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Machining Fixture Redesign

Patrick Haight
Iowa State University, plhaight@iastate.edu

Joshua Schaudt
Iowa State University, jschaudt@iastate.edu

Tyler Smith
Iowa State University, tmsmith@iastate.edu

Ryan Werner
Iowa State University, rwerner@iastate.edu

Joseph R. Vanstrom
Iowa State University, vanstrom@iastate.edu

See next page for additional authors

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Problem Statement

Current fixture for machining an OEM part is lacking robustness and ease of use. Our team has been chosen to develop an improved machining fixture for use in a horizontal machining center. Our client is Quality Manufacturing in Urbandale, Iowa. QMC serves OEM manufacturers with high tolerance parts that range in a variety of sizes. Fixture lacks repeatability and ease of use for operators.

Disciplines

Bioresource and Agricultural Engineering | Industrial Technology

Authors

Patrick Haight, Joshua Schaudt, Tyler Smith, Ryan Werner, Joseph R. Vanstrom, and Jacek A. Koziel

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Machining Fixture Redesign

Patrick Haight [a*], Joshua Schaudt [b*], Tyler Smith [c*], Ryan Werner [d*], Joseph R. Vanstrom [e*] and Jacek A. Koziel [f*]

[a] Agricultural Systems Technology, ABE, ISU, plhaight@iastate.edu
[b] Industrial Technology, ABE, ISU, jschaudt@iastate.edu
[c] Industrial Technology, ABE, ISU, tmsmith@iastate.edu
[d] Industrial Technology, ABE, ISU, rwerner@iastate.edu
[e] Dept. of Agricultural and Biosystems Engineering, ISU, 2321 Elings Hall, Ames, IA 50011, vanstrom@iastate.edu, 515-294-9955
[f] Dept. of Agricultural and Biosystems Engineering, ISU, 4350 Elings Hall, Ames, IA 50011, koziel@iastate.edu, 515-294-4206

*course instructors and corresponding authors.

Client: *Quality Manufacturing Corporation, 4300 NW Urbandale Drive, Urbandale, Iowa, 50322, qualitymfgcorp.com*

- Adrian Stamper/VP Operations, AdrianStamper@qualitymfgcorp.com
- Ryan Jensen/Programmer, RyanJensen@qualitymfgcorp.com

PROBLEM STATEMENT

Current fixture for machining an OEM part is lacking robustness and ease of use. Our team has been chosen to develop an improved machining fixture for use in a horizontal machining center.

- Our client is Quality Manufacturing in Urbandale, Iowa. QMC serves OEM manufacturers with high tolerance parts that range in a variety of sizes.
- Fixture lacks repeatability and ease of use for operators.

Business Case Statement - Our client needs to speed up the process of loading/unloading and machining an OEM part in a horizontal machining center. The sole purpose of researching, designing, and building a new fixture is to machine more parts in the same amount of time, in doing so increasing the profitability of the machine. Also, better robustness leads to fewer scrapped parts thus.

GOAL STATEMENT

- **Main Objective(s) and Specific Objectives**

Department of Agricultural and Biosystems Engineering (abe@iastate.edu) aims to be a premier team serving society through engineering and technology for agriculture, industry and living systems. ABE welcomes opportunities to discover and improve new technologies for all stakeholders.

The main objective is to design and implement an improved machining fixture to increase productivity and profitability.

- Design a fixture that meets some/all client criteria and constraints:
  - Reduce part load time
  - Reduce machine cycle time
  - Improve operator ergonomics
  - Improve machined feature accuracy
  - Fixture must be compatible with Makino A51nx including machine reach, total size and available tooling (A51nx Specifications, 2018).
  - Must utilize *Jergen's Ball-Lock®* mounting system (Jergen's, 2017).
  - Must be produced primarily with methods available in-house.
  - Must provide improvement over current fixture in one/all areas of: load time, machine run time, operator ergonomics, machined feature accuracy.

