2018 SkillsUSA

Additive Manufacturing Adaptive Device Challenge Guide

Challenge Overview

Introduction

Additive manufacturing/3D-printing is changing the face of medicine as engineers and physicians are able to develop adaptive devices that are fully customized to the wearer. These devices often serve as assistive devices or tools for unique activities such as sports, hobbies or professions that the wearer is engaged in. Thanks to the ability to easily add customization and design with complexity with 3D printing, people who were disabled are now differently abled. For example, in athletics, additively designed devices exist like the freestyle swim foot or an upper extremity archery device.
Additive manufacturing is rapid compared to traditional forms of manufacturing and this allows for multiple design iterations in which designs can be tested and improvements can be made immediately.

Challenge Goal

The goal of this challenge is to demonstrate additive manufacturing skills by designing and fabricating a real-world 3D printing application in healthcare.

Challenge Description

Students will need to solve a real-life problem given to them by a real patient that they will meet in an introductory video. The patient, a veteran that has endured the traumatic amputation of the thumb on his left hand, is left with not only a missing digit but other side effects of the amputation.

After viewing the video introduction students will need to consider the patient's disability and what gaps this has caused in his ability to do things needs and wants to. As students will see in the video the veteran has a silicone prosthetic with some challenges including rigidly and tactile response. The students are tasked with designing a new adaptive device that assists the veteran in doing one of his favorite pastimes: playing his Playstation 3. The new adaptive device should be utilized **without** the veteran's current silicone prosthetic.

There may be many solutions to the problem of enabling the veteran to use a Playstation 3 controller, but the adaptive device needs to satisfy the following requirements:

1. The device should be comfortable and reliably usable to operate the left-hand controls on a Playstation 3 controller (see image below for details).
2. The adaptive device must remain usable and stable with only the help of the veteran's 2 hands (the left hand has the amputated digit presented as an STL file and PNG file on the students' USB sticks).
3. The device may **only** consist of 3D printed parts and **2 optional rubber bands** provided on-site. No adhesives or other materials may be used in the final solution.
4. The 3D printed part may be lightly sanded for quality or fit purposes after soluble support removal. However, no substantial geometric changes may be made. Sandpaper and needle-

nosed pliers (for support removal only) are the only allowed tools; knives, hammers, chisels or other tools are not allowed.

5. The device must be designed in a way that follows the "Contest Outline" given below.
6. The device should enable "tactile feedback" when pressing the in-scope controls (green in Figure CG-1 below).

Figure CG-1 - The controls that are circled in green on the PS3 Controller pictured above must be fully operable by the adaptive device. The buttons with red "X"s through them do not need to be operated.

Figure CG-2 - The Testing Rig holds the controller and thumb simulator in place for testing.

Challenge Agenda

Day 1, Tuesday

Tuesday is the Day 1 of the competition. There will be 3.5 hours of design time available to contestants to design for their first of two opportunities to 3D print overnight. During the design time on Tuesday, the Testing Rig (see Figure CG-2 in Challenge Overview) will be available for measurement and planning.

Reminders:

- Throughout the design process, students should document their journey in their engineering notebook (see judging rubric for details). This notebook may be taken home with students each night to review and finalize documentation.
- At the end of the design time, contestants must submit a file folder on their USB drive that matches the Print Deliverable Specifications specified below.

Day 2, Wednesday

Wednesday is Day 2 of the competition. Students will receive their 3D printed parts from Tuesday's design efforts to test. Students will receive 3 more hours of design time. During the design time on Wednesday, the Testing Rig (see Figure CG-2 in Challenge Overview) will be available for part testing.

Reminders:

- Throughout the design process, students should document their journey in their engineering notebook (see judging rubric for details). This notebook may be taken home with students each night to review and finalize documentation.
- At the end of the design time, contestants must submit a file folder on their USB drive that matches the Print Deliverable Specifications specified below.

Day 3, Thursday

Thursday is presentation day. At the end of the day on Wednesday, students were given their "judging time." Students are allowed to show up at the contest location 30 minutes prior to their judging time. Upon arrival, students will check in and receive their printed part from Wednesday. Students are allowed to inspect their Wednesday print and perform any sanding or assembly (as well as testing) desired before judging.

When the judges are ready (no sooner than the "judging time"), the team will be called to the presentation table, given 10 minutes to present their process, engineering notebook and printed designs. Judges will ask necessary questions to fully score student design before moving to the functional testing portion of judging. Students should fully review the Judging Rubric below to assist crafting their final presentation.

