softness and durability. Recognizing that this specific TPU is commonly used in injection molding, and might be suitable for material-extrusion additive manufacturing, the team processed their own filament from purchased pellets and established the proper printing parameters. The resulting printed parts met or exceeded the team's design specifications of water absorption, compressive strength and storage modulus at relevant playing temperatures. Perhaps, most importantly, they found that it provided a comfortable and customized means for learning a proper golf grip.

Through SME's Digital Manufacturing Challenge, these students might just have given us all a glimpse of the next evolution of design for additive manufacturing. Their interdisciplinary approach to product development, which included mechanical engineers, chemical engineers and polymer scientists, enabled the concurrent design of both the product geometry and the material itself.

To learn more about SME's annual Digital Manufacturing Challenge and review the winning design entries, please visit sme.org/digital-manufacturing-challenge.