- **Rationale**
  - Increases profitability by:
    - Decreasing NVA time
    - Decreasing cycle time
    - Decrease load time
    - Decrease scrap rate by improving tolerancing abilities

PROJECT PLAN/OUTLINE

- **Methods/Approach**
  - Reference Material(s)
  - Machinery's Handbook 30th Edition
  - A51nx Specifications. (2018). 2nd ed. Makino Milling Machine Co., pp.1-41.
  - **Data collection**:

    We gathered data from operators, quality control engineers and programmers. This data consisted of CMM reports regarding non-conforming parts, operator feedback and issues regarding current design and process, and also the needs of the programmer for tooling being used. Machine specifics specifications were collected form literature accessible from Makino (A51nx Specifications, 2018).
  - **Skills**:
    - Our project required our team to utilize Autodesk Inventor for designing of the new fixture.
    - As a team we also used communication skills learned in Speech Communication 212 and English 150, 250, and 314.
  - **Solutions**:
    - As a group we made a few important trips to our client to figure out what the problem was and figure out where the current process was at.
    - Measurement of the solution's performance will be gauged by run time decreases, load time decreases, and operator ergonomic feedback.
  - **Organization:**
    - Our team communicated almost weekly with our main contact at Quality Manufacturing.

        - We used email as our main communication device and scheduled phone calls during weekly meetings to touch base on project progression.
- **Results/Deliverables**
    - Our main deliverable for this project was a working, physical machine fixture to be functional by our project presentation day (4/20/18).
    - The following steps we will have to complete our project are:
        - Help assemble the fixture components into the final assembly.
        - Gather feedback from machine operators on loading and use of the new fixture.
        - Be present when parts are being run on the new fixture.
        - Record new data regarding cycle time, load time, and CMM reports.
        - Bring all data together and assess whether or not the new fixture improved in the areas of cycle time, part load time, and quality.

BROADER OPPORTUNITY STATEMENT

While the initial scope of this problem is limited only to a single machine fixture for a single production part for a single manufacturer, the possible impact for this solution could reach much further. The work of improving a machine fixture is applicable to nearly any industry that utilizes CNC equipment to produce parts, especially manufacturers who partake in high count production runs. Current fixtures in use by any manufacturer could all benefit from evaluation/redesign for robust fixturing strategies as well as ergonomic consideration. With an increased push in the manufacturing industry for lean production techniques, development of machining fixtures that reduce as many non-conforming parts as possible lead the industry in the direction of high cost efficiencies.

