GNG 1103

Design Project User and Product Manual

Flush-Bolt Jig

Submitted by:

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Table 1 Acronyms

Acronym	Definition
BOM	Bill of Materials
BOP	Block-off Plate
BS	Back-stopper
LS	Lead Screw
UNC	Unified National Coarse thread form
UPM	User and Product Manual

Table 2 Definitions

Term	Definition
Back-stopper (BS)	A template to guide the center of the jig a fixed distance from the end of the door
Block-off plate (BOP)	Flat template surface for routing the mortise. Also provides markings for the cutout.
Jig	A fixture used to guide a tool to perform a specific operation.
Lead screw (LS)	The main screws used to tighten the jaws.

1 Introduction

This User and Product Manual (UPM) provides the information necessary for an AMBICO employee to construct and use the jig effectively. This document also documents our design process including our prototyping phase.

2 Overview

AMBICO presented a unique problem during the first client meeting, needing a product to be able to create mortises for flush bolts in various sizes of doors more efficiently. They needed a product that was easy to manufacture using their existing toolings, cost-effective, efficient for a worker to use, and intuitive to use. Our product provides a self-centering mechanism and very fine adjustability, as well as modularity to solve this problem, allowing for a simplistic design that is incredibly easy to learn and use. The product is fully self-centering over the entire size range of AMBICO's doors and provides a flat and measured cutout and routing surface for an even depth and size mortise. It includes soft contacts to not damage the product it is being used on, as well as an interchangeable back-stopper for the user's choice of axial offset.

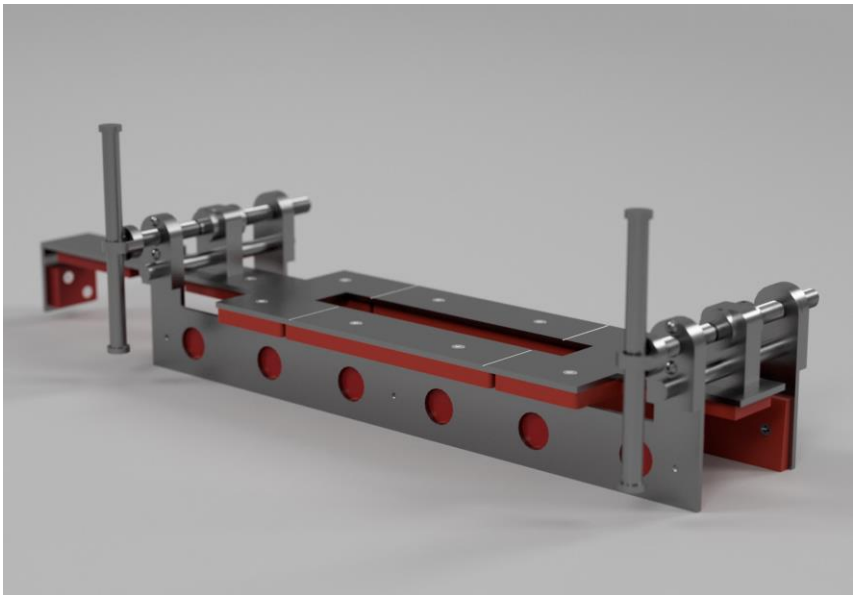


Figure 1

3 Using the System

The following subsections provide detailed, step-by-step instructions on how to use the various functions or features of the jig.

