MAKER: 3D Printing as an Alternative toFabricatethe Motorsports Parts

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1. Abstract

Today, saying Additive Manufacturing (AM) is changing our world is an understatement. Current applications include additively manufactured shoes, jewelry, prosthetics, and food products. In this study, a steering rack extension for Tennessee Tech's Formula SAE (FSAE) car was replaced with various 3D printed alternatives. Numerous beta testing studies were performed to measure its sustainability. Utilization of a Steering Rack Extension is made to adapt a quick ratio steering rack to interface with the steering system designed for the TTU Motorsports FSAE car. The current study reports the design, analysis, and manufacturing studies performed to replace the steering rack extension with a 3D printed component. Various tests and 3D printing operations have been performed to show the improvements made to replace the currently used piece. This presentation will report the design, printing and testing studies performed for the newer steering rack extension. Student feedback received from the FSAE team and engineering students will be also presented.

2. Background

FSAE is the name of a student design competition organized by SAE International (previously known as the Society of Automotive Engineers, SAE). This competition was started initially in 1980 by the University of Texas-Austin SAE student branch. The main idea behind the FSAE is that an imaginary manufacturing company has contracted a student design team to develop a small Formula-style race car. The prototype race car is to be evaluated for its potential as a production item. The target marketing group for the race car is the non-professional weekend autocross racer. Each student team designs, builds and tests a prototype based on a series of rules, whose purpose is both ensuring on-track safety (the cars are driven by the students themselves) and promoting clever problem solving [1].

Tennessee Tech University has a very well established FSAE team that competes in the top FSAE competitions within the US. In the Spring, 2017 semester, one project was conducted to replace some of the FSAE parts with additively manufactured newer ones. In this paper, steering rack seen in Figure 1 will be presented, and studies performed will be reported.

Figure 1: Location of the Steering Rack on FSAE

This steering rack chosen to give the desired steering feel was too short to work with the system designed. In order to make the rack work a custom part was made to extend to rack out wide enough to connect the rest of the system together. This part was to be as light as possible while maintaining a strong reliable part. This piece extends the rack roughly 5 in out in each direction to connect to a sliding bearing in a vertical pitman arm. The extension experiences max forces of 300 pounds in a linear compression or extension during hard cornering. The finished design was a 78-gram machined piece of aluminum that allowed a firm solid feel in the steering system. As part of a National Science Foundation-Advanced Technological Education Project called AM-WATCH (Additive Manufacturing Workforce Advancement Training Coalition and Hub), this study has been performed in order to provide the capabilities and availabilities of composite 3D Printing as an alternative to conventional CNC (computer numerical control) practices.

3. Composite based Additive Manufacturing (CBAM)

Current steering rack is a CNC machined aluminum workpiece. In this study, MarkForged's desktop 3D printer was used to perform an experimental study to show that a CBAM machine operating with carbon fiber, fiberglass and Kevlar components could produce reliable FSAE workpieces. Currently, MarkForged's CBAM technology is not only capable of producing carbon fiber 3D printed parts with a higher strength-to-weight ratio than 6061-T6 Aluminum, it is also apparently able to do so up to 90% faster and 70% cheaper compared to traditional methods [2]. MarkForged's patented CBAM technology relies on two print heads: one extrudes nylon filament, while the other continuously reinforces the nylon with proprietary reinforced composite materials, including carbon fiber, fiberglass, or even Kevlar. The result is cost-efficient CBAM parts that can displace components that would typically be machined in metal [2].

4. Testing Studies

Steering rack extensions have been printed in various fused deposition modeling machines available at the Tennessee Tech University. Then, produced samples were tested on a Tensile Test machine. It has been proven that the highest values of the results were received from the parts built via CBAM technology. Figure 2 shows a test part attached to Tensile Test machine.

Figure 2: Steering Rack made with CBAM under Tensile Testing Equipment

Table 1 presents the list of currently tested specimens. Figure 3 is various tensile test results from the specimens.