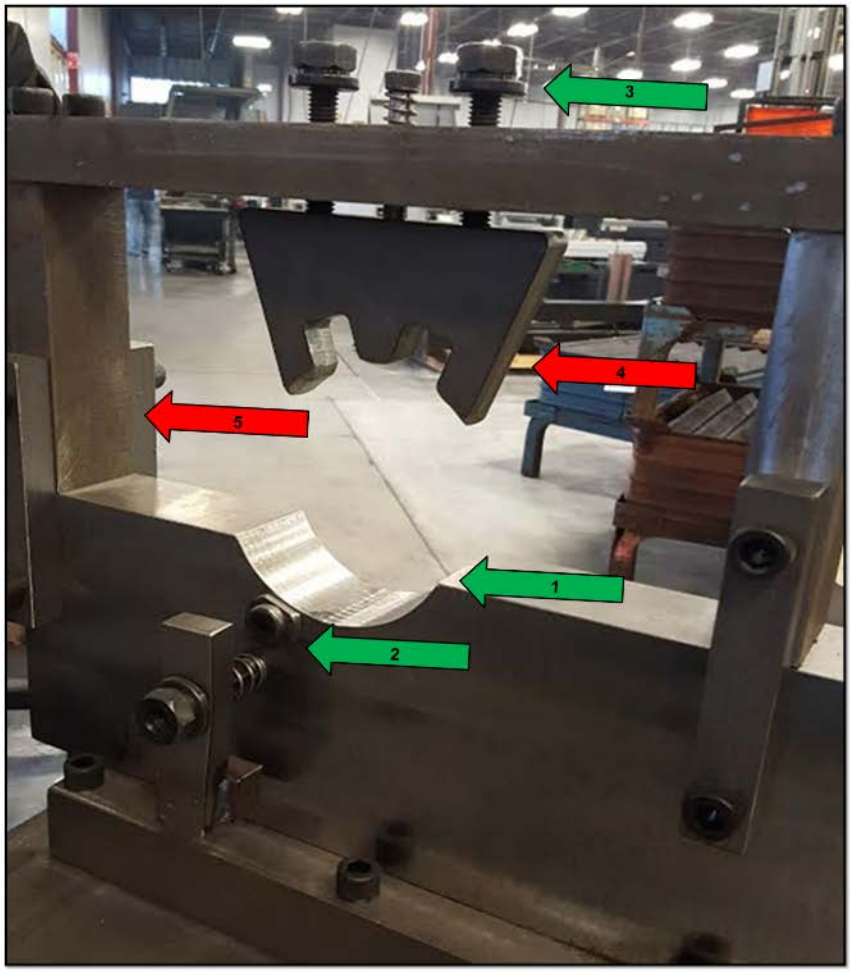
PROJECT SCOPE

The initial scope of this project was to provide the client with a ready-to-implement design for a single machining fixture capable of producing a single part utilizing their Makino A81nx HMC. This project was to only supply intellectual material, including solid models and production drawings, but no physical components were to be supplied by the team. A shift in the project scope happened very early on with the clients request to design the fixture for use in their Makino A51nx, a smaller HMC. With this change no other areas of the project scope were affected. The team was to work primarily with the machining department, the quality department therein, and direct questions to other departments when necessary.

GRAPHICAL ABSTRACT

Pros:

- Distributes clamping force across bottom of part [1]
- Locates front flange against hardened pin [2]
- Reduced number of clamps that must be actuated by operator [3]



Cons:

- Top clamping structure pin-points force and deforms part [4]
- General lack of rigidity [5]
- Unnecessary space between parts
- Operator must manually align part feature with digital level

DESIGN IMPLEMENTATION

Once the team completed the design and technical drawings all information was handed off to QMC for production. All primary components were internally routed and completed in the machining department. All accessory components, such as hardware, were either internally sourced or purchased by QMC. The team worked closely with production staff