Print Deliverable Specifications

On Tuesday and Wednesday, students will submit files to be 3D printed overnight (see agenda above). Below is the deliverable that must be submitted on your USB drive to have parts 3D printed.

File Folder Specifications

- A file folder titled “Team [#] - [Day of Week] Submission” (fill in “[#]” with team number)
- Within the above folder, include the following files (**all** files must be formatted in this way: “Team [#] - [Day of Week] - [File Description]”):
    - processed CMB for uPrint SE Plus (0.010” slice height with default ABS P430XL material)
    - all STL files of design
    - a “.txt” (Notepad) document very clearly explaining the orientation of each part and infill style: sparse high density, sparse low density, or solid (this is because the administrators likely will need to rearrange files for actual printing, creating a new CMB).
        - Near the top of the .txt file include the estimated time for the CMB that was submitted.

Design Specifications

- The total print must fit in a build envelop of 4.7”(L) x 4.7”(W) x 4.7”(H)
- Review rubric on material usage judging criteria
- The print must take no longer than 2 hours to print (according to GrabCAD Print’s approximation of the submitted CMB)
    - Prints that are at or under 2 hours are guaranteed to be printed. Longer prints may not be finished on schedule or at all

Judging Procedure

On Thursday, your parts will be judged based on functional testing and a team presentation. Below is the procedure for the judging session:

1. Prior to judging time, ensure that the adaptive device is fully assembled and ready for demonstration. *Note: Do NOT perform geometry-altering changes to your model to "make it fit" right prior to judging. This will result in penalties. Refer to items 3 and 4 in the design requirements list in the Challenge Overview for details on legal assembly practices.*
2. The team will give a 10-minute presentation.
    a. Optional visual aids may include the following:
        i. Powerpoint (or similar program) slides
        ii. Your engineering notebook
        iii. 3D printed parts printed **from Tuesday and Wednesday**
    b. Review the rubric below to ensure that your Presentation & Engineering Notebook cover all judged points. (review rubric for Engineering Notebook criteria)Use your engineering notebook to demonstrate:
        i. Design Process (How did you go about brainstorming and designing your parts? How did you effectively respond to Tuesday's print results during Wednesday's design time?
        ii. Team Functions, Roles and Responsibilities (How did you split up roles and take advantage of each other's strengths?)
        iii. Limitations and Lessons Learned (Did anything go wrong during the past few days that was preventable? Where does your design fall short? What would you ask the patient if you had the opportunity?)
3. When ready to test the device in the Testing Rig, indicate to the judging panel which team member will be the Demonstrator.
4. The Demonstrator will use a 3D printed version of the veteran's hand (provided) and a PS3 controller (provided) to illustrate to the Judges how the 3D printed adaptive device functions.
    a. Please speak about the part as you are demonstrating it so that the Judges understand how it is intended to work.
5. The Judges will then ask the Demonstrator to press certain buttons on the left-hand directional keypad or point a direction with the left-hand joystick (see Figure CG-1 in Challenge Overview). The Demonstrator will demonstrate that the controller can be reliably operated.
6. The Judges will take the adaptive device and operate it themselves.

2018 Additive Manufacturing SkillsUSA "Mini Challenge"

Overview

The "Mini Challenge" is a short activity that tests a different area of competitors' knowledge of additive manufacturing. This year, the focus is "Design for Additive Manufacturing". How well are you able to identify a "well-designed" 3D printed part? Complete the challenge as described below to be graded.

Procedure and Rules

1. Read the scenario and questions below. Students will have 60 minutes to complete the Mini Challenge.
2. Open a blank .txt file (Notepad document). At the top write team number in the format "Team #". Below team number, copy the numbered questions and answer appropriately and professionally.
3. Save the .txt file onto a USB drive labeled with team number and submit before 60 minutes are up. There will be no late submissions accepted.

Scenario

You work at a company in the Manufacturing Engineering department, responsible for designing new manufacturing processes as products are developed.Your company has recently purchased a Stratasys Fortus 450mc FDM 3D printer to assist in various factory functions.

A new product, named the "front bracket" is announced as an urgent new project. It is a high-value machined metal bracket that requires a logo to be pad-printed on the top of it. See below:

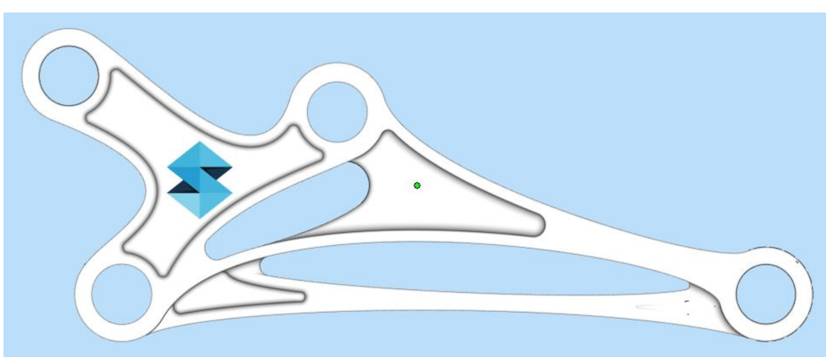

Figure MC-1: The company's new "front bracket" has a logo pad-printed on the top of it.