Table 1: Specimens used in the Tensile Test

Specimen	Printer	Material	Infill
1	MarkForged 1	Nylon+Carbon Fiber	CF-15.3cm^3-Nylon-19.5cm^3
2	Ultimaker 2+	PLA	25%
3	Ultimaker 2+	PLA	35%
4	Monoprice I3	PLA	35%
5	PrintrBot	PLA	35%
6	MarkForged 1	Nylon+Carbon Fiber	CF-11.20cm^3-Nylon-23.93cm^3
7	Ultimaker 2+	PLA	35%
8	Ultimaker 2+	PLA	35%
9	Ultimaker 2+	PLA	25%
10	Ultimaker 2+	PLA	25%

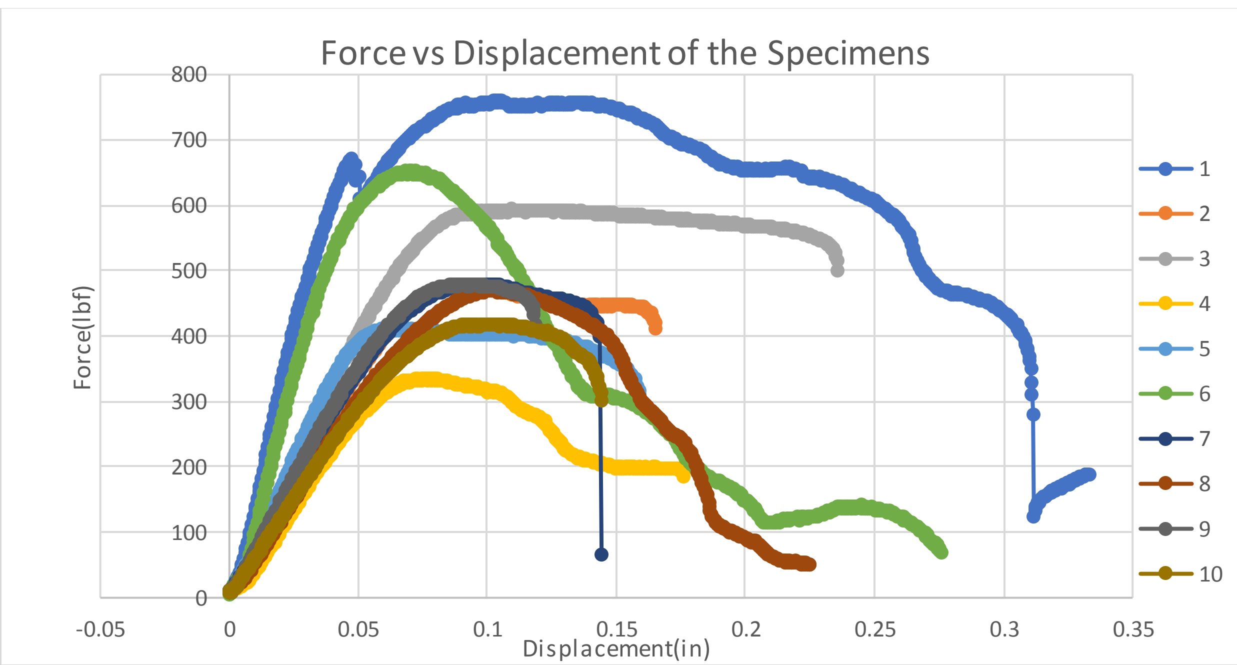

Figure 3: Tensile Test Results of Steering Racks made with Various AM Technologies

5. Feedbacks received from Engineering Students

The following will provide a beneficial feedback about the impact of the current study to engineering education. The experience of two students will be shared here.

Undergraduate Student:

"Working on this project has provided useful feedback in how far AM has developed. During work on this project I have learned useful information about how to properly design parts that are additively made so that they will withstand the forces placed on them during use, while still being able to print them easily."

Graduate Student:

"In a world where AM applications seem to be fitting everywhere, having the chance to work on one of them is a changing mindset experience. AM can be used to print things that would be unique not only because they were 3D printed, but also, they could be used in real life applications. This project provided an extra edge to my knowledge on how to think about designing and manufacturing a part that would not have the obstacles of subtracting manufacturing but in thinking of how to manufacture those parts for additive manufacturing."

6. Conclusions

There are many studies on replacing the current automotive parts with 3D printed metal and non-metal components. In this study, one metallic component used in the FSAE car was replaced with various additively manufactured pieces. It was seen the parts produced with CBAM provide highest level of strengths compared to other conventional AM technologies. Also, students engaged to this study provided very enthusiastic and critical feedbacks indicating that such kind of experiential activities is a good way to help students retain in engineering programs and support their learning with real world experiences.

Acknowledgements

This work is part of a larger project funded by the Advanced Technological Education Program of the National Science Foundation, DUE #1601587. Authors greatly appreciate the funding provided by the National Science Foundation.

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