and management to ensure accurate assembly and provide troubleshooting for any problems that arose. Initial alterations were made to the manufacturing process after advisement from QMC staff. This change consisted of waiting to machine the features that the part rested against until it could be loaded into the machine that will use it for running production. This change will increase the accuracy by ensuring that the features are completely aligned with that specific machines axis.

RESULTS

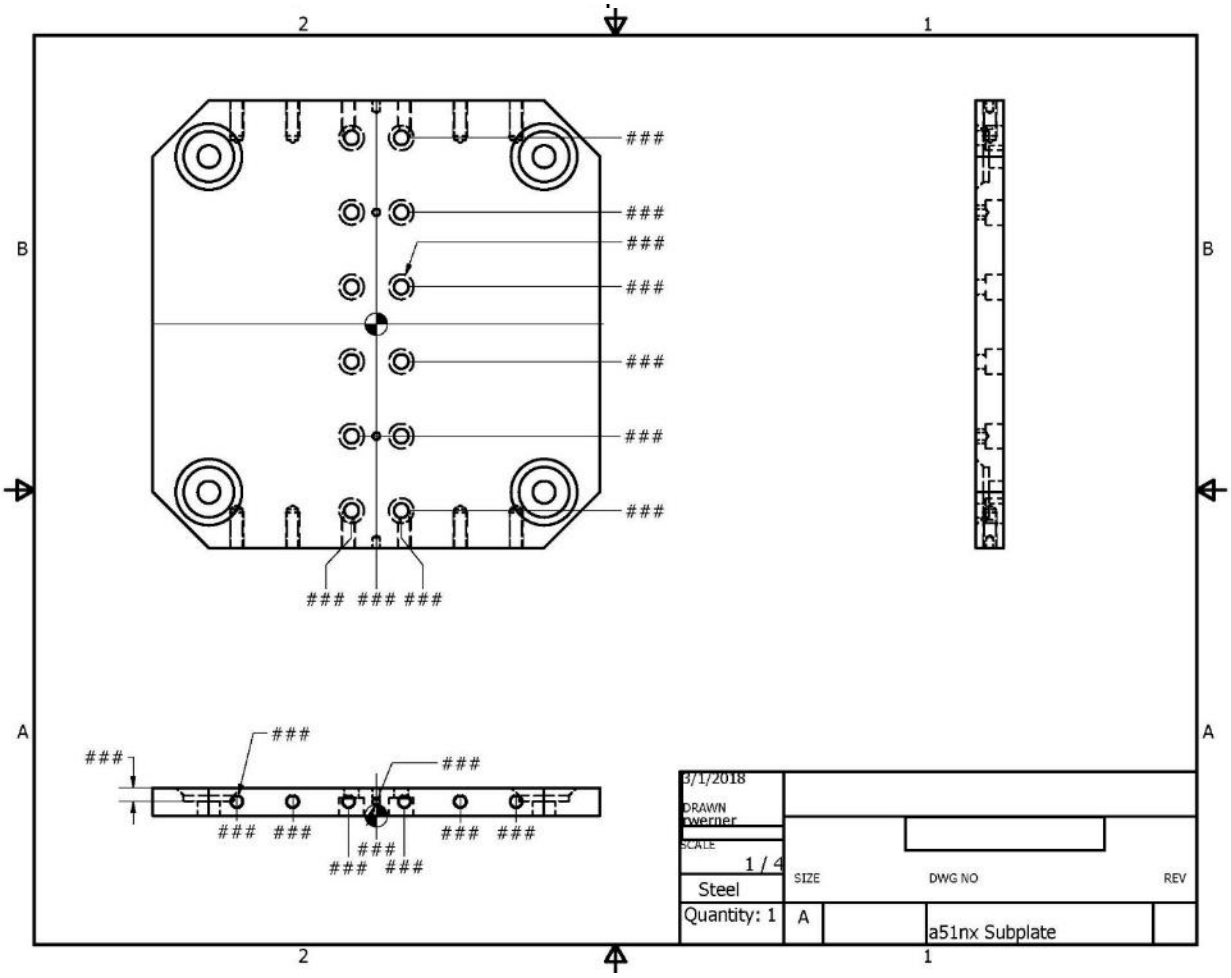
Once the fixture was fully implemented and used for production the team was able to visit QMC again for data collection. The new fixture had dropped the load time required for two parts to 2.5 minutes. This is a 4.5 minute reduction from the previous 7 minutes load time. The increased fixture rigidity, along with the transition to a machine with faster axis speeds, has led to a new cycle time of 18.5 minutes for two parts. This is a 7 minute reduction from the previous 25.5 minute cycle time. Along with the quantitative data the team also collected qualitative data from the machine operators about the new fixtures ergonomics. This feedback showed a preference for the reduced number of clamping bolts needed to be actuated, as well as the replacement of the labor intensive alignment process. Constructive feedback from the operators included requesting stiffer springs for the guide rods and possible modifications to the clamp bar that accommodate parts that have been distorted from welding.