1. Attach appropriate BS using the removable screw. This screw should be no more than hand-tight

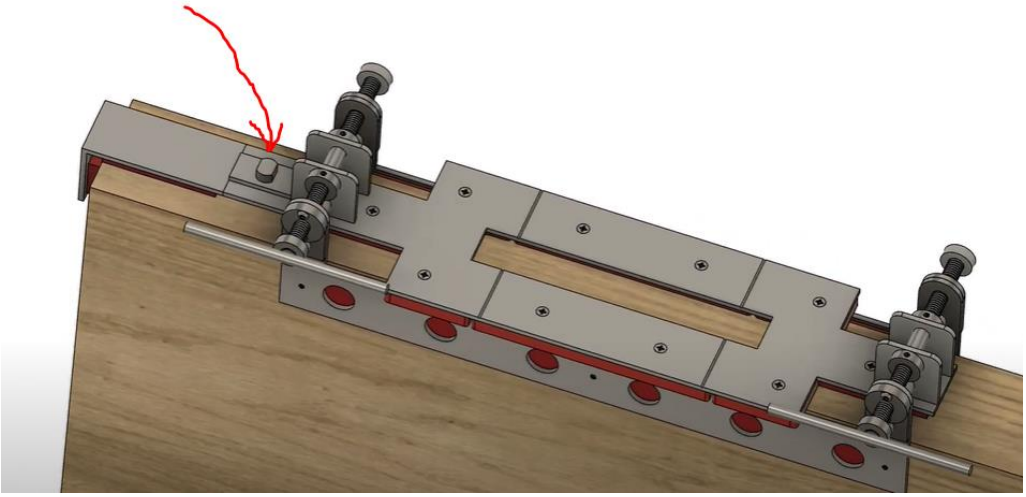


Figure 2

2. Stand beside the door with the bevel facing the user.

3. Place the jig on the door with handles facing the user. Align the BS with the end of the door.

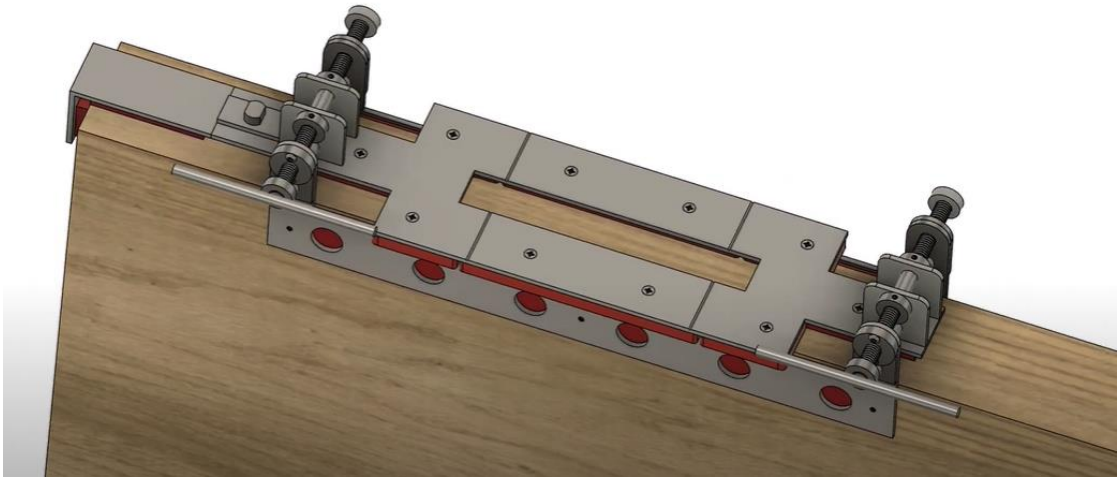


Figure 3

4. Tighten both handles evenly until the jig is tightly clamped to the door.

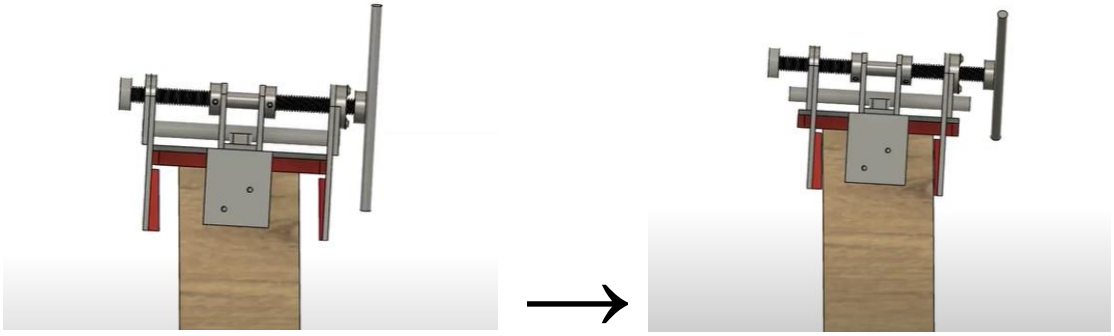


Figure 4

5. Route the mortise out using the BOP to trace.

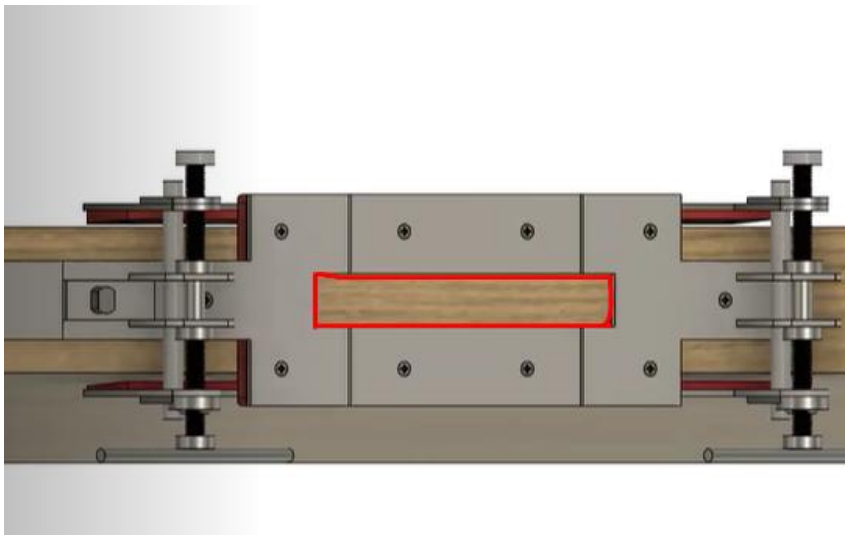


Figure 5

4 Troubleshooting & Support

4.1 Preventative Maintenance

- Occasionally apply lithium grease to the LSs as necessary with use to ensure smooth operation of the device.
- Before each use, inspect the jig for any signs of wear or damage. Clean the contact surfaces so that no debris damages the door. Do not wipe the grease off the LS.
- Store the jig in a dry, dust-free environment when not in use. This prevents corrosion and accumulation of debris on critical components.

4.2 Potential Problems and Mitigation

Table 3 Problems and solutions

Problem	Solution
One handle is unable to turn	Turn both handles at approximately the same time.
The jig does not align correctly, resulting in off-center mortises.	Check the alignment of the BS and ensure it is correctly installed. Adjust the BS for the desired axial offset.

