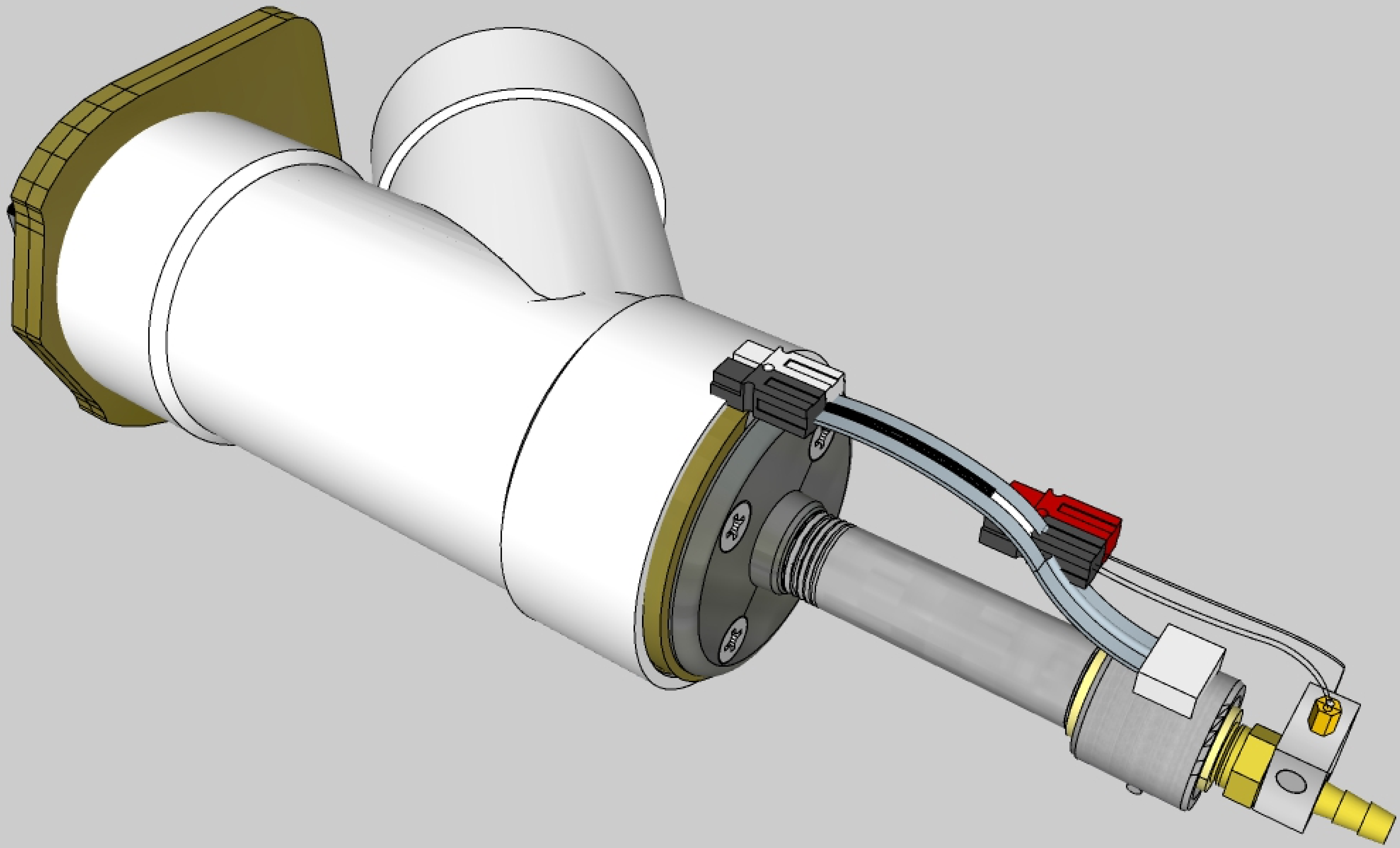
TRASH PRINTER

4.20.2020
VERSION 4.1.1



A FLAKE EXTRUDING LARGE FORMAT 3D PRINT HEAD FOR
3D PRINTING FROM PLASTIC WASTE WITHOUT FILAMENT

PROBLEM STATEMENT

Plastic waste is increasingly prevalent in our communities, and this waste poses a significant threat to human health and the health of the environment, if not properly utilized. 3D printing technology enables plastic feedstock to be turned into a wide range of useful and valuable objects, that can be rapidly customized, shared, adapted, and replicated at very low cost. It seems inevitable that 3D printers should be able to utilize locally-available plastic trash as their source of plastic feedstock, instead of having to rely on expensive virgin plastic filament that must be shipped from elsewhere in the world. However, actually utilizing truly post-consumer, locally-available waste plastics for 3D printing poses some unique challenges that must be overcome before 3D printing of plastic trash can become a widespread technology.

PROBLEMS:

POST CONSUMER PLASTIC IS RARELY CLEAN

Truly post consumer plastic waste is almost never perfectly clean. Almost all recycled plastic will have bits of dirt, food, oil, adhesives, or labelling that will be difficult or impossible to remove entirely. A successful design must be as tolerant of these imperfections as possible, without clogging or jamming.

COMMON PLASTICS ARE NOT IDEAL FOR 3D PRINTING

Polypropylene and Polyethylene are strong, flexible, and widely available plastics that make up over 50% of household plastic waste. These plastics have higher shrinkage/warp than the more rigid plastics commonly used in 3D printing, such as PLA and ABS. A successful design will be able to utilize these plastics and exploit their useful qualities, such as their strength and flexibility, and mitigate their tendency to warp, to create the widest range of objects possible.

MOST 3D PRINTERS ARE DESIGNED FOR LOW-VOLUME PRINTING

The sheer volume of plastic trash that is available around us is often staggering. Most common 3D printers have very small nozzles designed for high detail/low volume prints that take many hours or days. A successful design will be able to sink as much plastic waste as possible into useful objects as quickly as possible.

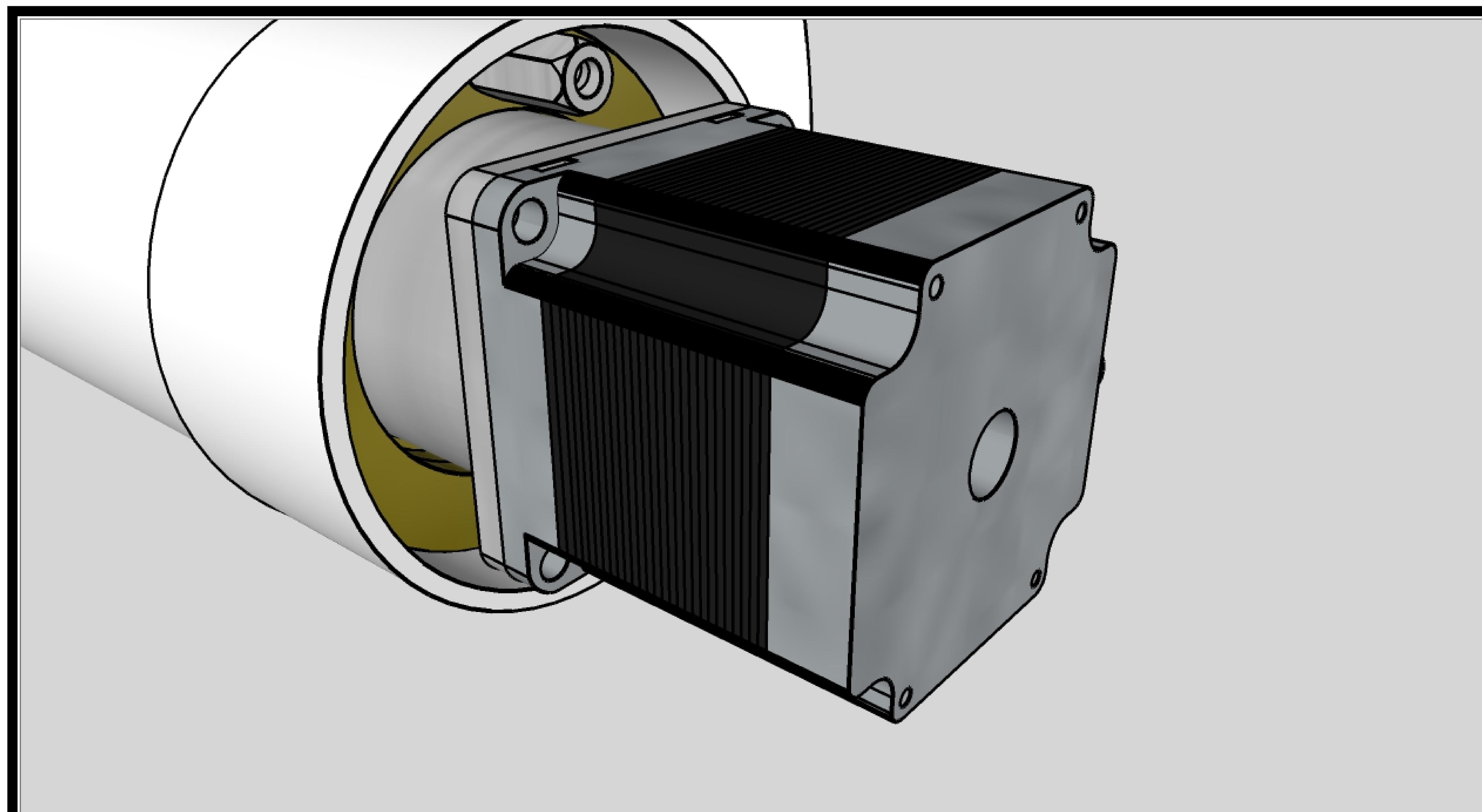
MAKING USEABLE FILAMENT IS TIME CONSUMING

Extruding plastic flakes into a useable filament for existing 3D printers that will not clog or break during long prints is difficult, and requires additional post processing, time, energy, and equipment. A successful design will minimize the amount of processing required to turn actual trash into finished 3D objects, with as little time, effort, energy, equipment, and skill as possible.