REFERENCES

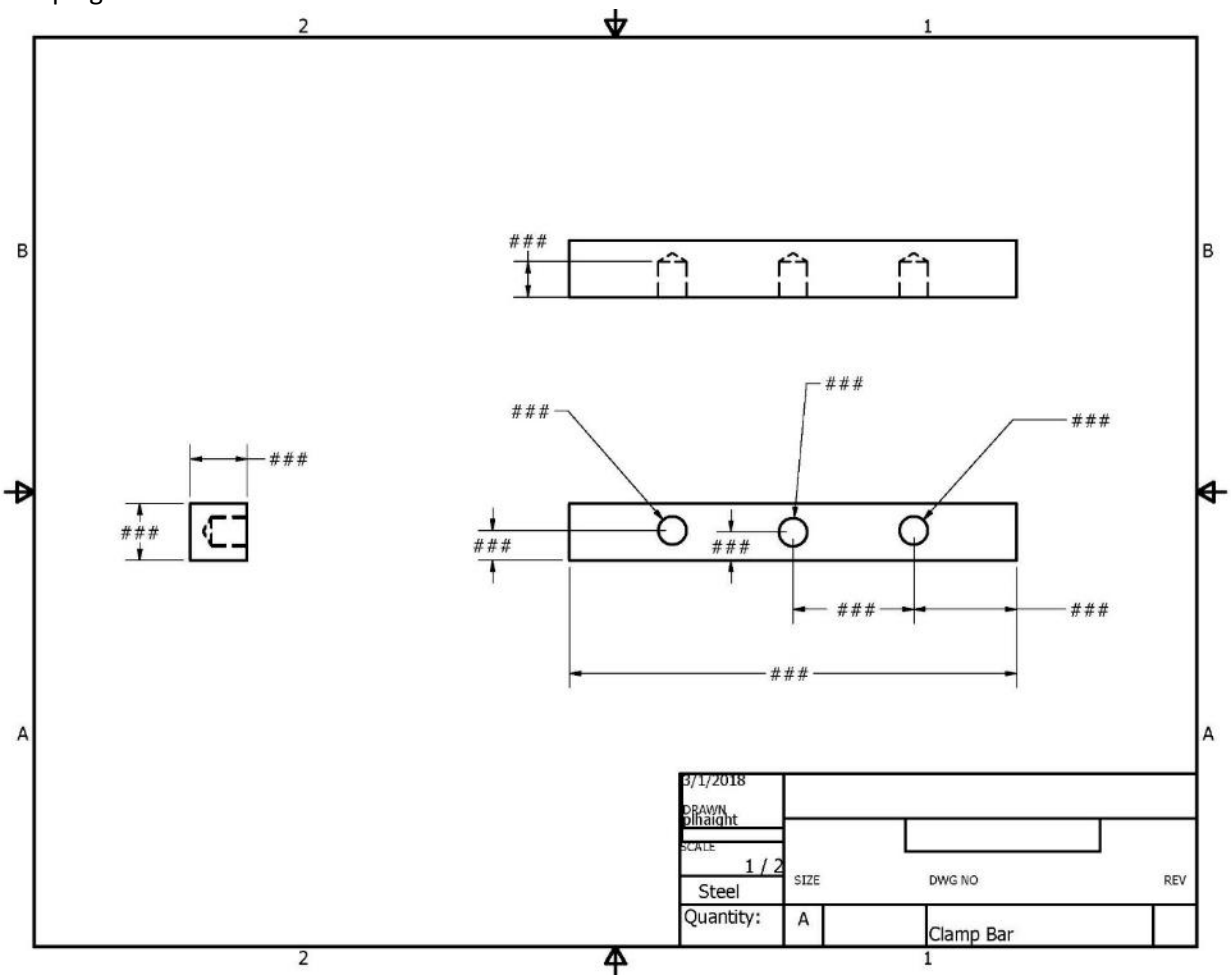
- A51nx Specifications. (2018). 2nd ed. Makino Milling Machine Co., pp.1-41.
- Jergens Workholding Solutions. (2018). Cleveland, OH: Jergens Inc, pp.19-27.
- Oberg, E., Jones, F. D., Horton, H. L., Ryffel, H. H., & McCauley, C. J. (2016). *Machinery's handbook: A reference book for the mechanical engineer, designer, manufacturing engineer, draftsman, toolmaker and machinist* (30th edition.). New York: Industrial Press.