5 Product Documentation

5.1 Estimated BOM (Bill of Materials)

Table 4 BOM

Item	Quantity	Unit Cost	Total Cost	Price source
⅛” hot rolled steel sheet	12”x18”	$15 per square foot	$22.5	Metalpros.com
¼” hot rolled steel sheet	4”x6”	$33 per square foot	$5.28	Metalpros.com
⅜” precision ground cold rolled steel rod	24”	$10 per foot	$20	Metalpros.com
⅜” hot rolled steel rod	12”	$1 per foot	$1	Metalpros.com
PLA Filament	~300g	$0.03/gram	$9.00	Filaments.ca
TPU Filament	35g	$0.14/gram	$4.90	Filaments.ca
Total			$62.68	

5.2 Equipment list

Table 5 Equipment list

For construction by AMBICO	Used during prototyping
Laser cutter	Milling machine
Left and right hand ⅜-16 UNC taps	Lathe
Left and right hand ⅜-16 UNC dies	Drill
Right hand 6-32 UNC tap	Right hand ⅜-16 UNC tap
MIG or TIG welder	Right hand 6-32 UNC tap

Screwdriver	TIG welder
	Screwdriver

5.3 Instructions

The detailed technical drawings (Appendix I) for each subsystem show how each part is to be constructed. Each part can be manufactured using any logical order or method unless otherwise specified in the drawing. However, assembly of certain parts must be done in a particular order. The following steps describe the assembly order and steps. Refer to the drawings when reading these instructions whenever necessary.