SOLUTION STATEMENT

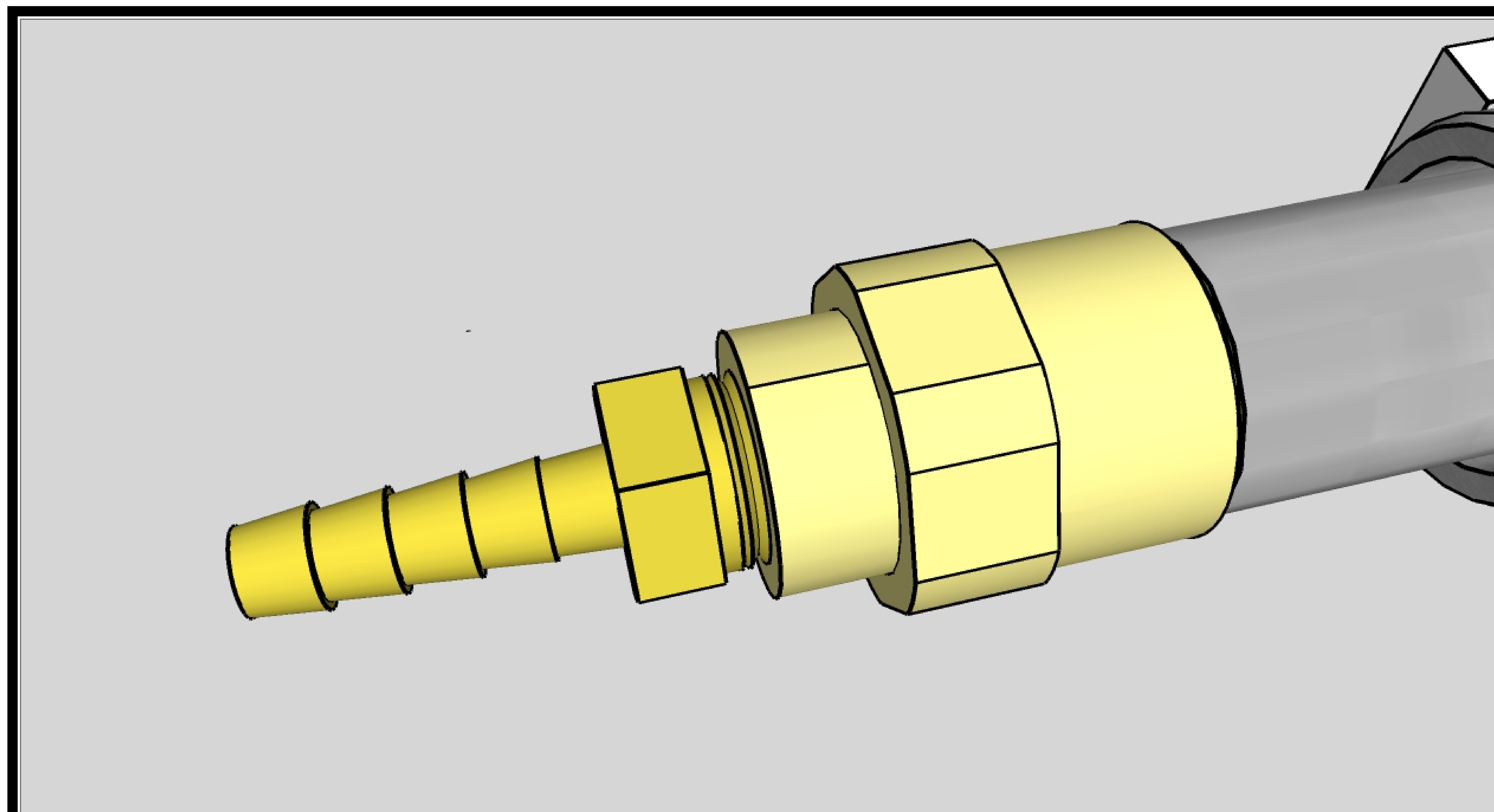
The Trash Printer extruder is an attempt to solve these problems. It is a plastic extruder, inspired by the “precious plastic” extruder, that has been modified so that it can be easily attached to a CNC router gantry or large format 3D printer. It uses a 5:1 planetary geared NEMA23 stepper motor and a 7/16” wood auger to push the plastic through the barrel and out the nozzle. This extruder can be mounted onto any CNC gantry that has a few inches of Z travel, and can print large, strong objects with a wall thickness of 3/16-1/4” (3-5mm). It takes shredded plastic flakes directly as they come from the precious plastic shredder, about 1/4” particles. While this large-format approach cannot deliver the detail and resolution of typical 3D printed parts, it can create a wide range of large, strong, flexible, objects in just a few hours, using plastic waste and about 100-200W of electricity as it’s only inputs.

FEATURES



GEARED MOTOR

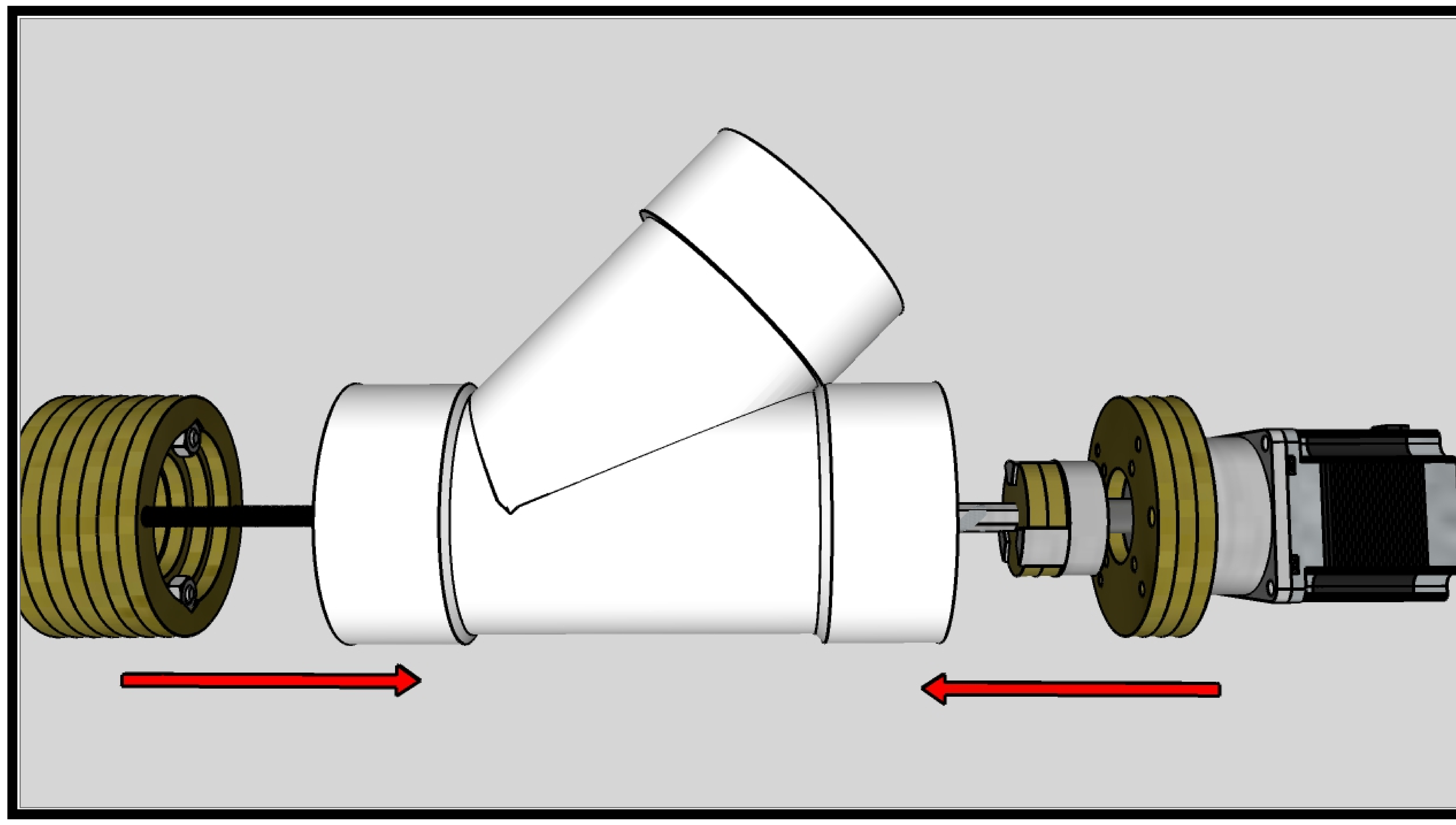
Plastic extruders typically use powerful, high torque motors to push molten plastic through the nozzle. 3D printers typically utilize much smaller stepper motors, which provide very high accuracy, but are not typically very powerful. A 5:1 planetary geared NEMA23 stepper motor provides a satisfactory compromise between ease-of-control, cost, and torque.



COMMON PARTS

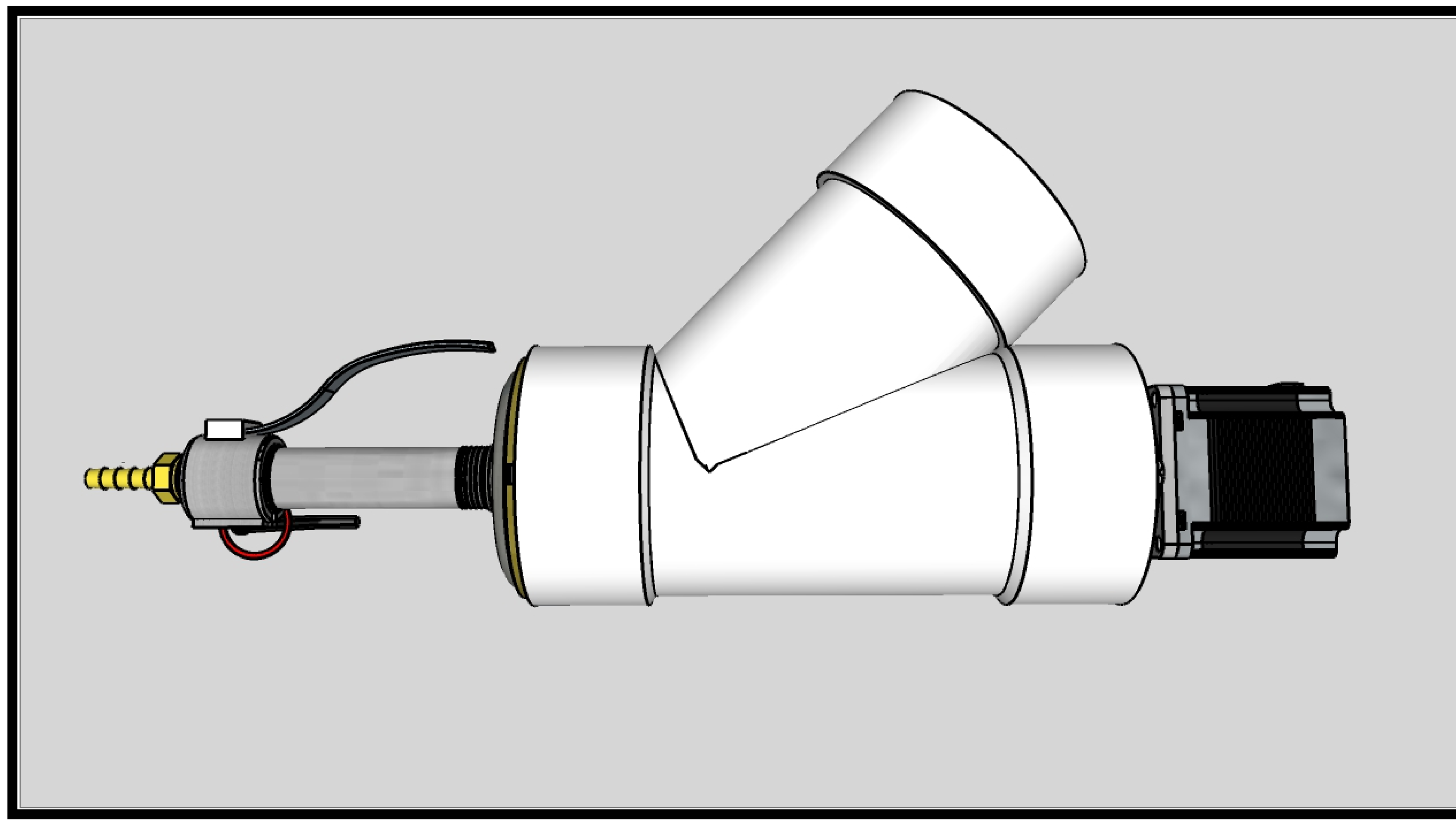
The Trash Printer extruder is designed so that it can be built using primarily parts that are commonly available in local hardware stores. It uses a 1/4” air hose barb as a nozzle, a 1/2” NPT pipe as it’s barrel, and a 3” PVC plumbing wye as a hopper. These parts are easy to find and are very cheap.

SOLUTION STATEMENT



SIMPLE ASSEMBLY

The extruder is held together by two sets of laser-cut wooden spacer plates that seat into the PVC housings, and pulled together with two through bolts. This creates a light, strong extruder body that is easy to assemble and disassemble.



CNC-ROUTER COMPATIBLE

The extruder was designed to have roughly the same weight and form factor as a router, so that it can be mounted onto a gantry designed for CNC routing. Any existing CNC router with a few inches of Z-travel should be able to operate as a large format 3D printer with this extruder head.

