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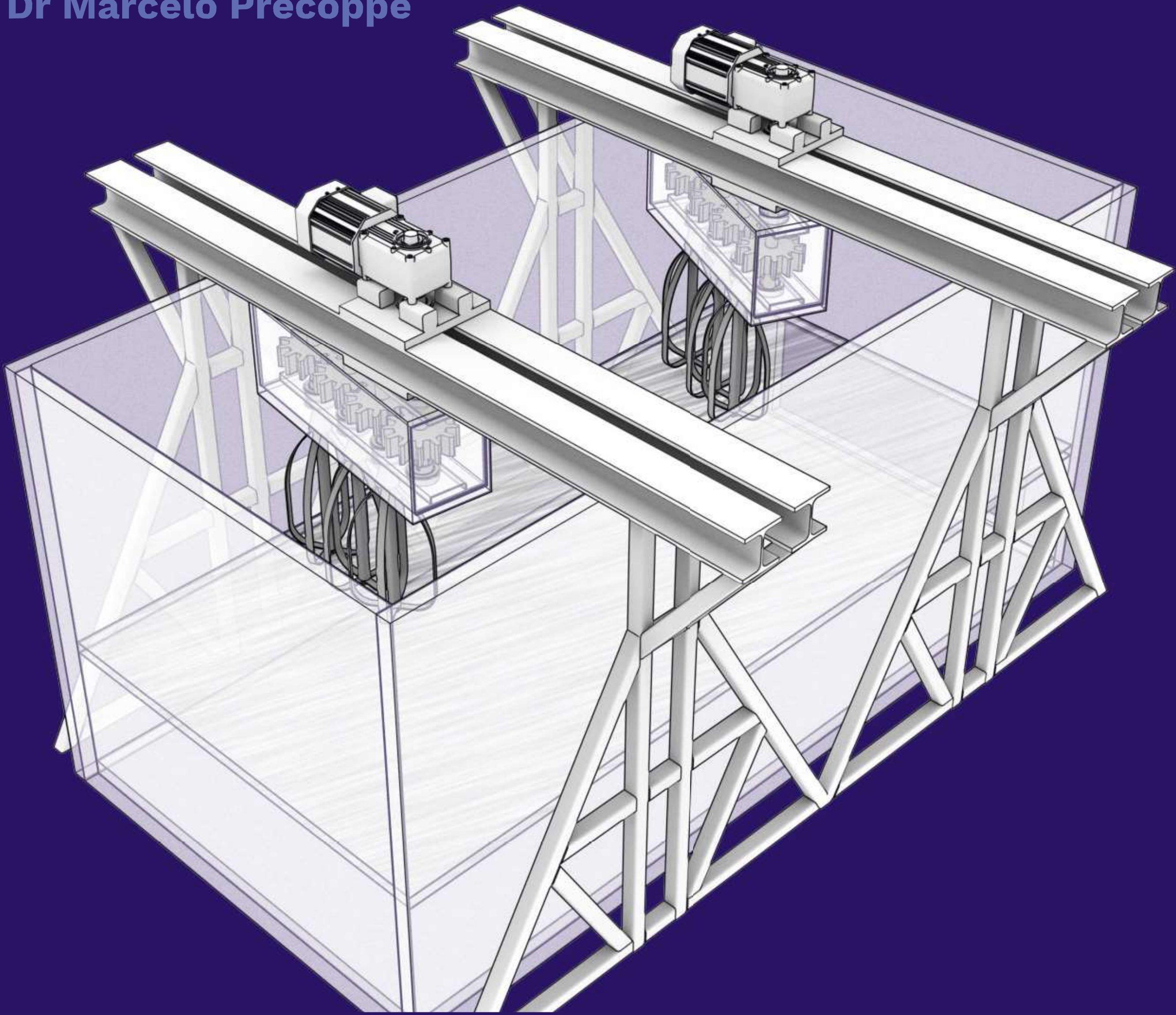
Flatbed Dryer Stirrer