5.3.1 Setting up the adjustment system

1. Precisely align the holes in the two support pieces (Adjustment Item 1) and tack weld the parts together. Repeat for the second adjustment mechanism.

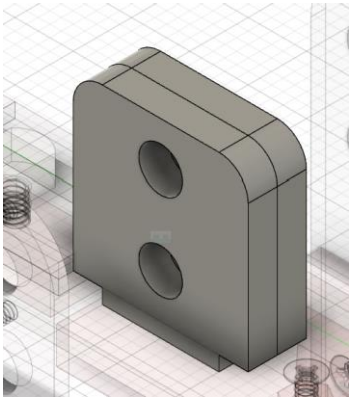


Figure 6

2. Insert both supports into their corresponding slots in the backer plate. Square the parts to the backer plate and weld them in place. Do not allow the parts to warp. For this step, the guide rods (Adjustment Item 2) can be inserted into the holes to serve as an indicator. They should be parallel to the backer plate.

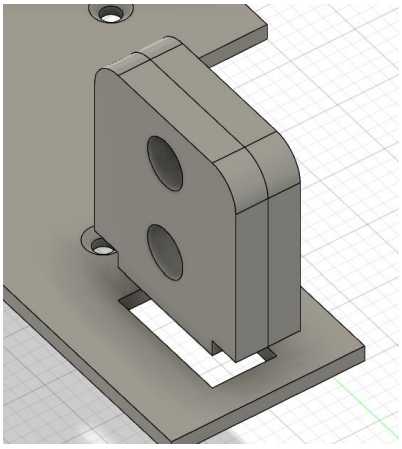


Figure 7

3. Align the holes in the left thread extensions (Adjustment Item 14) to the corresponding holes in the left contact backer plate. Weld the extensions to the contact backer. Once this is complete, the upper holes in the backer/extension can be threaded with a ⅜-16 UNC right-hand tap.

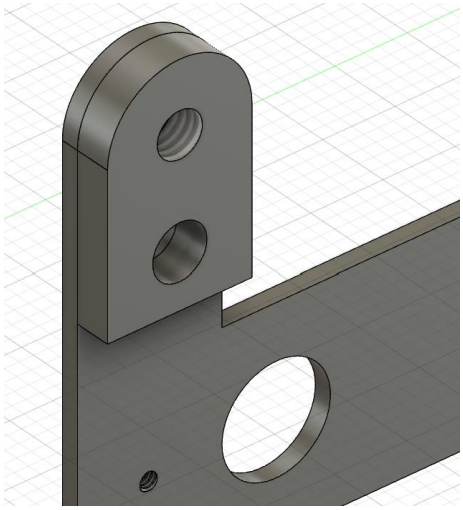


Figure 8

4. Align the holes in the right guide extensions (Adjustment Item 15) to the lower holes in the right contact backer plate. Ensure the edges of the extensions are parallel to the edges of the backer. Weld the extension to the backer. Do not weld on the inner radius (top side) of the extension because another part fits in there.

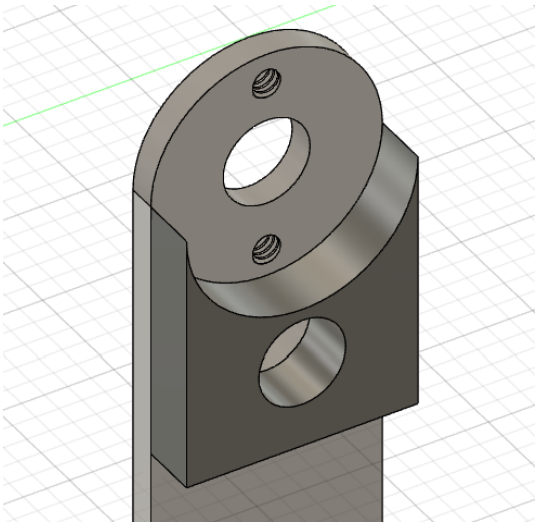


Figure 9

5. Insert the LSs (Adjustment Item 4) into the upper holes in the center supports. Install the collars (Adjustment Item 5) on the LS using roll pins. The LS should freely rotate but should not be restricted in axial movement (~<0.010" axial movement). If the fit is too tight, the inside faces of the collars can be ground until it is loose enough. Insert the guide rods such that they are centered. Weld the guide rods to the supports, ensuring that no spatter gets on the threads and no warpage occurs.