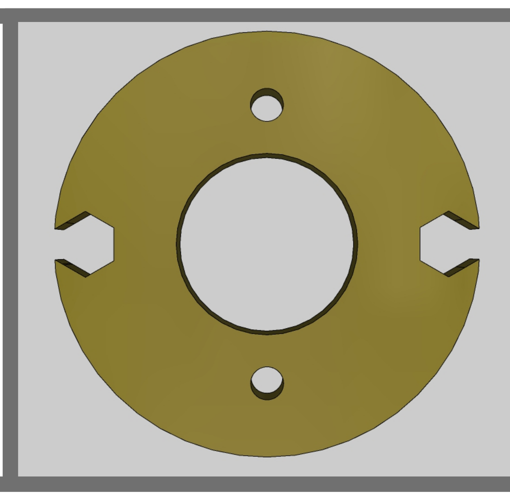
ASSEMBLY: TOOLS

	POWER DRILL OR DRILL PRESS
	1/8” DRILL BIT
	3/8” DRILL BIT
	3MM TAP SET
	LASER CUTTER OR CNC ROUTER (OPTIONAL)

ASSEMBLY: TOOLS

	3/8" NUT DRIVER
	1/4 HEX BIT DRIVER
	METRIC HEX KEY SET

ASSEMBLY: PARTS

A		2	**LASER CUT WOODEN SPACERS** NAMED A1-A12, FILES AVAILABLE AT:
B		2	**3" PVC PLUMBING WYE** 3"ABS WORKS TO, BUT IS SLIGHTLY HEAVIER, AND HAS SLIGHTLY SMALLER DIMENSIONS, REQUIRES DIFFERENT SPACERS
C		2	**1/4-20 HEX BOLTS, 7.5" LONG** FILENAME ON SD
D		4	**1/4-20 NUTS** FILENAME ON SD
E		2	**1/4-20 HEX BOLTS, 2" LONG** FILENAME ON SD
F		1	**7/16" X 7.5" WOOD AUGER** AN AUGER WIDER THAN 7/16" CAN WORK BUT WILL REQUIRE MORE TORQUE AND IS MORE PRONE TO JAMMING
G		1	**SHAFT COUPLER** 12MM TO 10MM

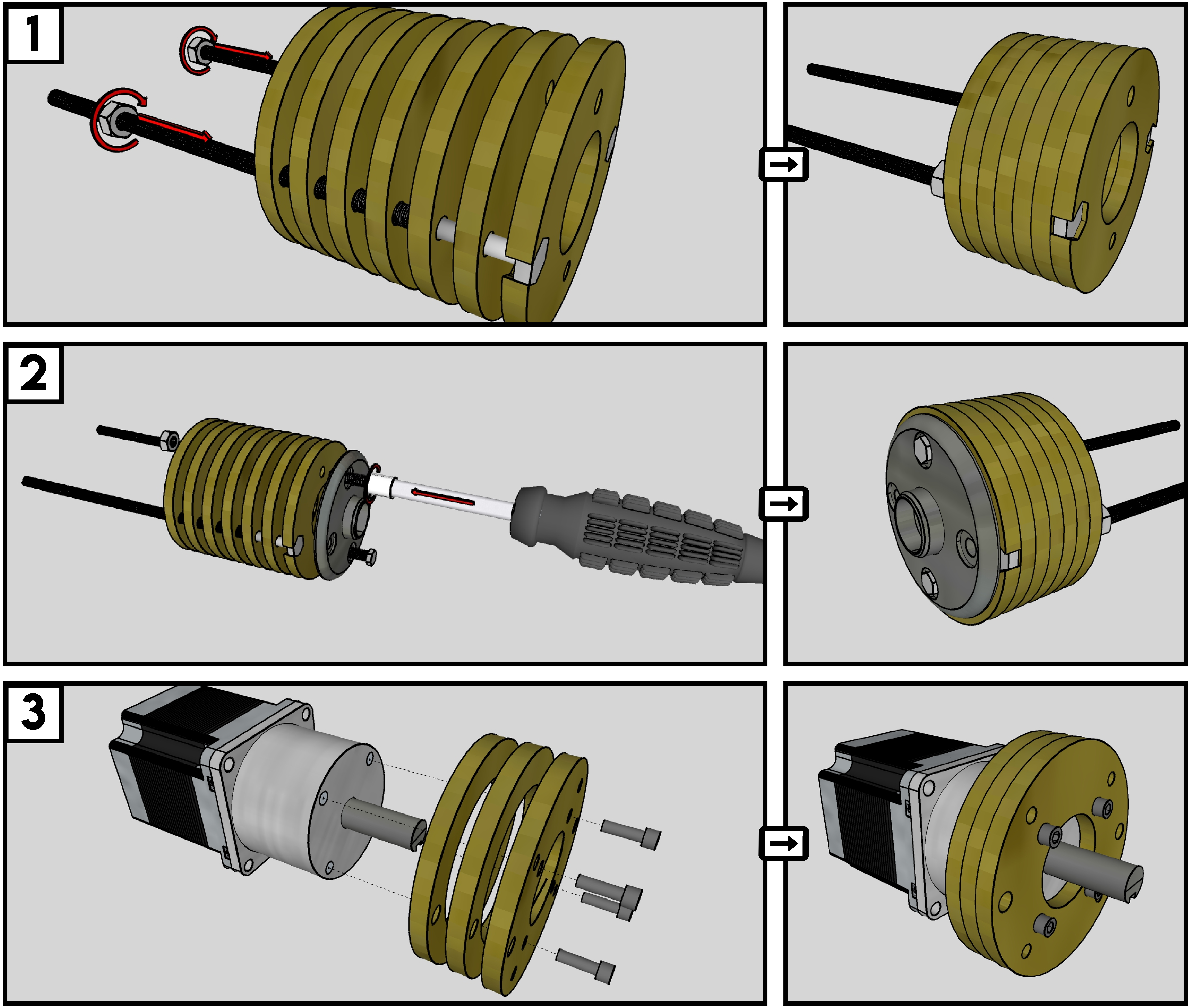
ASSEMBLY: PARTS

H		1	**5:1 NEMA23 STEPPER MOTOR**
I		1	**1/2" BLACK IRON PIPE FLANGE** FILENAME ON SD
J		1	**300W 1" BAND HEATER** 25MM DIAMETER TIGHTENS EASILY OVER 1/2 BRASS FITTINGS.
K		1	**24VDC HEATING CARTRIDGE**
L		1	**SCREW IN THERMISTOR** SCREWS INTO THREADS ON HOT END BLOCK
M		1	**CARTRIDGE THERMISTOR** FITS IN BETWEEN BRASS FITTING AND HEATER BAND
N		1	**ALUMINUM HOT END BLOCK** COMMON SOLD IN PACKS OF 5 - YOU CAN MAKE DIFFERENT BLOCKS TO FIT DIFFERENT NOZZLE SIZES.

ASSEMBLY: PARTS

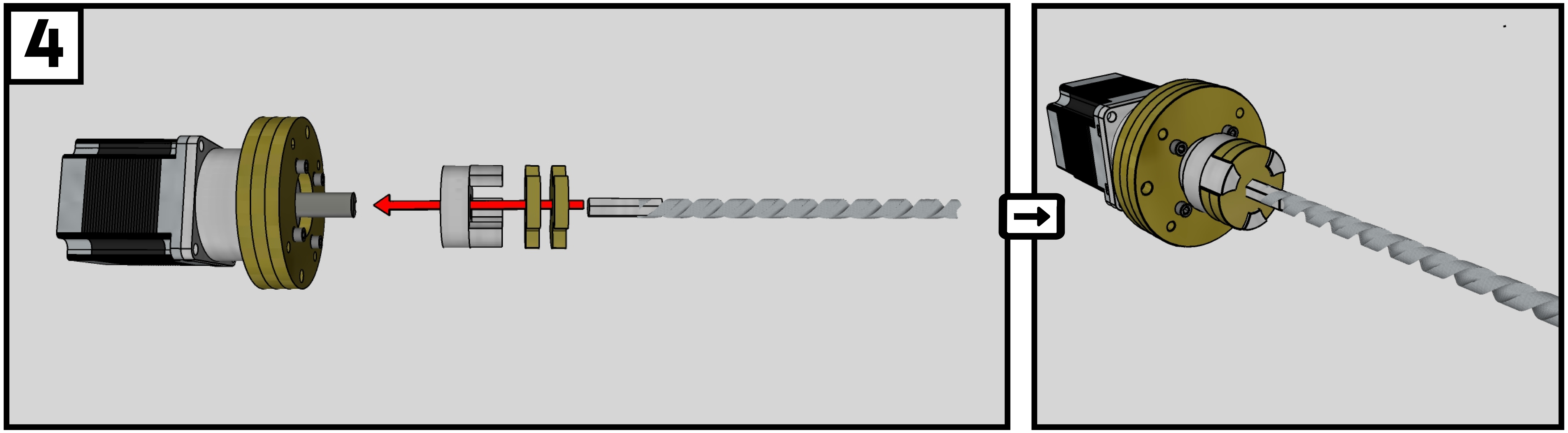
O		2	**1/4-20 COUPLING NUT** FILENAME ON SD	
P		1	**1/2" NPT BRASS PIPE 4-5" LONG** FILENAME ON SD	
Q		1	**1/2" TO 1/4" NPT BRASS FITTING** FILENAME ON SD	
R		1	**1/4" NPT TO 1/4" BRASS HOSE BARB** FILENAME ON SD	
S		1	**M4 OR 10-24** **HEX HEAD BOLT, 25MM LONG**	
T		1	**3" PVC 30 DEGREE ELBOW**	

ASSEMBLY: STEPS 1-3



ASSEMBLY: STEPS 4-6

4



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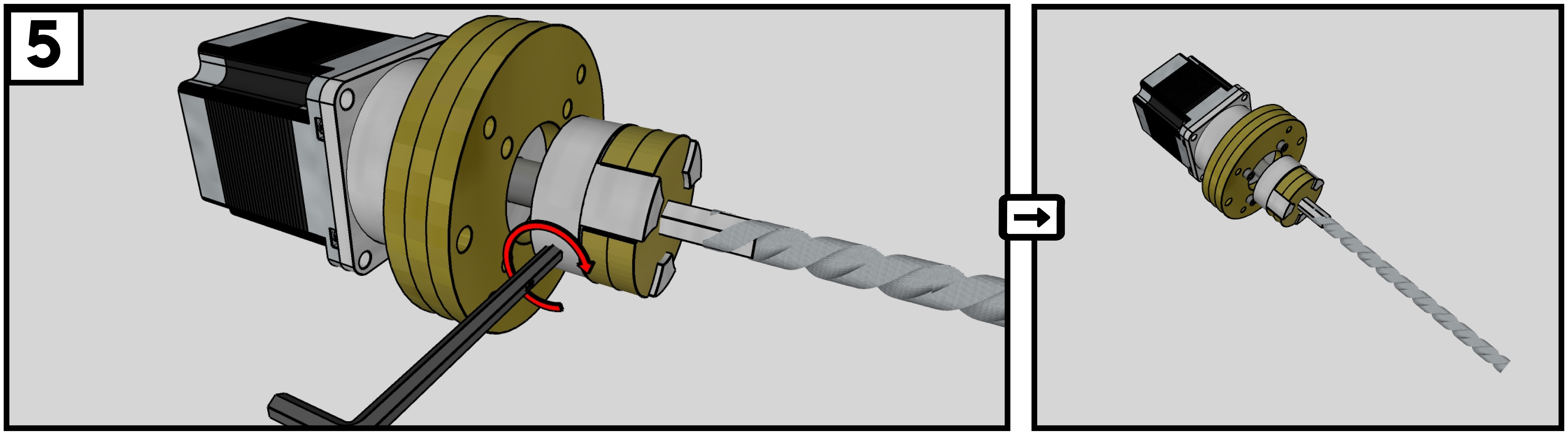