Dr Marcelo Precoppe

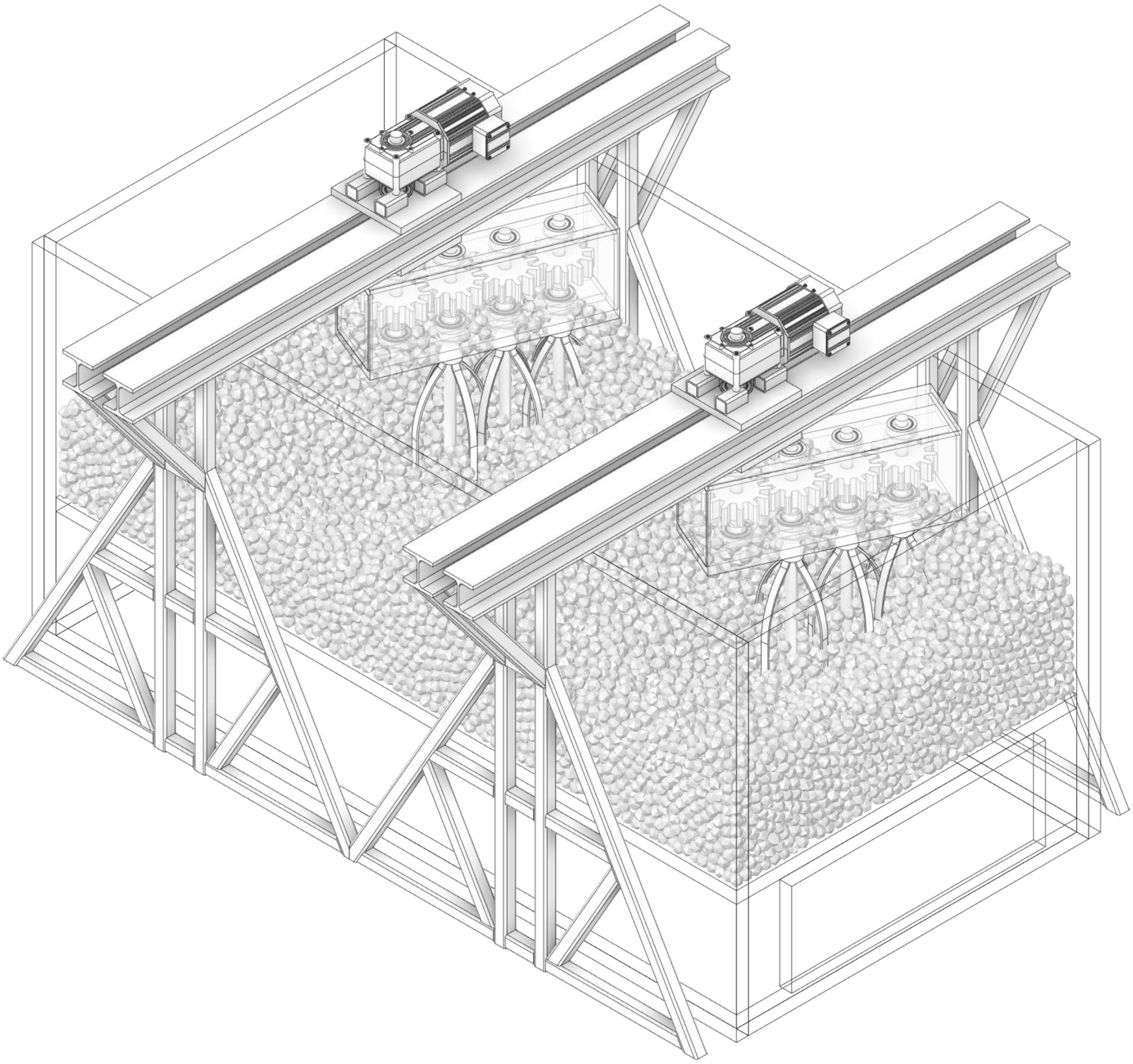


Construction guide delivered to **INTERMECH ENGINEERING LIMITED**, in fulfilment of the project *Upgrading the flatbed dryer with a solar-powered system for Tanzanian smallholders* funded by GCRF AgriFood Africa Innovation Awards Competition.