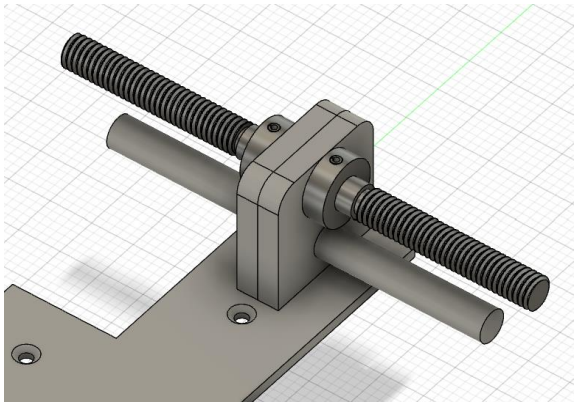
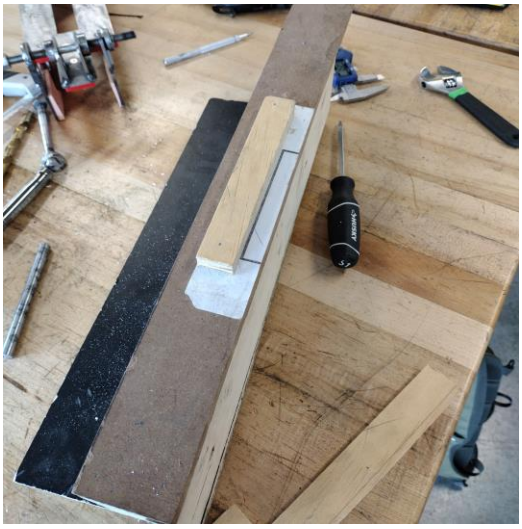


Figure 10

5.3.2 Assembling and calibrating the adjustment/contact system

1. Construct a jig using a longer piece of lumber (~ 2" wide) with another smaller piece 1" x 6-¾" (size of the flush bolt mortise) centred on the edge of the long piece (in the same

location the flush bolt would be on a door). Ideally, these pieces should be perfectly square and true (i.e. jointed and planed). Place the backer plate on the long piece, with the mortise hole indexed on the small piece. Ensure the backer plate is centred on the width of the long piece.



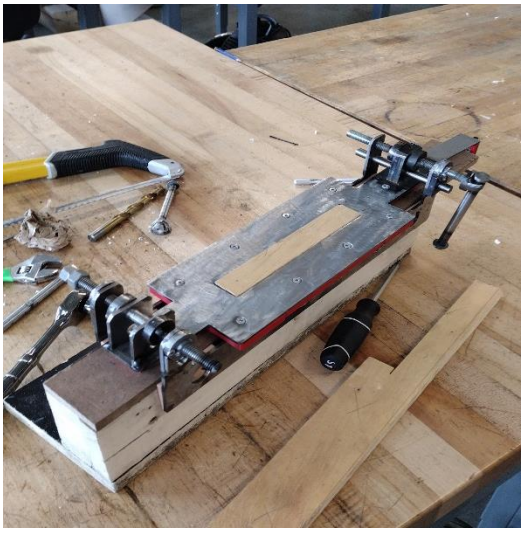


Figure 11

2. Thread the left contact onto the LSs. Tighten both screws such that the left contact is in contact with the long piece of wood. Using callipers, check that both sides of the left contact are the same distance from the edge of the block-off plate.