Your manufacturing engineering team has to design a fixture that will hold this bracket in place while the stamp is being applied. During the manufacturing process, a long conveyor belt with 100 fixtures on it will cycle the fixtures through a pad printing process. See below a diagram of pad printing:

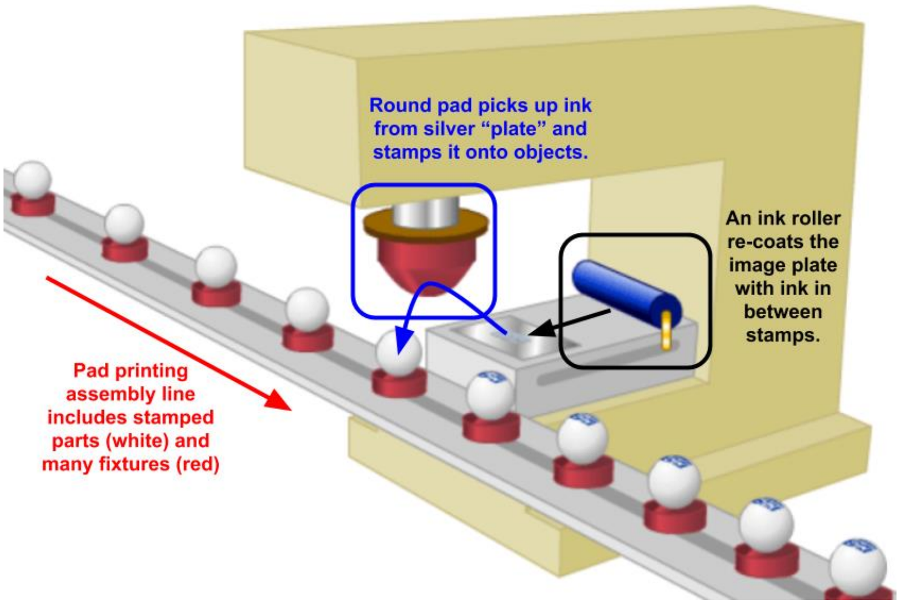

Figure MC-2: A diagram showing the pad printing process. In this diagram, a rack of products undergo stamping. In the company's operation at hand, the rack is instead a conveyor belt with metal plates that rotate continuously.

On Monday morning your team is tasked with designing and creating 100 fixtures for this important pad printing operation. The fixture requirements are simple:

1. They each need to have four ¼" **bolts on each corner for bolting down to metal plates on the conveyor belt**, and
2. They need to have **"centering pins" that allow a person to drop the "front bracket" in from above** while the conveyor belt is moving.

The fixtures need to be created very quickly, as production is already behind schedule. In fact, 100 fixtures need to be produced within 7 full 24 hour days (168 working hours at this 3-shift factory), in other words, by *next* Monday afternoon. During a team meeting, when everyone is scratching their head about how to do this, Team Member A raises his hand and suggest to 3D print the fixtures to save time. Everyone agrees that this may be the solution to creating the fixtures in a short time frame, so he designs a fixture that meets the 2 requirements above and estimates the time required to build it:

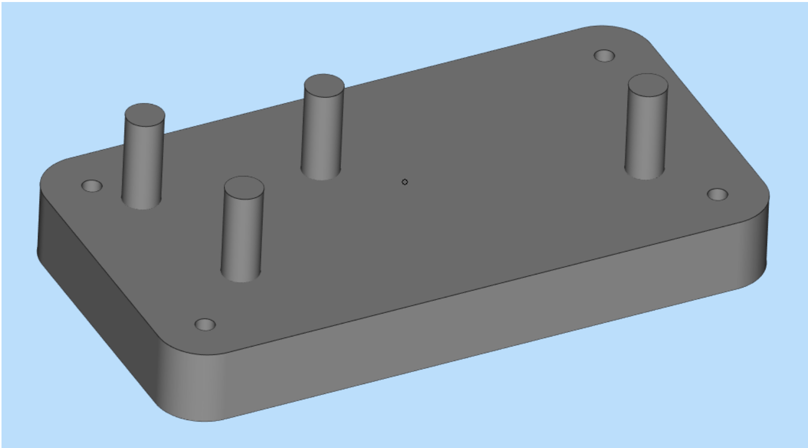

Figure MC-3: Team Member A's fixture design

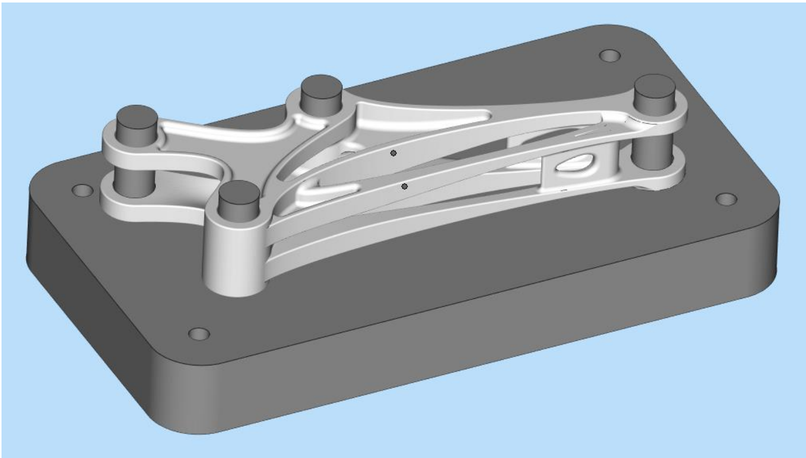

Figure MC-4: Team Member A's fixture design with the bracket laying in the "centering pins"

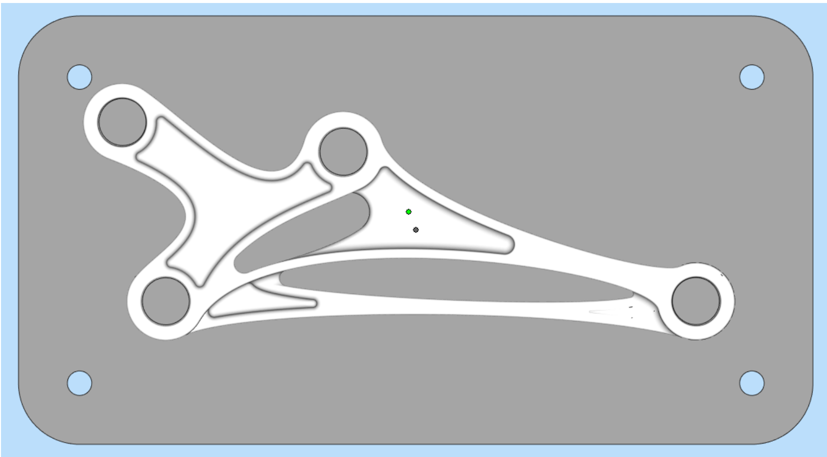

Figure MC-5: A top view of Team Member A's fixture design

Team Member A reports back to the team later on Monday morning that building each fixture will require 6 hours and 12 minutes (see the CMB file on your thumb drive).

Question 1: <u>Do the math</u>… if 168 printing hours are available, what does the per-part printing time (in hours and minutes) have to be to complete the order assuming 80% machine utilization rate ("up-time") and that 10% of the printed fixtures will not pass quality standards?

Team Member B scribbles some math onto a piece of paper and announces that the time will need to be dramatically reduced in order to meet the deadline. He adds that he'd be willing to redesign the bracket to save significantly on time and simultaneously improve the bracket's functionality.

An hour later, Team Member B presents the following design (MC-6 below) to the team, and declares that it only requires 1 hour and 3 minutes to print. He is congratulated for his creativity, and additive production of the fixture begins right away. See the CMB file of Team Member B's design on your thumb drive.