August 2021

Flatbed Dryer Stirrer

Construction Guide



Dr Marcelo Precoppe | Natural Resources Institute | University of Greenwich | Chatham Maritime | United Kingdom

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About the Natural Resources Institute

The Natural Resources Institute (NRI) is a specialist research, development and education organisation of the University of Greenwich, UK, with a focus on food, agriculture, environment, and sustainable livelihoods.

About the author

Dr Marcelo Precoppe is NRI's Crop Postharvest Technologist. He obtained his PhD at the University of Hohenheim in Germany. His research interest lies in developing postharvest technologies for small-sized enterprises.

Disclaimer

Introduction

Cassava (*Manihot esculenta* Crantz) is a perennial root crop native to South America and the main source of calories for many people living in sub-Saharan Africa. However, two days after harvest, the cassava roots become unsuitable for human consumption. To extend its shelf-life, the roots need to be processed into flour; a dried product that is used as the basis for many dishes.

To process cassava into flour, the roots are peeled, grated, pressed, pulverized, dried, and milled. From those steps, drying is the most expensive and energy-intensive one. Pneumatic dryers, also known as flash dryers, are the most efficient equipment to produce cassava flour. However, in sub-Saharan Africa, flatbed dryers are more commonly used. This is because flatbed dryers, compared to pneumatic dryers, have lower capital costs, are easier to operate, and are more versatile. Flatbed dryers, also known as bin dryers, consists of a simple container with a perforated screen in the middle, as a false floor, where the solid to be dried is placed.

Pneumatic dryers are the most efficient equipment to produce cassava flour because drying occurs while the solids are being pneumatically transported. During the transport, the material is suspended by the hot air, and this improves greatly the contact between solid and the drying medium, enhancing heat and mass transfer and consequently improving efficiency. Differently, in a flatbed dryer, the material is stacked on top of each other, reducing the contact between the solid and the drying medium, thereby jeopardizing efficiency.

In addition to the inferior efficiency, an uneven air distribution that results in non-uniform drying is another problem present in most all flatbed dryers. Several solutions have been tested to improve this and the most common one is to add air-guides underneath the perforated screen to improve the uniformity of airflow distribution. While this solution is effective, it must be developed and tested by each dryer individually, not being possible to replicate the same air-guide arrangements to flatbed dryers of different designs.

The objective of this guide is to provide instructions on how to build a stirrer for flatbed dryers. The stirrer was designed to enhance the contact between the product and the hot air, improving the dryer's energy efficiency, while at the same time mechanically move and turn the material during drying, improving product uniformity. This solution, different from adding air-guides, are not specific to each dryer and can be implemented on flatbed dryers of any design.

Stirrer overview

The stirrer consists of a *supporting structure*, a *motor with reduction drive*, a *system of spur gears*, a *gear-house*, and *beaters* (Figure 1). Because the dryer that the stirrer will be installed in Tanzania has an oblong shape two sets of stirrers will be constructed (Figure 2).

