Topic: Building Robot Model (D10)
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Building Model

Summary

Timely production of models and prototypes allows accurate evaluation of design concepts on many levels. We will use a modeling technique that produces a core mock-up of the design developed by the PSU HEDS-UP team. The importance of modeling, for the HEDS-UP team, is to determine usability, tolerances, and to visualize the developed concepts and ideas. The model will be fabricated to look exactly like the final production piece and be fabricated using rapid prototyping.

Introduction

Modeling a robot that can navigate Mars is a very important part of the HEDS-UP program at Penn State University. We are proposing to build a robot that will efficiently navigate the planet. We have a budget of only $2000, which limits the methods we can use to make a prototype robot. So in order to model a prototype robot that will sufficiently navigate on Mars we are going to use the tools available at the Learning Factory. With the aid of the Learning Factory, we intend on manufacturing the physical Mars robot model from laminate paper. To do this, we will use a rapid prototyping machine that layers paper upon paper to the design specifications. Each robotic design will need to be drawn by team members using Pro/Engineer, a 3-D CAD (Computer Aided Design) program. After fabrication, the modeling team can then finish, paint, decal, and present the robot model.

The Learning Factory

The Learning Factory is an integrated manufacturing facility accessible by registered PSU students. The physical industrial facilities offer a new approach to manufacturing by integrating engineering science and practices. Each student can attain access to the facility after completing a four-hour safety course. This safety course will allow the certified student access to power tools and some machining equipment. After acquiring the basic certification, the student may also earn more specialized certification.

The facility is equipped with the following equipment:

- **Machining**
  - 3 Axis CNC Machining Center
  - Mills
  - Lathes
  - Drill Press
- **Rapid Prototyping**
  - Helisys LOM Machine and Stratasys FDM 2000
- **Stock Cut-Off And Grinding**
  - Cut-Off Saw, Band Saw, Belt Sander, Pedestal Grinder, Surface Grinder, Bead Blaster
- **Welding And Cutting**
  - TIG, MIG, and Plasma Cutter
- **Sheet Metal Forming**
  - Metal Forming Machine
- **Assembly And Small Hand Work**
  - Workbenches, Hydraulic Press, Arbor Press, Hand Tools, and Hand Held Power Tools

The LOM (Laminated Object Manufacturing) Machine

To construct the model, each design concept is drawn using Pro Engineer. Once each part of the robot is drawn, the file can then be submitted to the Learning Factory for fabrication. To implement the prototype robot we plan to use the LOM machine. The LOM machine uses a unique process by which a thin adhesive coated material is laser cut and bonded to the layer beneath. The LOM builds layer by layer of paper to create a 3-dimensional object. The LOM offers a rapid yet powerful economical prototyping system to build a prototype of a model robot which. The LOM machine uses laminated paper, .004" (.1mm) thick, to produce a finished product that has approximately the same engineering properties as wood. Minimum wall thickness of the design is limited to .10" (2.5mm) with a maximum part volume equal to 14"L x 9"W x 13"H. Given the limitations of the machine, we can only fabricate a scaled version of the final design. Though the model is not full-scale, it will still resemble the finished product in functionality and design.

The learning factory will determine the price of the design after submittal of the file and prior to manufacturing. The cost of a single sheet of laminate paper is $.14 per foot used. Time for completing the product will depend on the backlog of the machine but is usually between two to four days.

After a price has been determined the LOM technique follows a sequence of five basic steps to produce a prototype design. The steps are as follows:

1. Create a CAD (Pro/Engineer) model of the design (as mentioned above)
2. Convert the CAD model to STL format
3. Slice the STL file into thin cross-sectional layers
4. Construct the model one layer atop another
5. Clean and finish the model

After fabricating the model, it will then have to be finished and prepared for display. Immediately following fabrication, the modeling team will de-cube and coat the model with a sanding sealer to minimize delamination and growth due to water absorption. Once the sealer is applied, the model can then be sanded, painted and decaled as determined by the design team.

The following are examples of designs fabricated by the LOM:

Visualization model for planning the Spirit Rocket project, in which an instrumented sphere will be released from a rocket to measure the accelerations that a typical rocket payload experiences. A modified LOM-built sphere may actually be sent into space.

Stats:
Dimensions: 9" diameter
Approximate Build Time: 12 hours per hemisphere
Build Orientation: Unknown

Aesthetic model of the Leonhard Building, future home of the Industrial Engineering Department:

Stats:
Dimensions: Built in several sections, each about 8" x 6" x 4"
Approximate Build Time: 8-10 hours per section
Build Orientation: Various

Conclusion

It is necessary to fabricate a physical model of the developed concepts and ideas for many reasons in the HEDS-UP Program. By developing a robot prototype model, the robot model design team can visualize each design, determine usability on Mars, and check tolerance, in order to update to specific requirements. Our design will be fabricated using the rapid prototyping LOM machine. The LOM is one of the most inexpensive resources used to build prototype models. This was the main reason we choose to use the LOM and also due to its accessibility at the Learning Factory. By building a prototype design of the robot that will navigate on Mars, we can plan fabricate a scaled version of the final design while maintaining resemblance. This will indeed be a successful process in the robot design model for the HEDS-UP Program.

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