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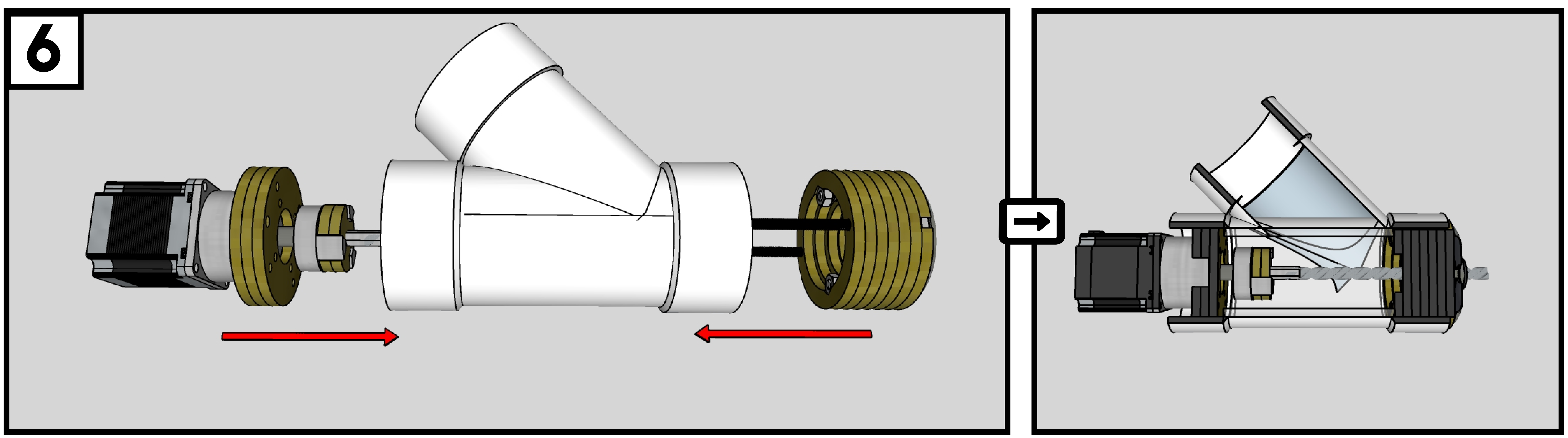
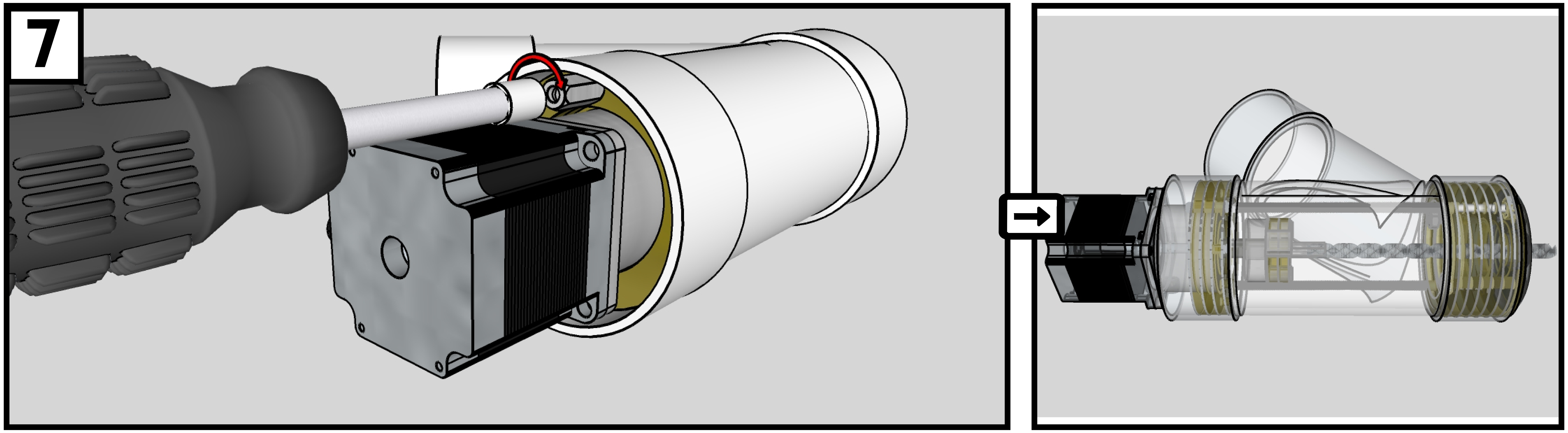
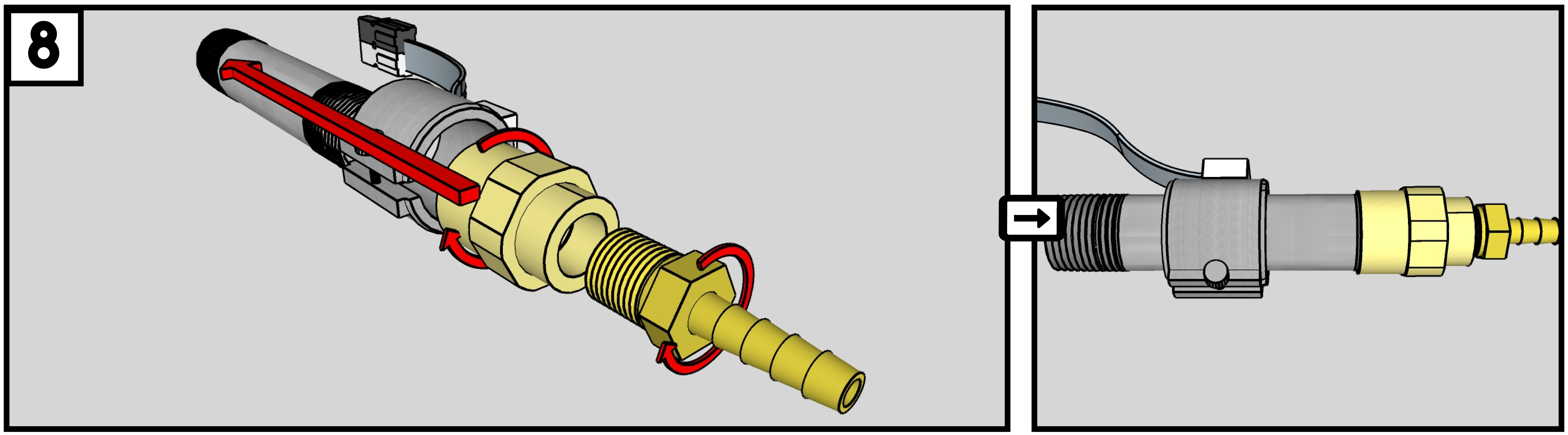
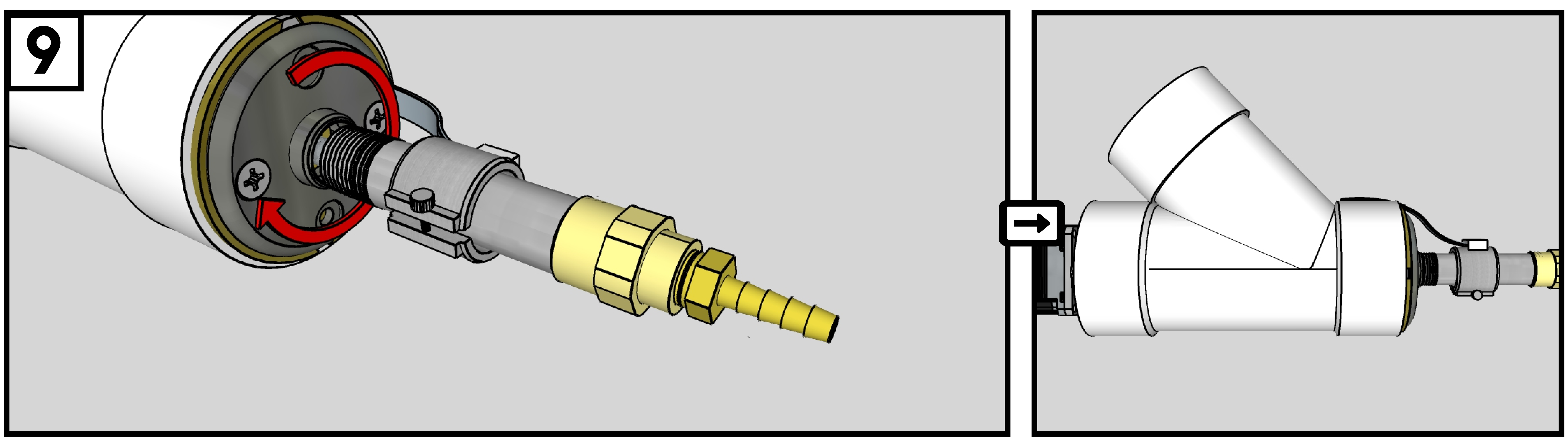


