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MAKER: Locomotive Steam Engine Valve Plug

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Locomotive Steam Engine Valve Plug: Honor's Contract
Maker Space Project

Acquiring replacement parts for ageing equipment and mechanisms has become increasingly difficult due to the lack of original engineering drawings, the variability between the machines themselves, and the low to nonexistent availability of replacements. Additionally, older machine parts tended to be single-made, versus mass produced, which further complicates finding an appropriate replacement. This is a distinct problem when dealing with ageing machines that are still in use, but cannot be easily fixed. This paper presents an example of how reverse engineering, modeling, and prototyping using a Maker Space may be employed to generate a part for an ageing steam locomotive. To further student learning of reverse engineering and modeling, this project was additionally used to fulfill and Honor's Contract in an introductory 3D constraint-based modeling course.[1]

To graduate with an Honors diploma, students at Western Carolina University must meet established GPA requirements and complete 24 Honors credit hours. The Honors' credit and diploma may be earned through both Honors courses and/or Honors contracts. Honors' contracts are administered through participating courses where the student engages in a challenging project that require work above and beyond the normal course materials and exercises. The current paper presents an example of how a 3D constraint-based modeling course and a Maker Space was used to complete three hours of Honors' credit for a sophomore engineering student.

A local train museum contacted the Department of Engineering and Technology at Western Carolina University to inquire about making a replacement value plug for a locomotive steam engine, as shown in Figure 1. The curator had previously performed an extensive search for a replacement valve plug, but was unsuccessful. While the project's scope was not appropriate for a senior capstone project, a good fit was found in the introductory 3D constraint-based modeling course. Working through an Honor's Contract, the primary author reverse engineered and prototyped the value plug using precision measuring tools, a 3D modeling software, and the department's Maker Space.[2]

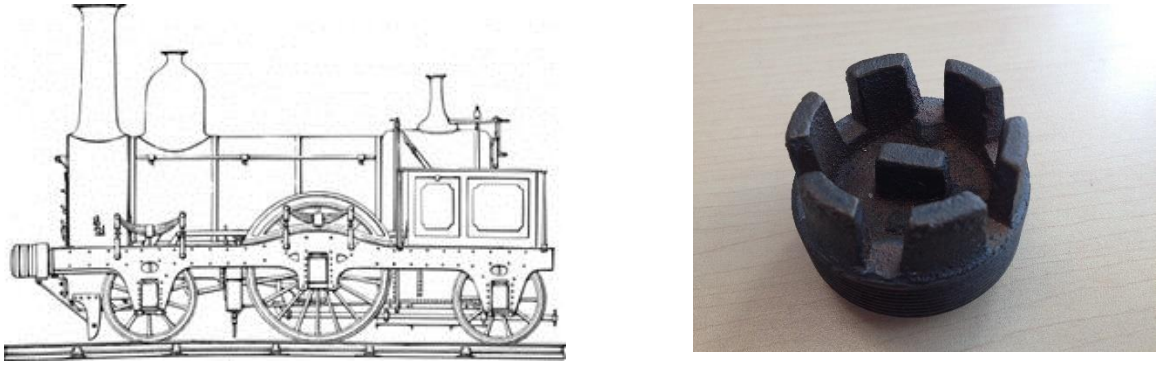

Figure 1: Steam Locomotive Valve Plug

The initial step in the process was to acquire precise measurements of the original part's dimensions using a digital caliper. The primary author investigated precise measurement

methods and was careful to employee these methods when measuring the features of the original part.[3] Individual measurements were transcribed to a hand-drawing during the process. The hand drawing was submitted to the professor for review and verification of dimensional accuracy.

After each measurements was verified, a 3D constraint-based model was created using Creo Parametric 2.0©. In creating the 3D model, the primary author considered design intent, the functionality of the part, and the crudeness of the part being measured. These considerations influenced the final part dimensions through rounding and averaging of measurements. After the final measurements were determined, standard modeling procedures followed, as depicted in Figure 2. The model required the use of several feature creation tools in Creo Parametric 2.0©, including: extrusions; revolves; variable section sweeps; and radial patterns.[4]

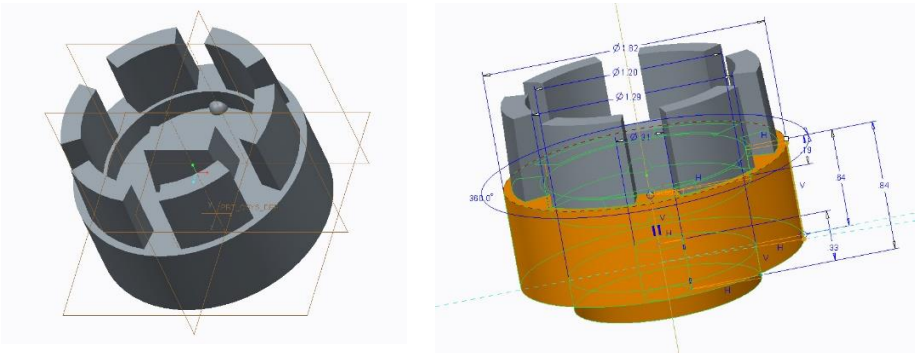

Figure 2: 3D Constraint-Based Model of the Valve Plug

Several iterations were conducted to ensure dimensional accuracy and adherence to the original design. A .stl file was generated from the 3D model and optimized for both functionality and aesthetics. The modeler smoothed the .stl model using a chord height of 0.001 inches and an angle control of 0.500 inches. The results of .stl creation are depicted in Figure 3.

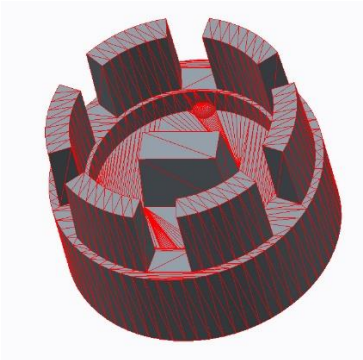

Figure 3: The .stl File of the Valve Plug

The .stl file was downloaded to the Cura© software and processed on a LulzBot© machine.[5] The author used the default machine settings for producing the prototype. Several iterations were conducted to finalize the parts orientation and build process. The process of producing the prototype took into account orientation, design intent, and manufacturability. Two variations of the model were produced in order to compare two potential designs to the original part. Figure 4 depicts the prototype models of the valve plug created in the Maker Space.

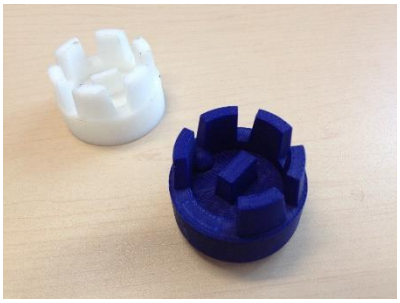

Figure 4: Maker Space Prototyped Valve Plugs

The authors believe this project was a success. Reverse engineering is a relevant solution to the need for parts no longer in production. Using precise measurements, an understanding of design intent, and 3D modeling, engineers can remake existing parts for a relatively lost cost and with minimal error. This allows for the integration of modern technology with more antiquated mechanisms still in use today. Overall, the primary author fulfilled the Honor's Contract and gained knowledge and skills, above and beyond the normal course, in the areas of reverse engineering, 3D modeling, and prototyping.

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