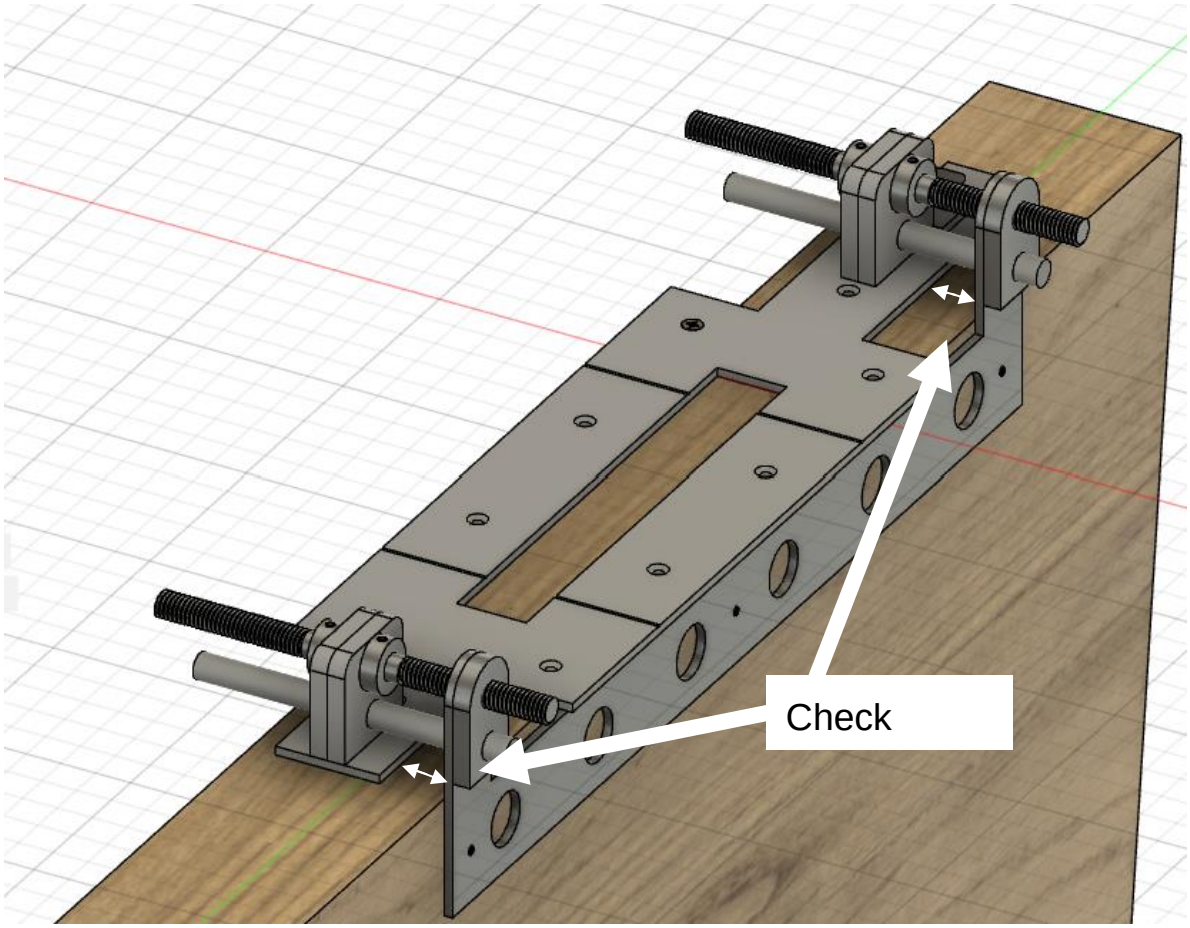


Figure 12

3. Insert the right contact onto the guide rods/LS. Remember that, at this point, there are no threads on the right contact, so it will slide freely on the guide rods. Slide the right contact in such that it is contacting the long piece of wood. Clamp the contact in place. Again using calipers, ensure that all four distances between the sides of the contacts and the BOP are the same.

4. Thread the right thread inserts (Adjustment Item 7) onto the LSs until they are finger-tight against the right contact. Secure the inserts to the contact (use super glue and/or vice grips).