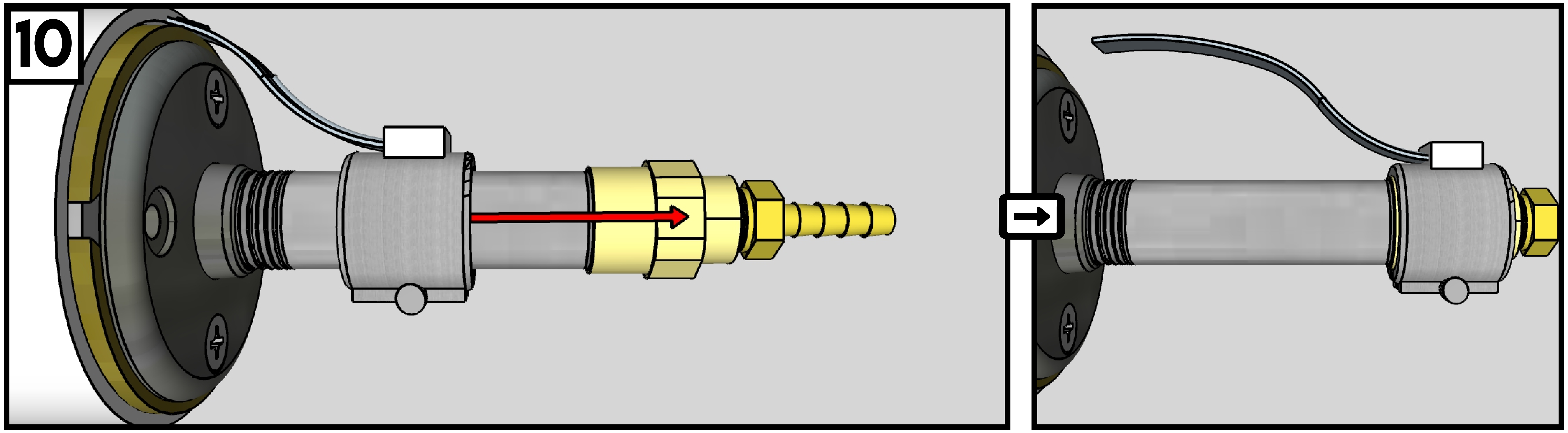
ASSEMBLY: STEPS 7-9

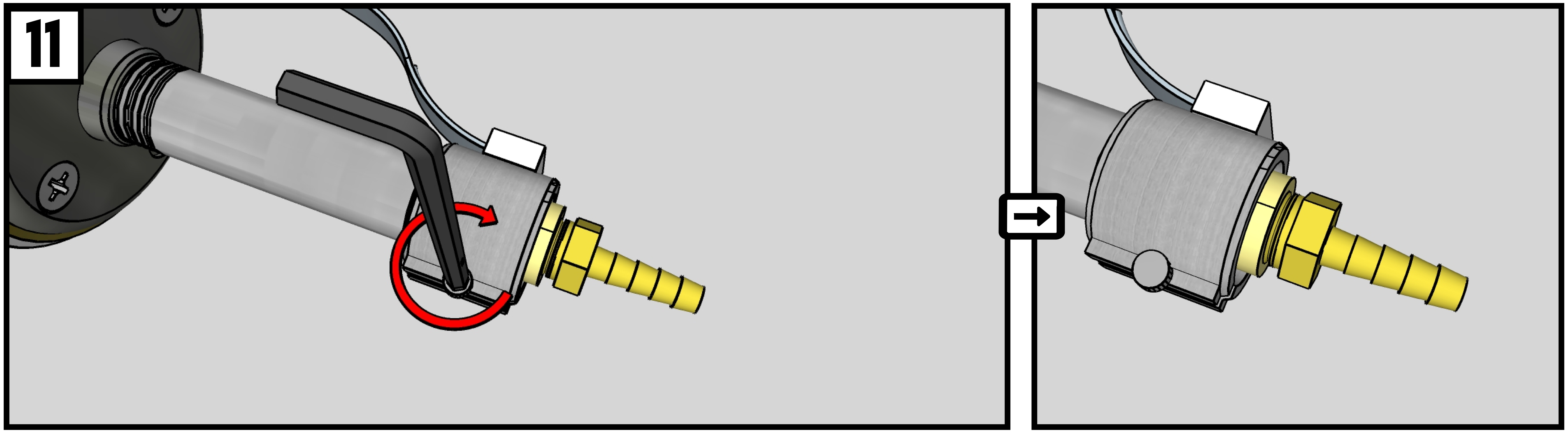


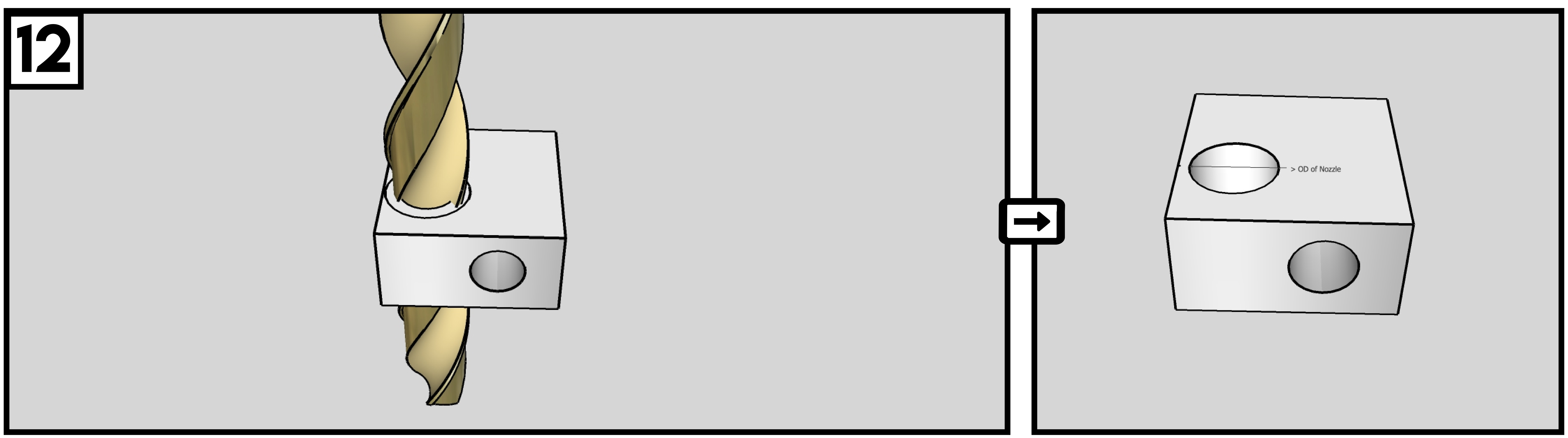




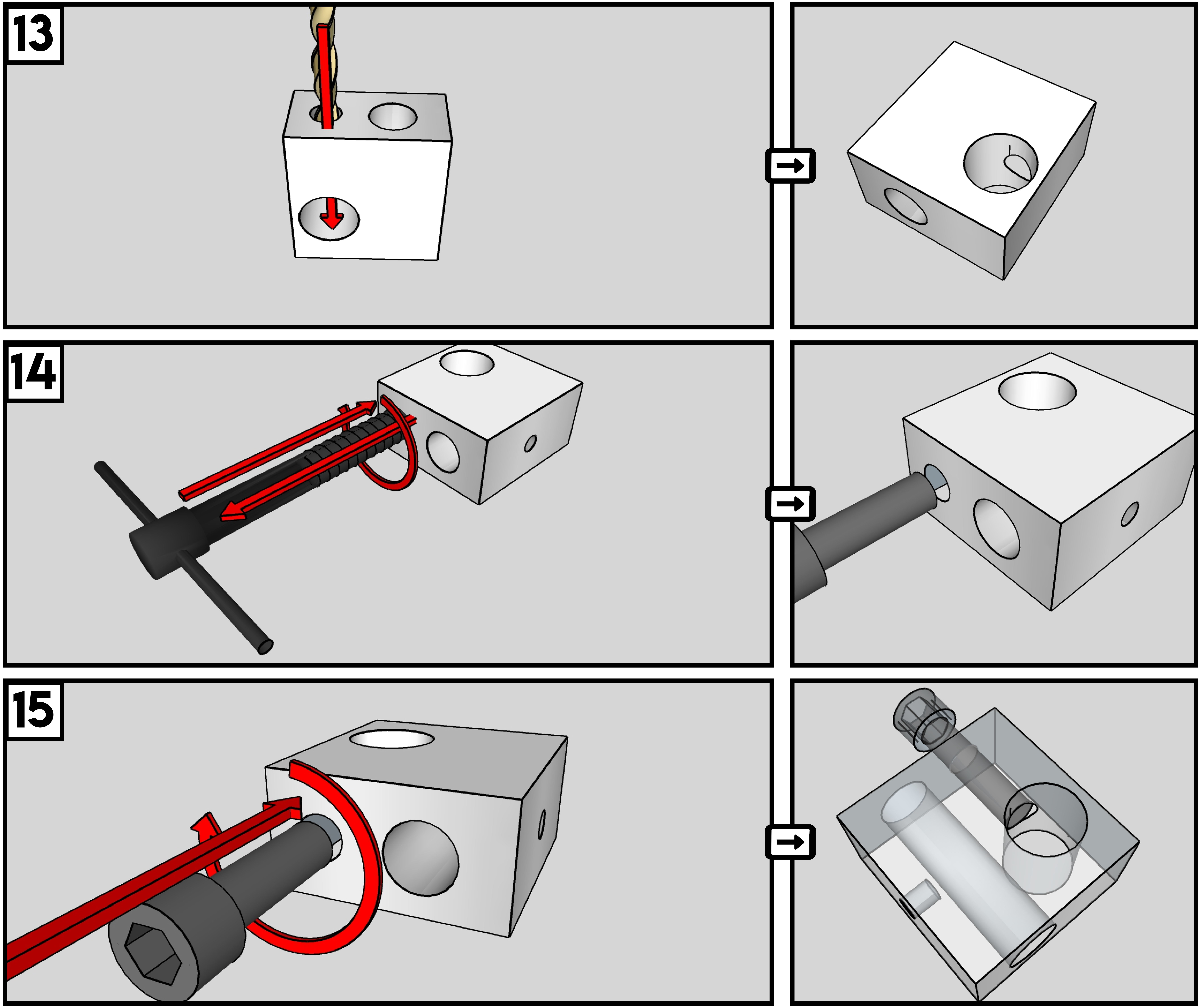
ASSEMBLY: STEPS 10-12



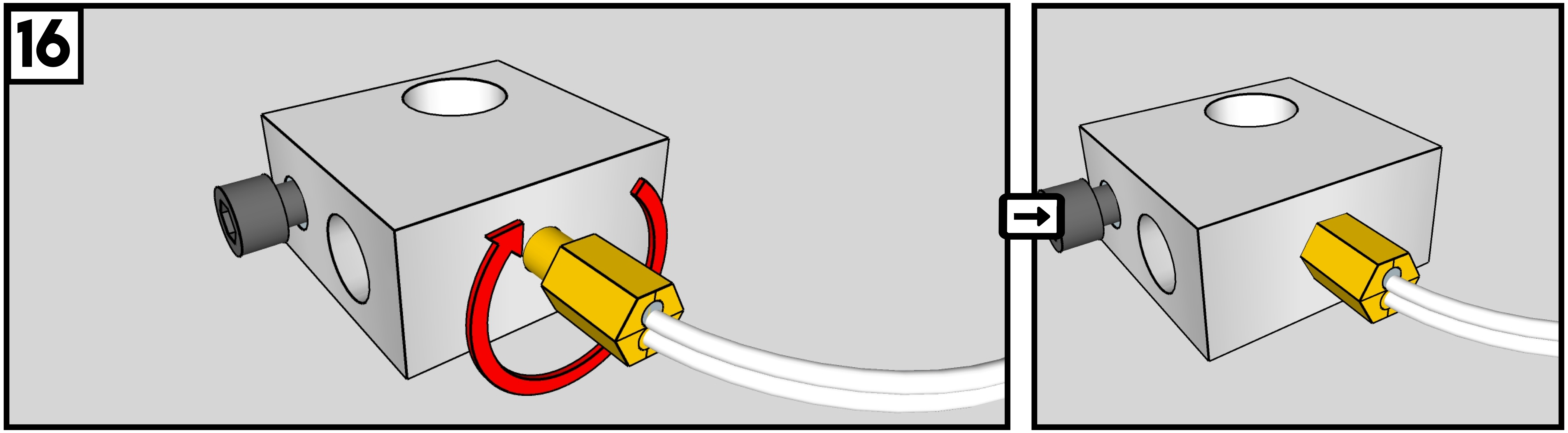


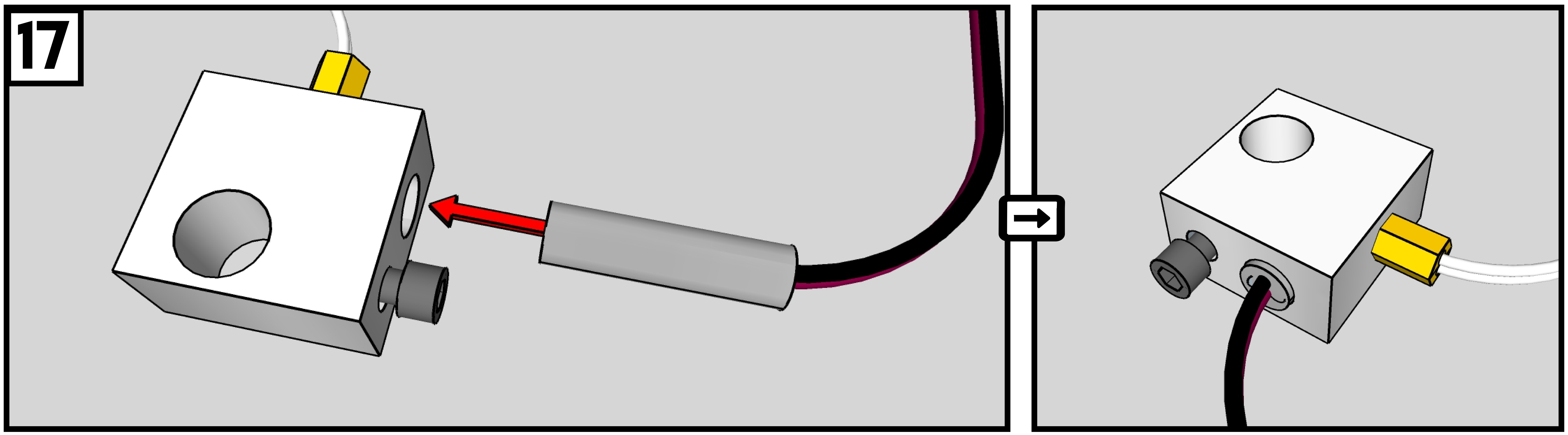