APPENDIXES

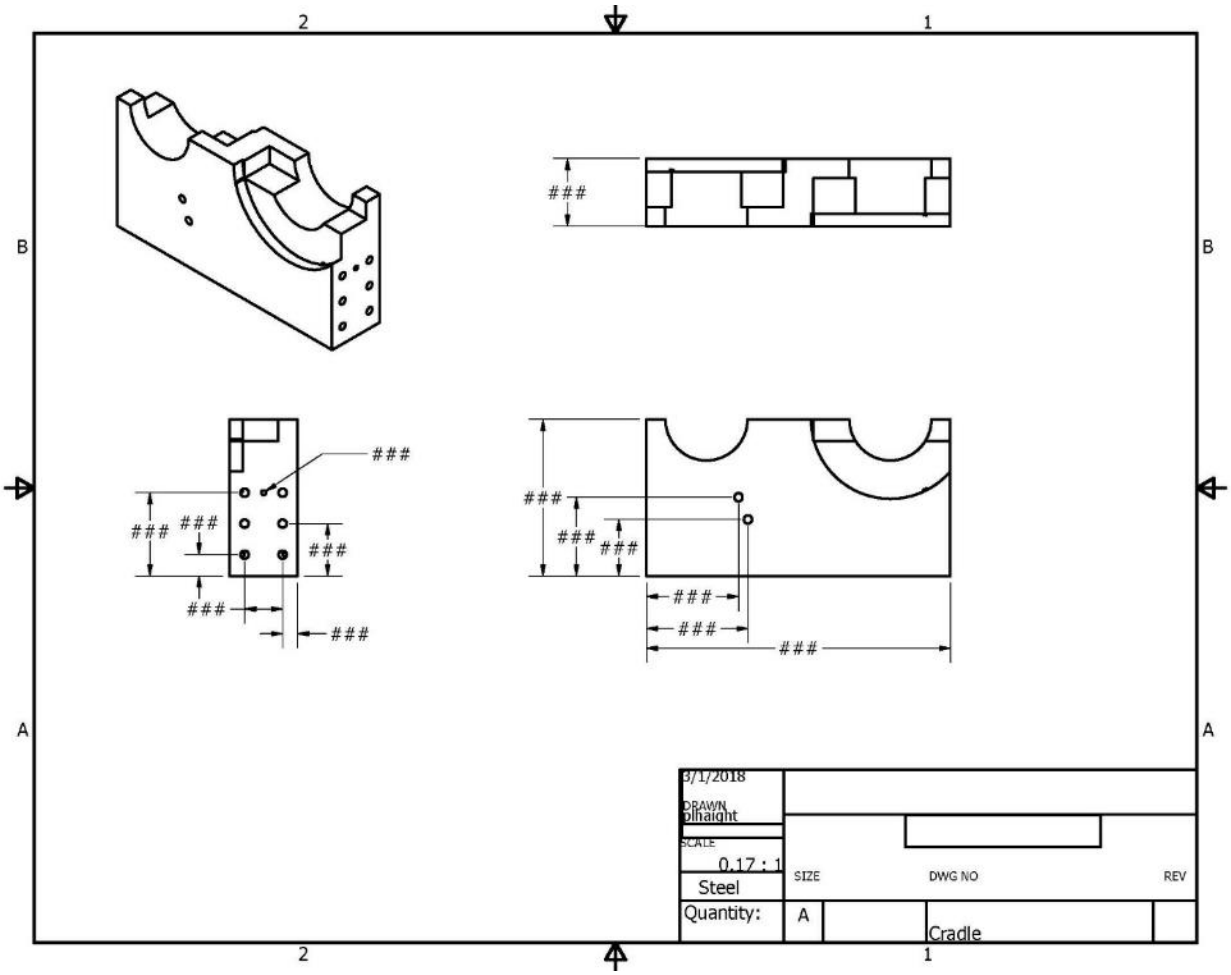
Subplate



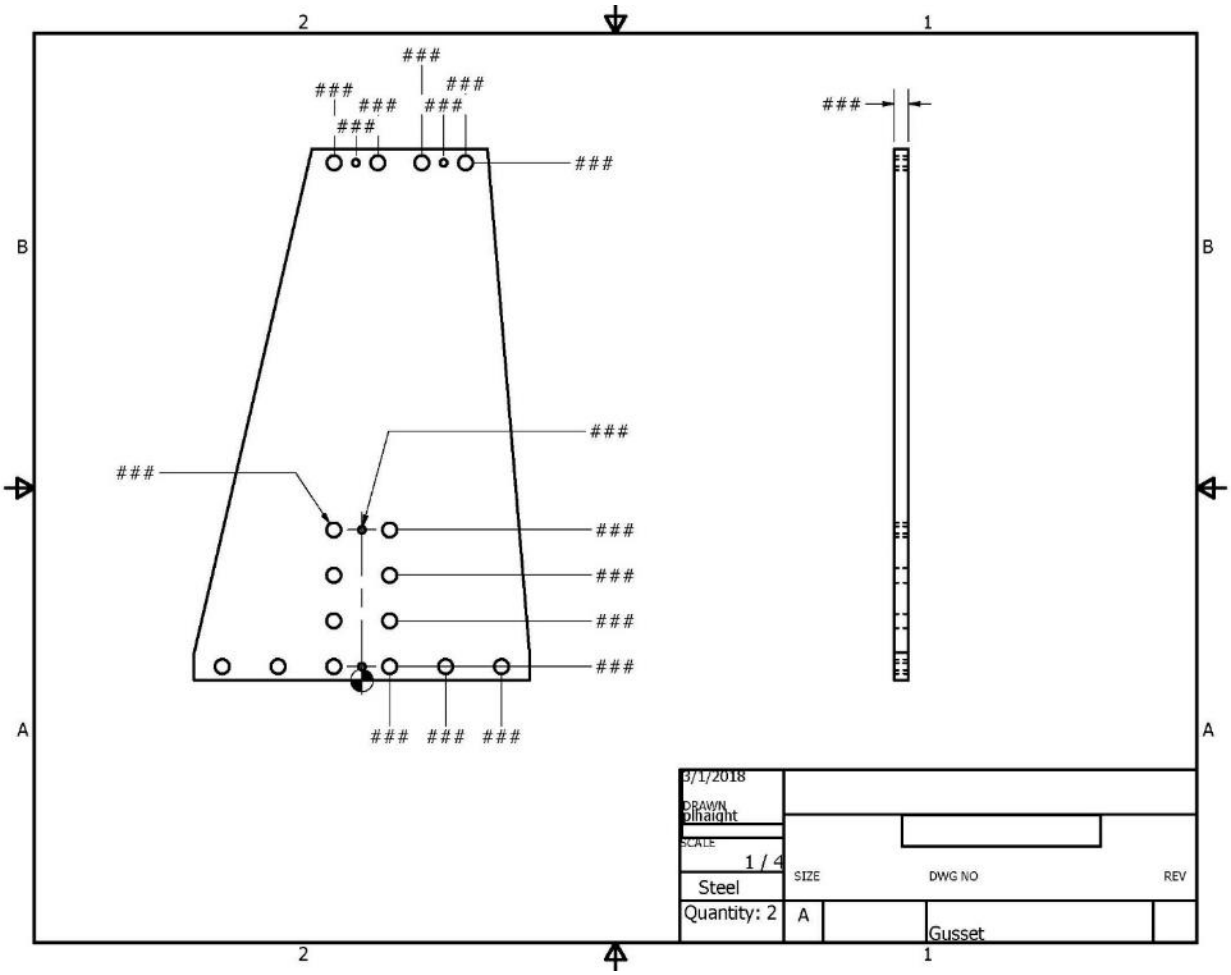
Clamping Bar



Cradle Block



Gusset


2
1