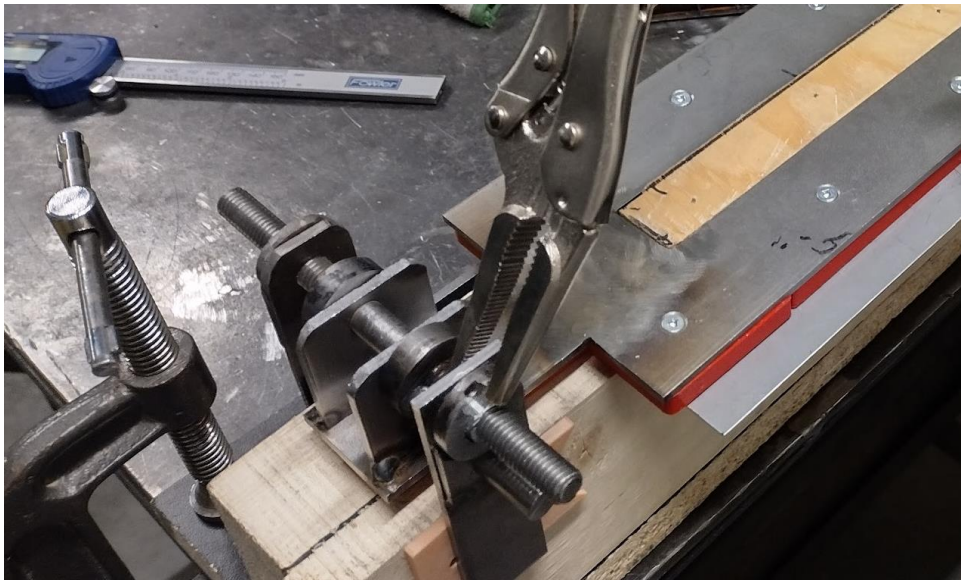


Figure 13

5. Using the holes in the thread inserts as a guide, drill into the contact with a #36 drill bit. If the LS is in the way of drilling, the LS can be turned to back the contacts out. If this is required, reconfirm that the distances between the contacts and the block-off plate are consistent (the distance will be larger than last time but they should all be the same relative to each other) to ensure nothing shifted.

6. Tap the holes for a 6-32 UNC screw. Install the screws.

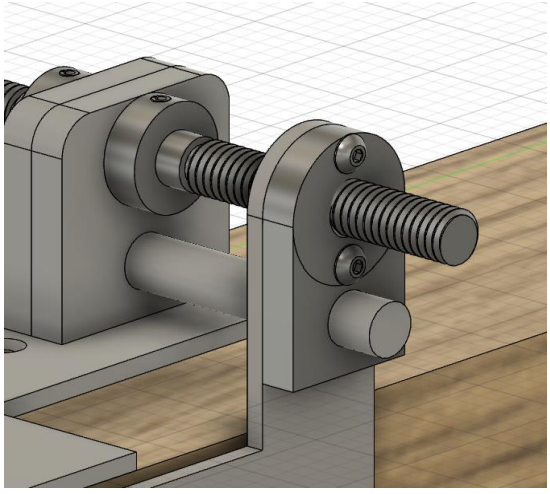


Figure 14

5.3.3 Final assembly

1. Install the bottom surfaces on the bottom of the BOP backer using 6-32 machine screws and nuts. Bottom surface “B” (BOP Item 3) is not symmetrical. The side closer to the screw holes installs towards the inside of the jig.
2. Install the soft jaws on the contact backers. Refer to the drawings to ensure the correct one is installed on the correct backer and in the correct orientation.