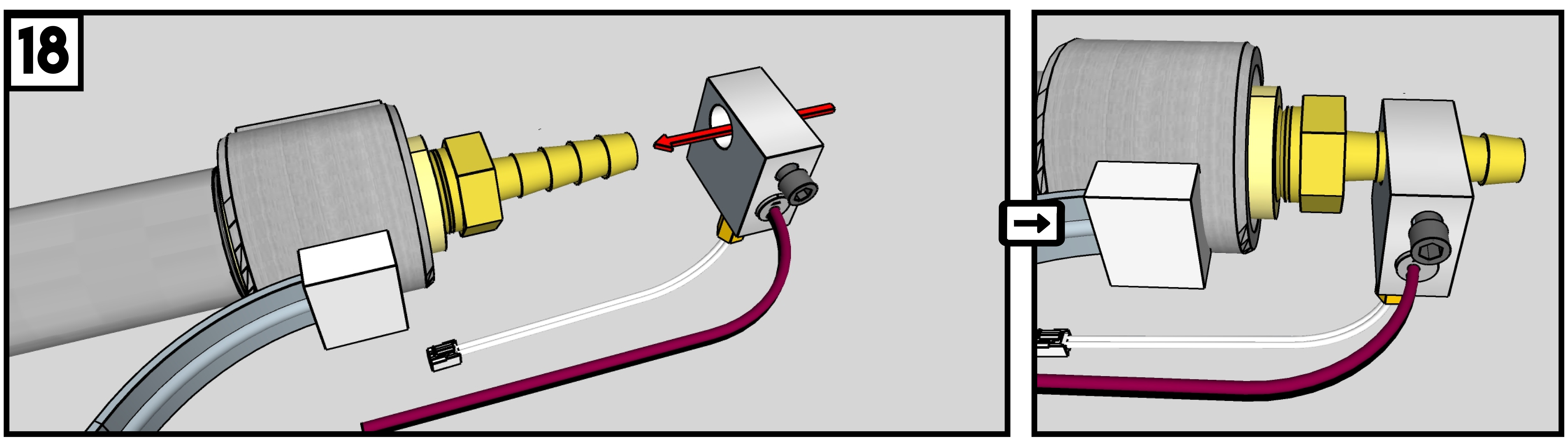
ASSEMBLY: STEPS 13-15



ASSEMBLY: STEPS 16-18

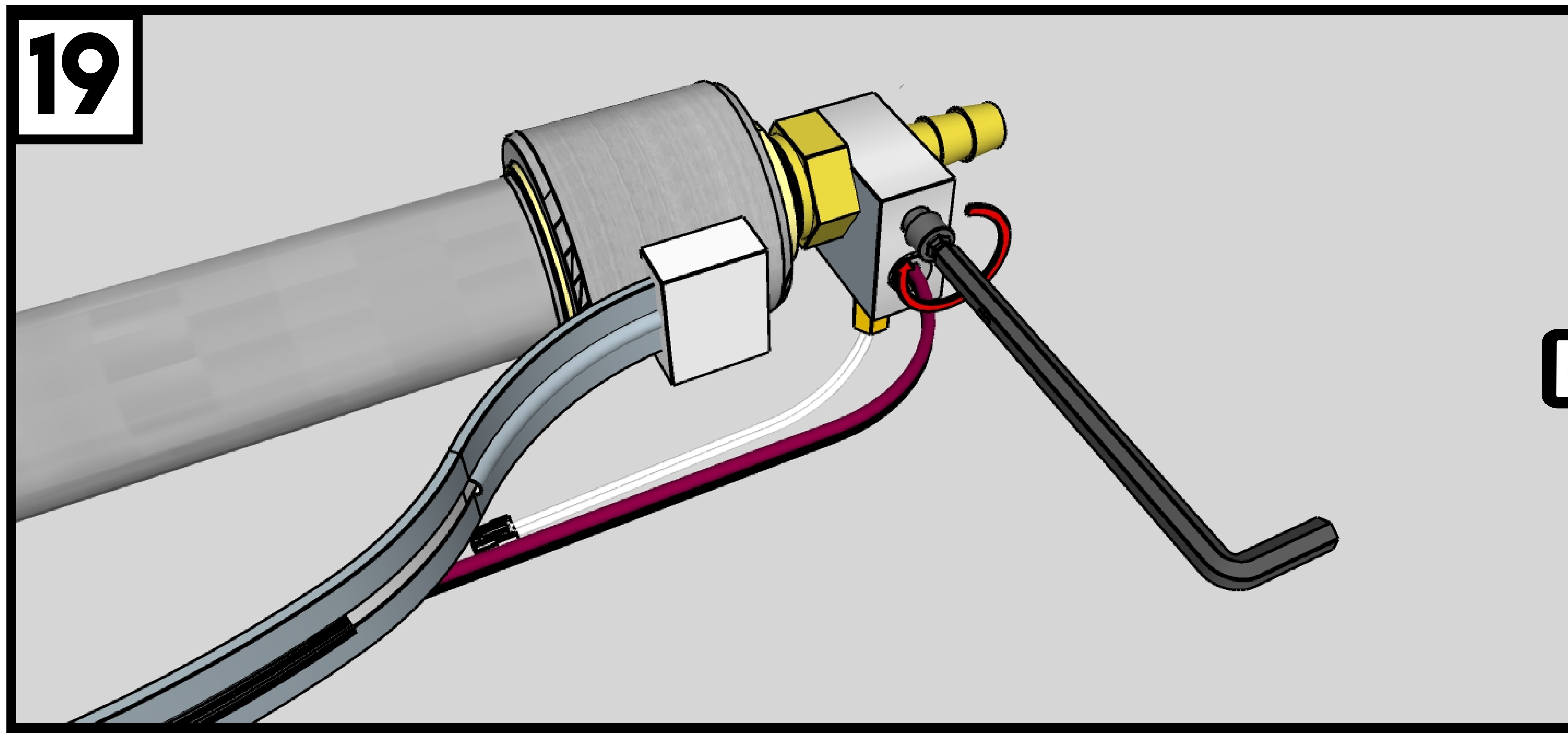


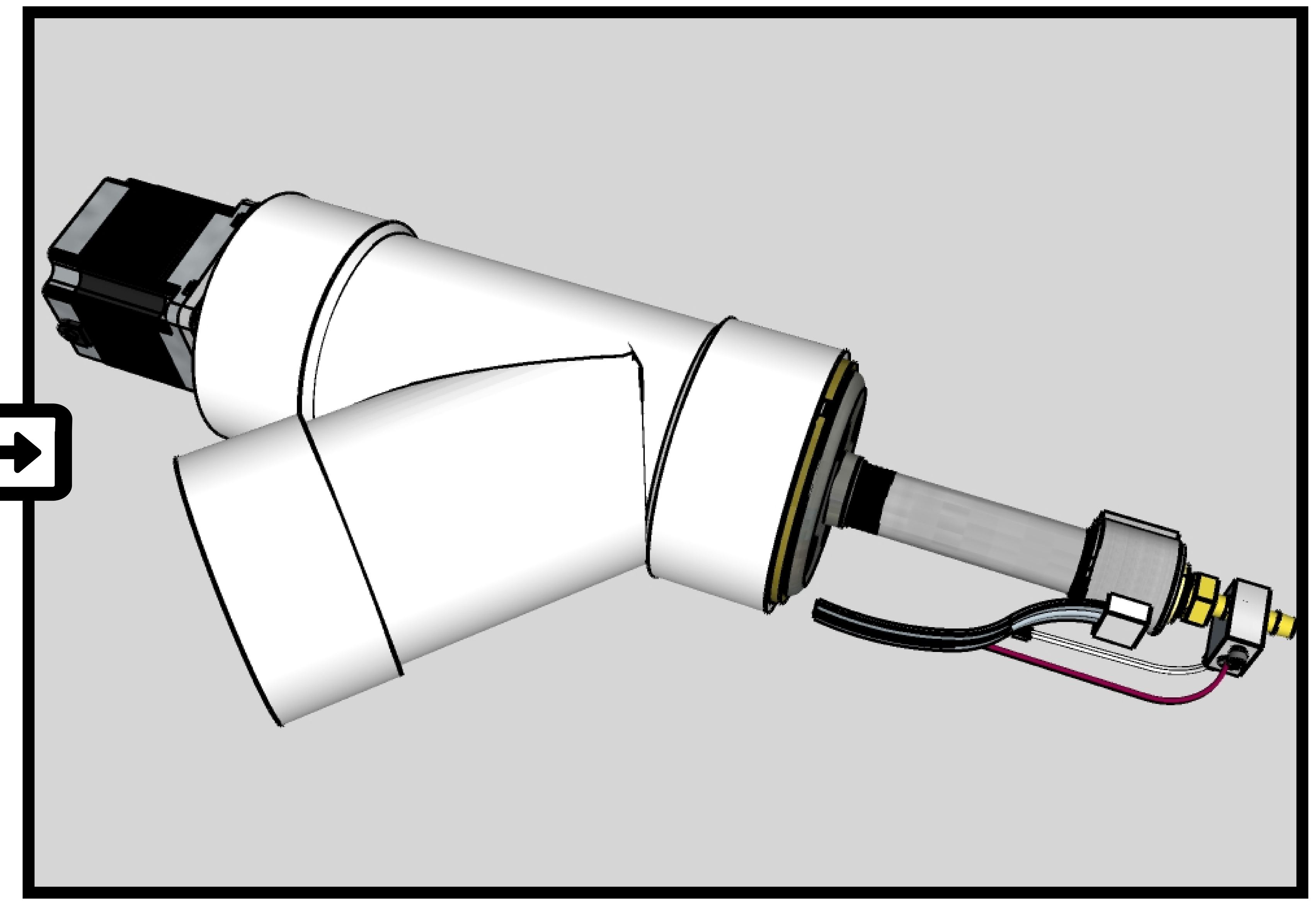




ASSEMBLY: STEPS

19





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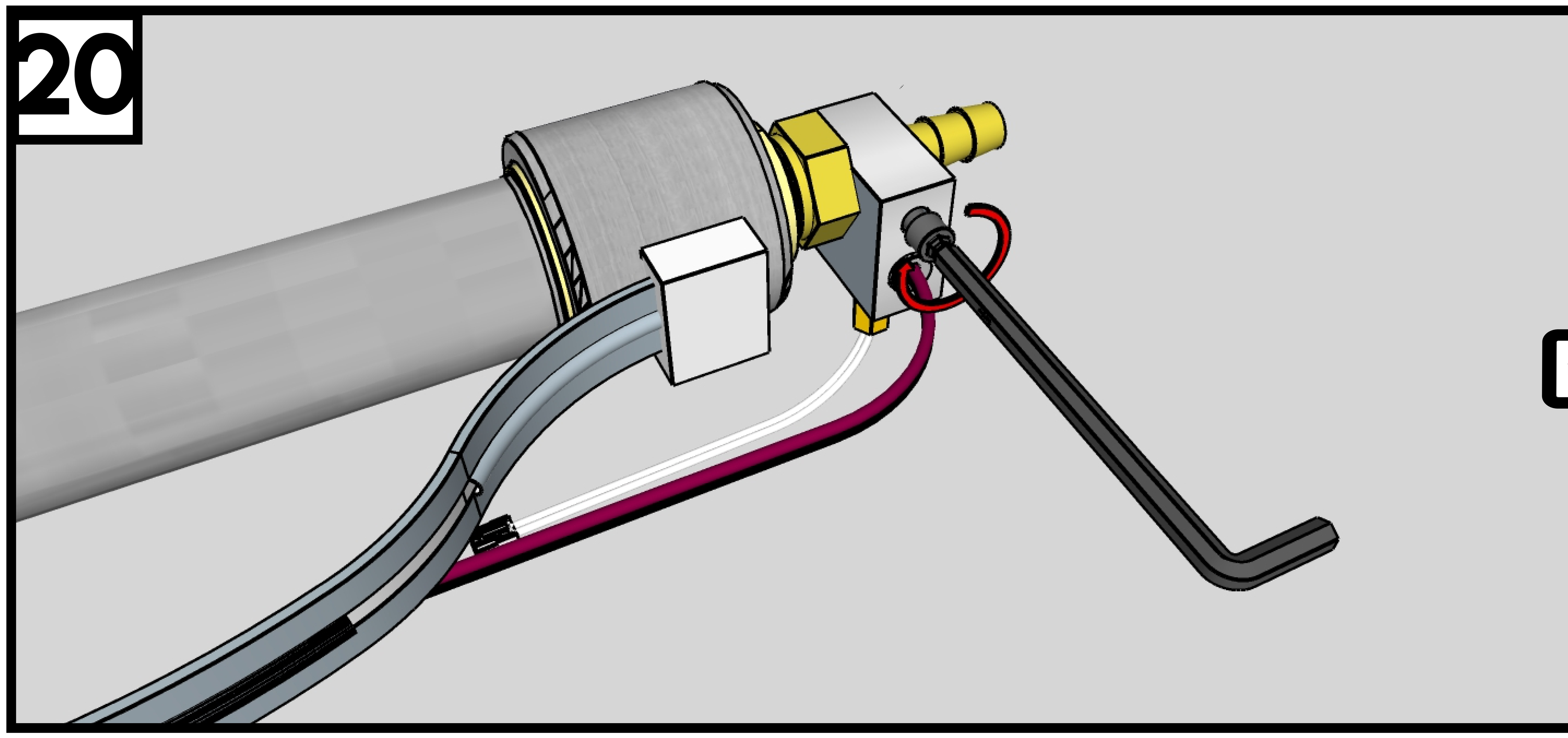