B
A
###
3/1/2018
DRAWN
blhaight
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Steel
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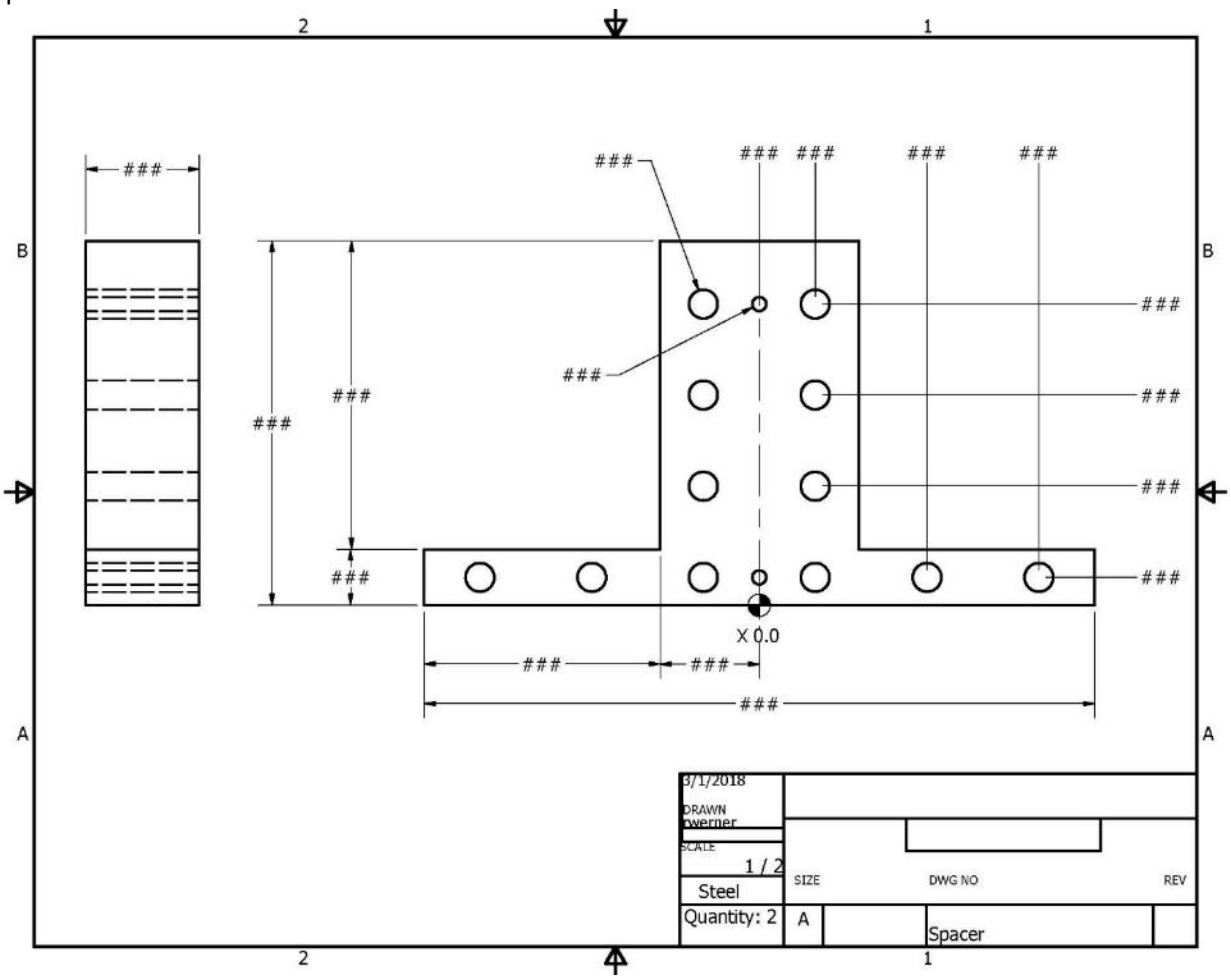
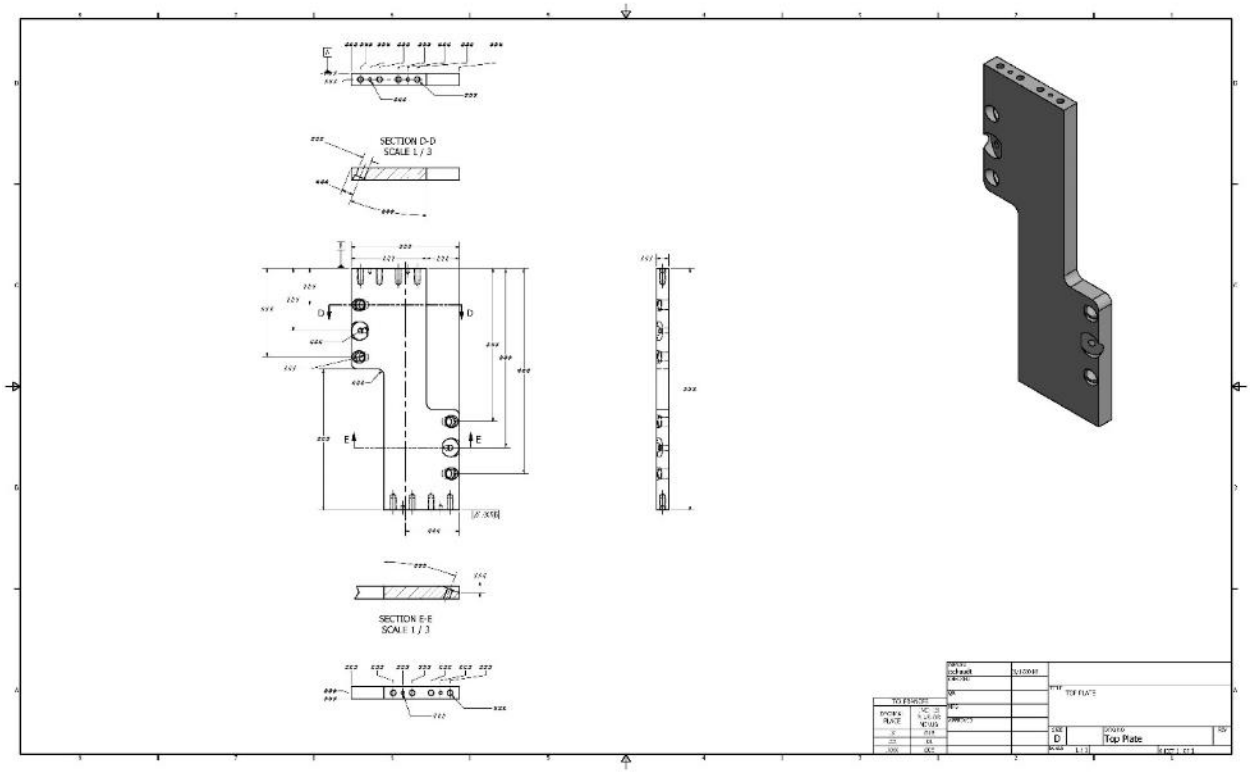
SIZE
DWG NO
REV
A
Gusset

Spacer Block



Top Plate



Full Fixture Assembly