5.4 Testing & Validation

Table 6 Testing

Test ID	Test Objective	Description of Prototype used and of Basic Test Method	Description of Results to be Recorded and how these results will be used	Results
1	Determine if there are any obvious interferences between different parts	CAD model Analysis	Yes or no	The only issue we found is that if the handles were welded to the screws, they may interfere with the router when at certain positions. To resolve this, we will allow the handle to slide out of the way, similar to a vice or clamp handle.
2	Determine if there are any immediate issues with the design being too clunky, difficult to use	3d printed prototype Visual Test	Subjectively determine if the design is acceptable or not	We determined the design to be acceptable and fairly streamlined.
3	Identify issues or possible improvements with a focused subsystem prototype	Prototype 2 Test	Issues should be noted and considered for improvement	The center support pieces were slightly difficult to align because they caused the screw to bind unless very nicely aligned. We were able to eventually align it, but this may have been easier to do with thicker material. For prototype 3, we will use ¼” steel for this.
4	Confirm	Prototype 2	Note any issues	The jaws have more than enough range to

	measurements are correct and verify adjustment range, and that they match the model	Test	and tolerances to be mindful of for the next prototype	clamp onto door thicknesses between 1-¾" and 2-¾". We found the jaws to have some slop in them. This is a result of poor tolerances in locating holes, which required us to make slightly oversized holes to allow movement. Our product was designed to be built with a CNC laser cutter, but we used a manual milling machine for our prototype, which resulted in some inaccuracies (due to user error). With a CNC laser cutter, these issues should be eliminated. However, even with our current prototype, the slop on either side should cancel out and result in a centred jig.
5	Determine how easily the product can be manufactured	During the construction of prototype 3 Test	Note any issues and make revisions to the design based on those	Our modification to the center support significantly improved the alignment of the rods and screws. However, during the manufacturing process of our jig, we still had some difficulty aligning other parts, but this mostly stemmed from the tools we had available. With Ambico's laser cutter, there should be no issues with alignment.
6	Determine whether or not the jig securely attaches to the door without damaging the door	Prototype 3 Test grip strength by shaking, knocking, etc.	Yes or no. If not, alter materials, certain dimensions, etc.	We conducted this test using a mock door edge which we made from a piece of softwood lumber cut at an 86.5 degree bevel. The jig was very secure and would not move no matter how hard we pulled or shook it. As well, the wood, which is softer than any wood that would be used on a real door, was not damaged in any way.
7	Reconfirm measurements are accurate, verifying the full adjustment range of the product	Prototype 3 Test	Note any issues and tolerances, and remanufacture parts if egregiously out of spec	After calibration, our jig met the dimensional tolerance of +/- 1/32" (0.03125). However, it could still be improved upon to an even smaller tolerance, which would be ideal for a tool that is repeatedly used. With Ambico's laser cutter and correct calibration, the tolerance could likely be reduced to at least +/- 0.015".

6 Conclusions and Recommendations for Future Work

The development of the Flush Bolt Jig represents a significant step forward in addressing the unique needs of AMBICO for creating precise mortises for flush bolts in a range of door sizes. This project has successfully demonstrated the feasibility of designing a tool that is not only effective in its function but also efficient, cost-effective, and user-friendly. Through iterative design, rigorous testing, and careful consideration of user feedback, the Flush Bolt Jig has achieved a balance between simplicity and functionality, making it a valuable addition to AMBICO's manufacturing process.

A better way to secure the right screw inserts would be to use set screws (perpendicular to the axis of the LS) to clamp them in place, rather than screwing (parallel to the axis of the LS) through the inserts. This would make the calibration stage easier and allow for more adjustment in case a mistake was made. The adjustment mechanism could be modified in the future to be easier to manufacture without a lathe.

7 Bibliography

3D printing materials and 3D printer filament supply - Toronto, Canada. Filaments.ca. (n.d.). https://filaments.ca/

Small Quantity Metal Shop: Online Pricing and availability. Metal Pros. (n.d.). https://www.metalpros.com/

8 APPENDICES

APPENDIX I: Design Files

Team Two Times Four | MakerRepo (makerepo.com)

Table 7 Documents

Document Name	Document Location and/or URL	Issuance Date
Adjustment System Technical Drawing	Can be found in the MakerRepo	25 March 2024
BOP System Technical Drawing	Can be found in the MakerRepo	25 March 2024
Contact System Technical Drawing	Can be found in the MakerRepo	25 March 2024