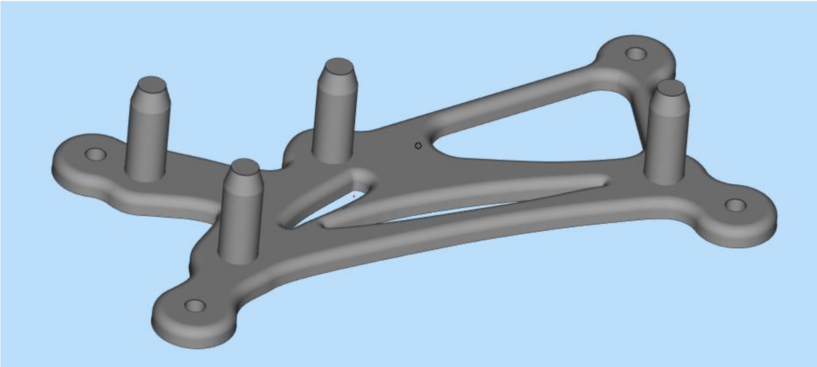

Figure MC-6: Team Member B's optimized fixture design

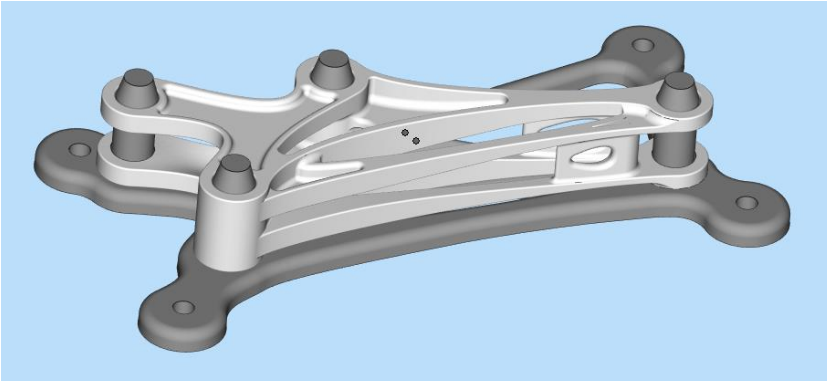

Figure MC-7: Team Member B's optimized fixture design

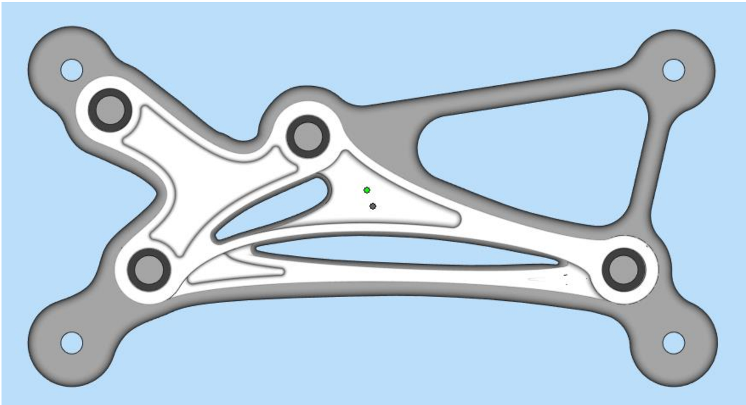

Figure MC-8: A top view of Team Member B's optimized fixture design

Question 2: **<u>Identify any TWO time-saving changes</u>** that Team Member B made to Team Member A's design. The ready-to-print CMB files for both designs are provided to you in your USB.

Team Member B boasts that his design also assists the operator who is loading the "front bracket" onto each fixture.

Question 3: **<u>Identify the TWO functionality improvements</u>** that Team Member B added that assist the operator in placing brackets onto the fixtures.

Team Member C expresses some concern about how thin the optimized design is. He picks one of the first printed fixtures up, twists hard, and it snaps along the red line shown in MC-9 below.

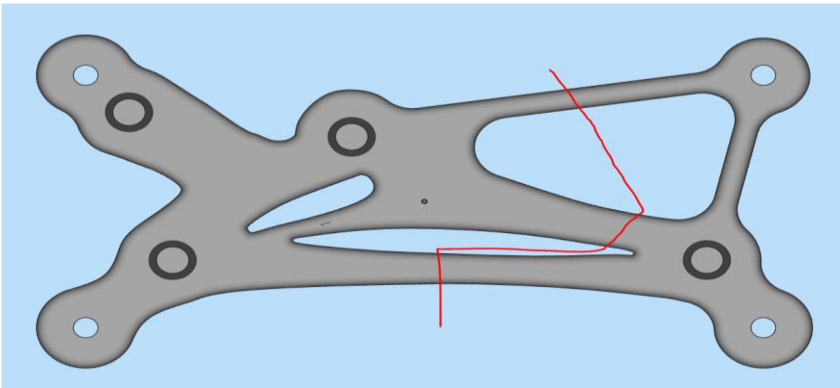

Figure MC-9: The fracture path that Team Member C identifies when twisting the part.

Team Member B reminds them of how the fixture will be used, and they all nod and dismiss Team Member C's concern.

Question 4: **<u>Remind the team:</u>** What did Team Member B specifically remind them of regarding the part's final use that makes Team Member C's concern irrelevant?