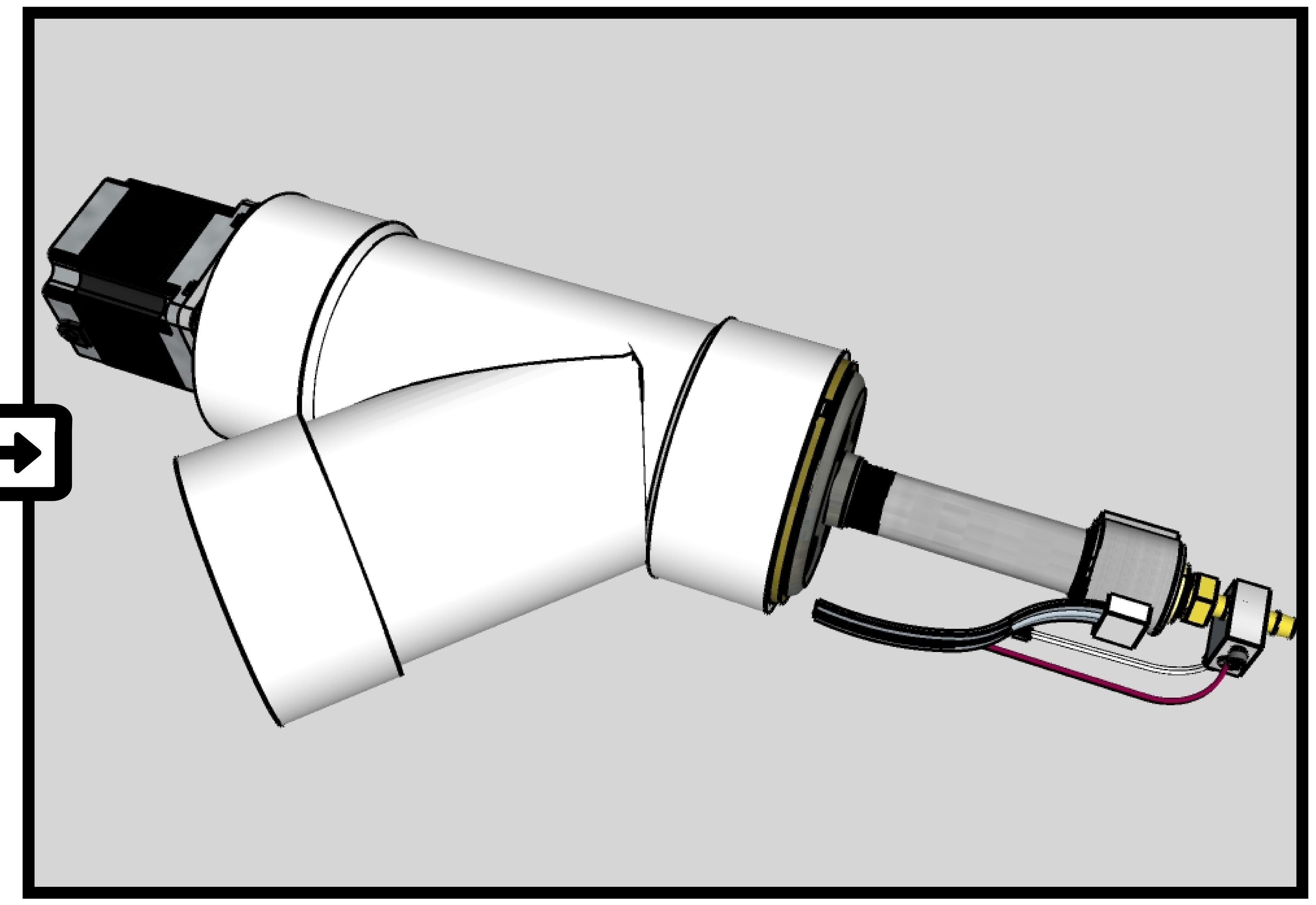

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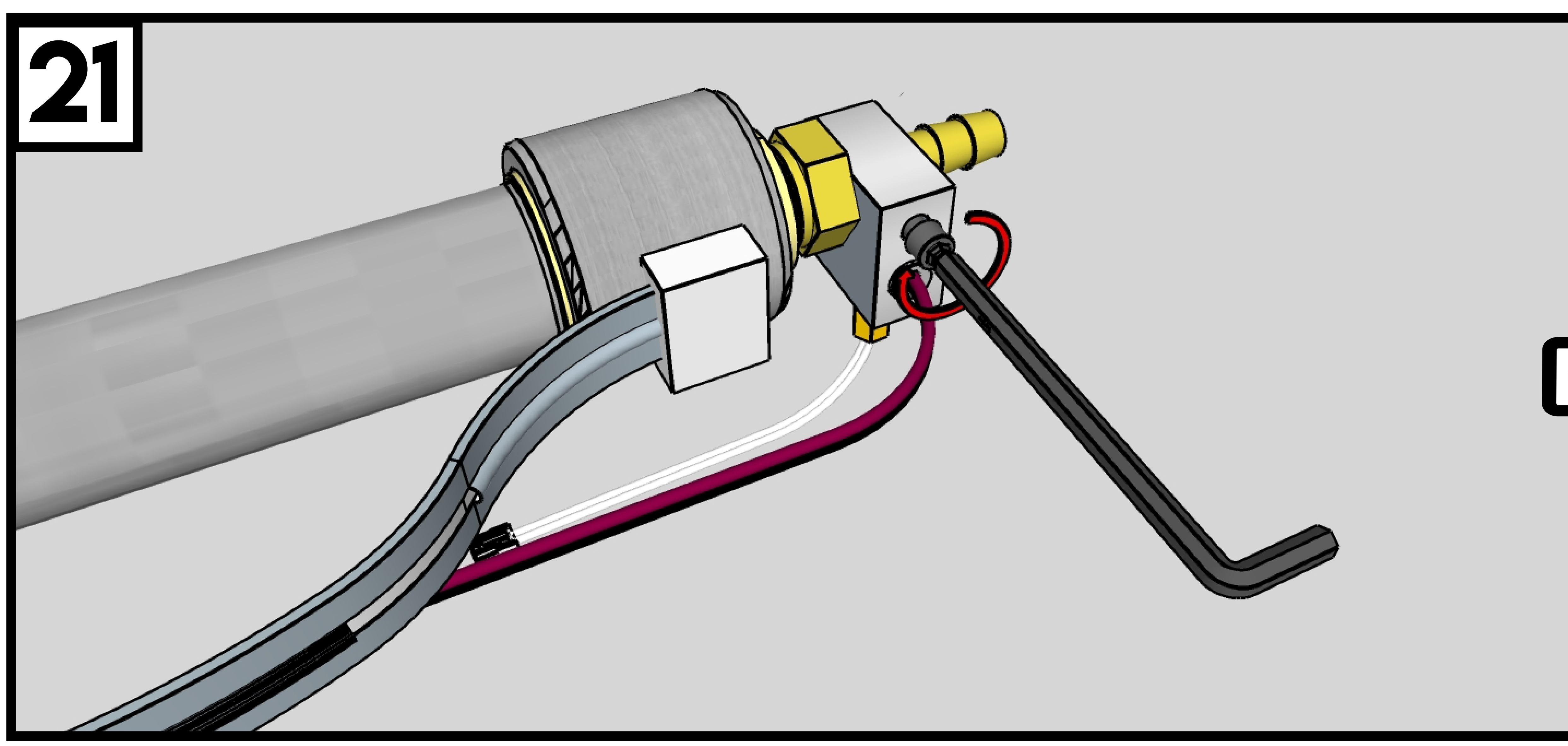
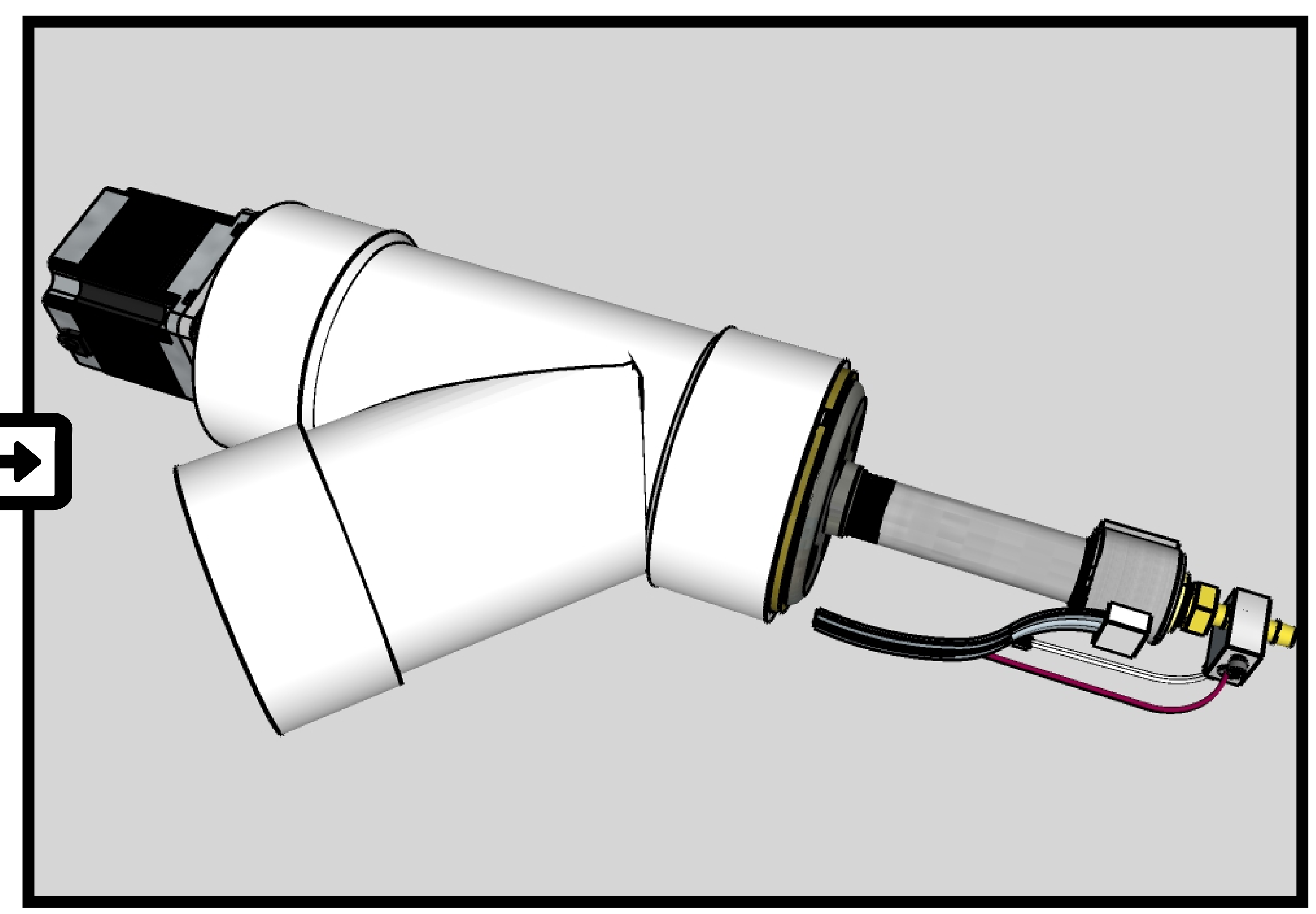




SUCCESSES

IT CAN PRINT DIRECTLY FROM RECYCLED FLAKES!

My first and foremost goal was to be able to 3D print directly from recycled plastic flakes, exactly how they come out of the Precious Plastic shredder, without any additional processing. I certainly does that! I've had excellent results with polypropylene, and some OK results with Polypropylene.

IT CAN PRINT OF THESE OBJECTS:

I've successfully printed planters, vases, water-tight cups, water turbines, signs, letters, brackets, and adapters. It can print objects with a 2-4mm thick wall, with up to . 2mm resolution in the Z axis. I've been able to print objects as tall as 12", and as wide as 15"x15" (but only about 4mm tall).

BED ADHESION BY PRINTING ONTO POLYPROPYLENE

One problem many people run into printing with PP and PE is that they warp a lot and tend to not stick well to anything, making bed adhesion difficult. I found that by printing Polypropylene onto Polypropylene at around 265C at the tip, I could get the plastic to adhere and slightly fuse, without fully welding, making the finished print easy to pry off. This was much cheaper and easier than designing a large format heated bed. Printing onto packing tape adhered face down to the work surface also seems to work well.

INSIGHTS

THE AUGER SHOULD BE SMALLER THAN THE BARREL

I originally assumed I wanted an auger that fit perfectly inside the 1/2” barrel, something like a 7/16”, but it turns out that causes unmelted plastic flakes to get caught in the space between the barrel and the auger, causing it to bind more often. Using a smaller auger, 12mm or 3/8” seems to work better and pushes as much plastic as the other one, with less binding.

THE AUGER SHOULD NOT REACH THE MELT ZONE

I also originally assumed that the auger needed to go all the way to the tip, in order to push the molten plastic. It turns out that I got better results with the auger only going about 1-2 inches into the barrel, so that it pushes the unmelted material into the melt zone, creating forward pressure. A more powerful motor could potentially fix this, but this kept the design simple and light, and still able to extrude consistently.

ROOM FOR IMPROVEMENT

THE MOTOR IS A LITTLE UNDER-POWERED

The 5:1 NEMA23 Stepper Motor I'm using is still less powerful than I would like. I would like to be able to extrude more plastic, faster, but the limiting factor seems to be the motor, or at least the motor/auger combo. I have used an ungeared NEMA23, and made successful prints, but it skips so much that I eventually burned one out.

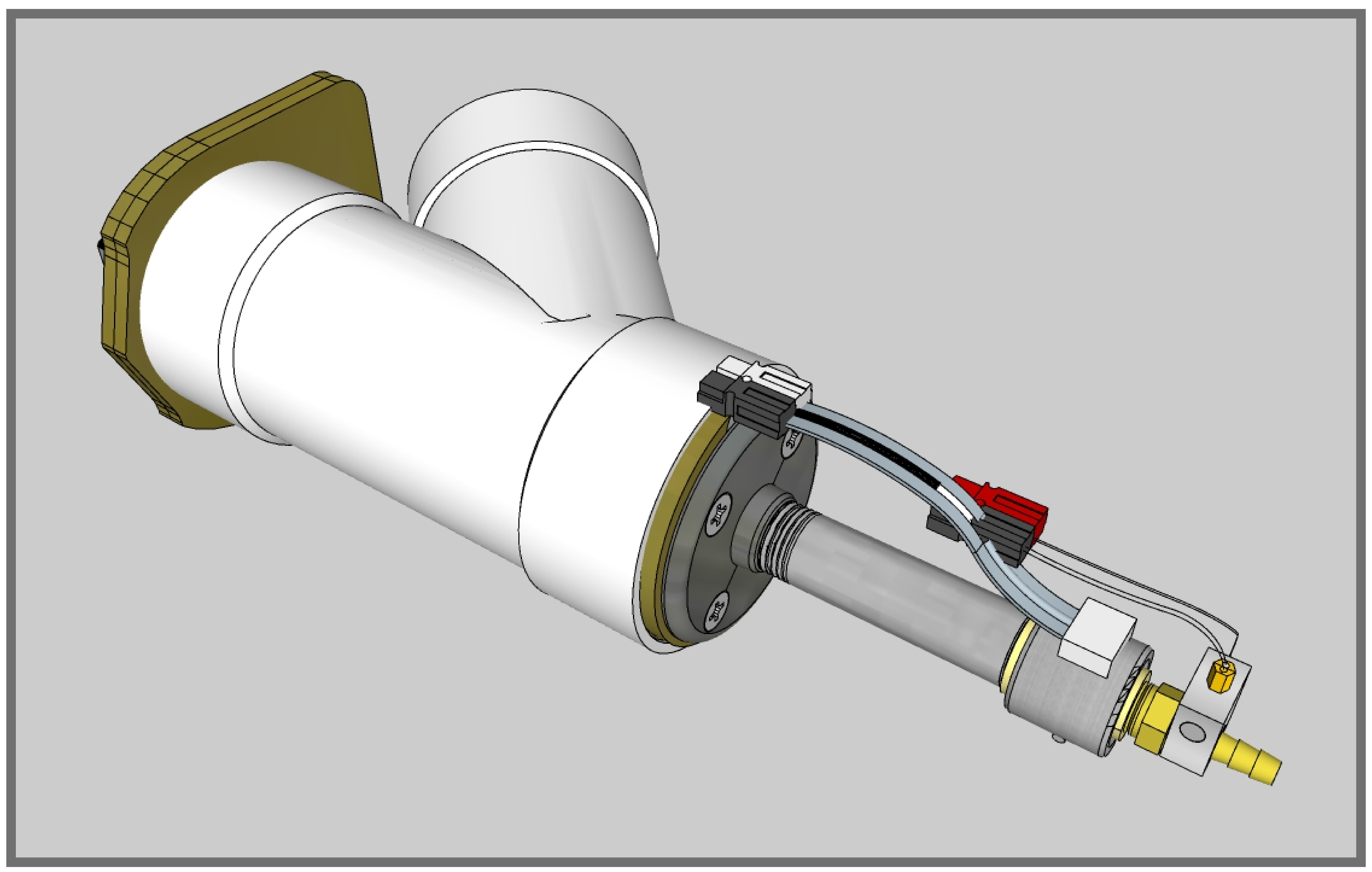
3/16-1/4" IS THE SMALLEST NOZZLE RESOLUTION I COULD GET

I tried going down to an 1/8", but I found that it put too much back pressure on the motor, and did not extrude well. However, although the nozzle resolution is limited to a fairly large size by typical 3D printing standards, you can still get sub millimeter Z resolution, and the prints are VERY fast compared to desktop printers. Large objects can be printed in 1-2 hours instead of days.

INSPIRATION

PRECIOUS PLASTIC EXTRUDER

This design is based heavily upon what I learned by building the Precious Plastic Extruder (V3) in 2017. The operating principle is exactly the same - a wood auger pushes shredded material through a heated barrel. To optimize the design for 3D printing, I turned the extruder onto a vertical axis, and replaced the motor with high torque stepper motor, so that it could be used by existing 3D printer software with no modification.

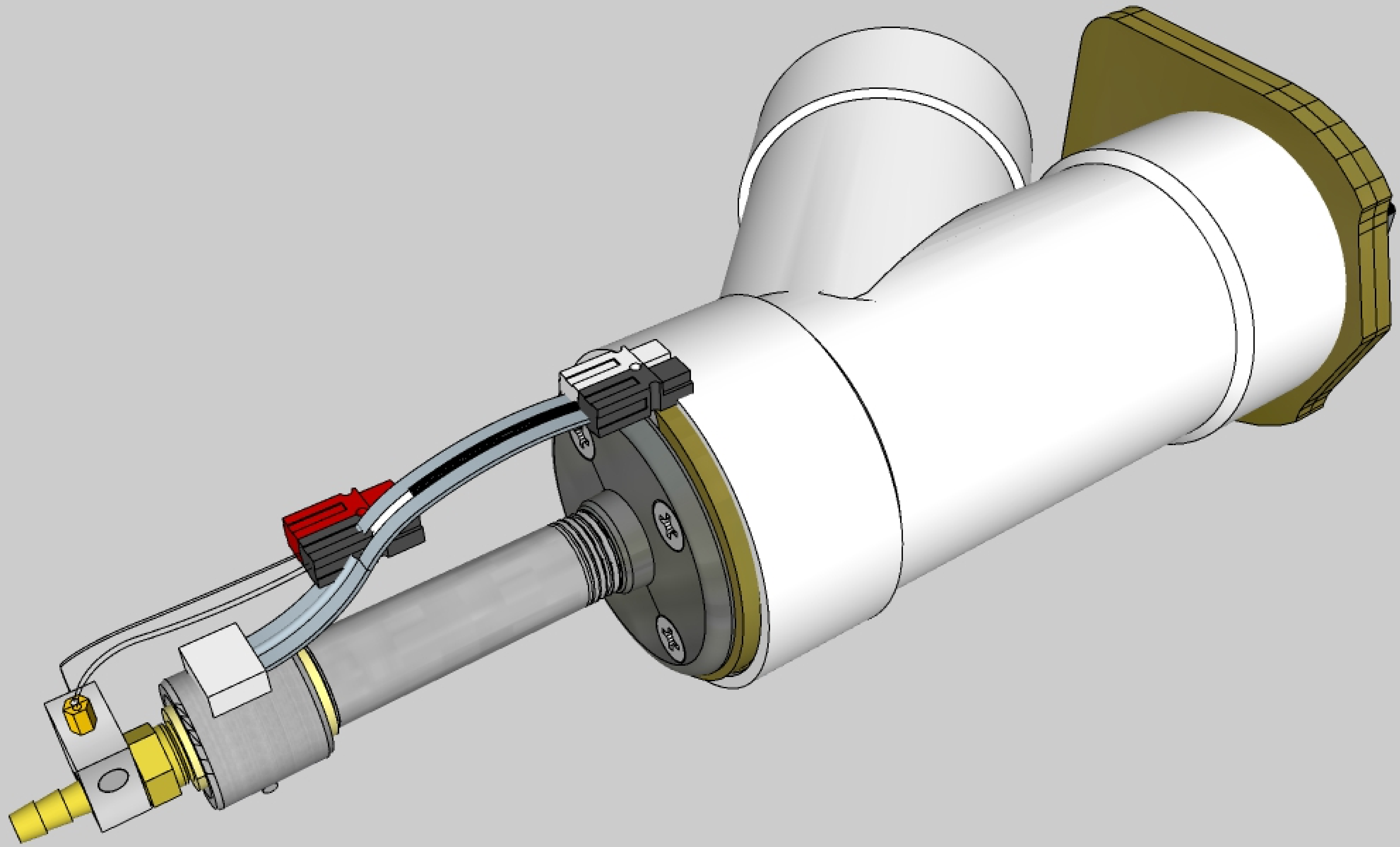


FILASTRUDER

There were a number of other filament extruder projects that helped guide my design process, the primary one being the Filastruder project. While I never built a filastruder myself, seeing other people getting reasonable results with this size of extruder helped me get a sense for what works.

BUILD STATUS: STABLE
ESTIMATED COST: $150-200

VERSION: 2.1.1
UPDATED: 4.20.2020



INPUTS

PLASTIC FLAKES
ELECTRICITY

OUTPUTS

RECYCLED PLASTIC OBJECTS

TEST TITLE

Describe a test that you did to determine a metric. Explain your method, results, and interpretation of results.

INPUTS

INPUT NAME

Describe a test that you did to determine a metric. Explain your method, results, and interpretation of results.

OUTPUTS

CONCLUSION

CREDITS

ASSEMBLY: STEPS