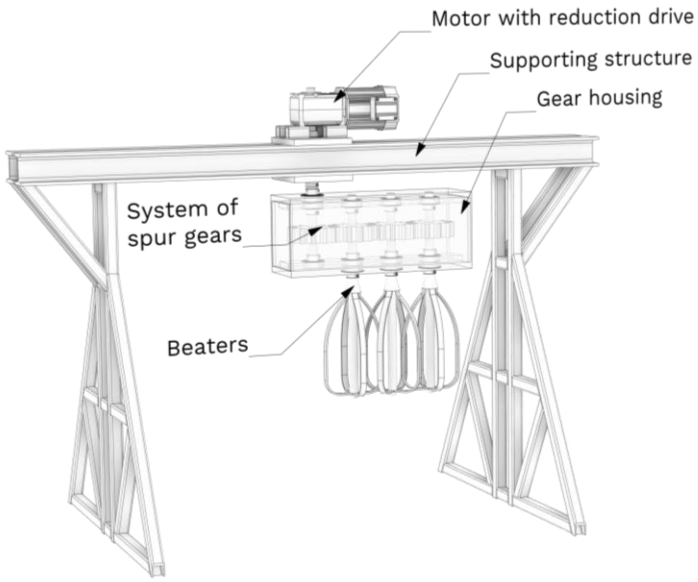


Figure 1 *Overview of the stirrer, featuring support structure, the motor with reduction drive, a system of spur gears, gear-house, and beaters.*

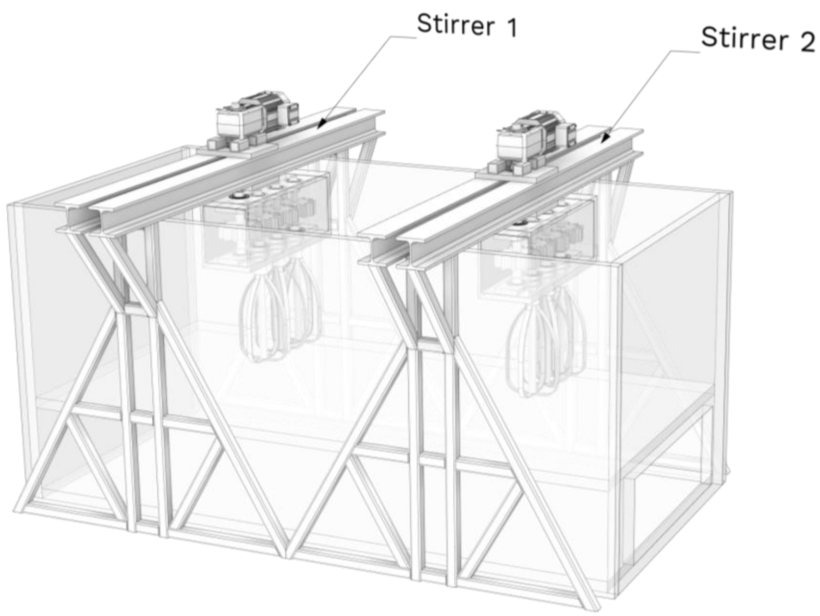


Figure 2 *Oblong shaped dryers require two sets of stirrers, while squared shaped dryers require only one.*

Construction Guide

Supporting structure

The leg of the supporting structure is built with 40 mm × 40 mm × 4 mm mild steel with a square hollow cross-section (Figure 3). However, it can be also built using mild steel of circular or rectangular hollow cross-section, depending on the local material commercial availability.

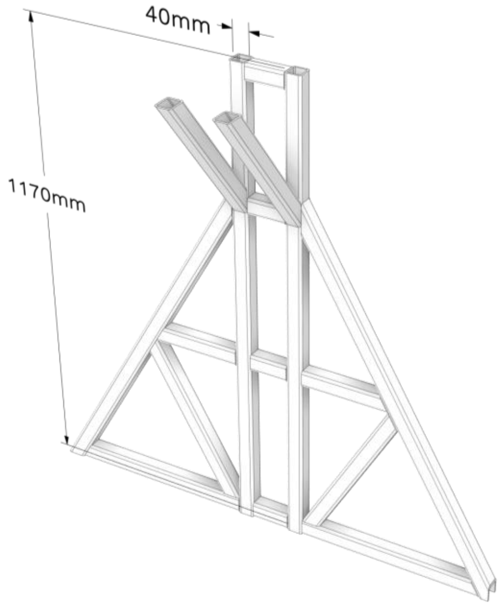


Figure 3 *The leg of the supporting structure is built with mild steel with a square hollow cross-section.*

The overhead of the supporting structure uses I-beams also, known as H-beam (Figure 4). The I-beam size has been dimensioned according to the predicted loads (Figure 5); however, its design allows for some variations on the I-beam size, according to local material commercial availability.

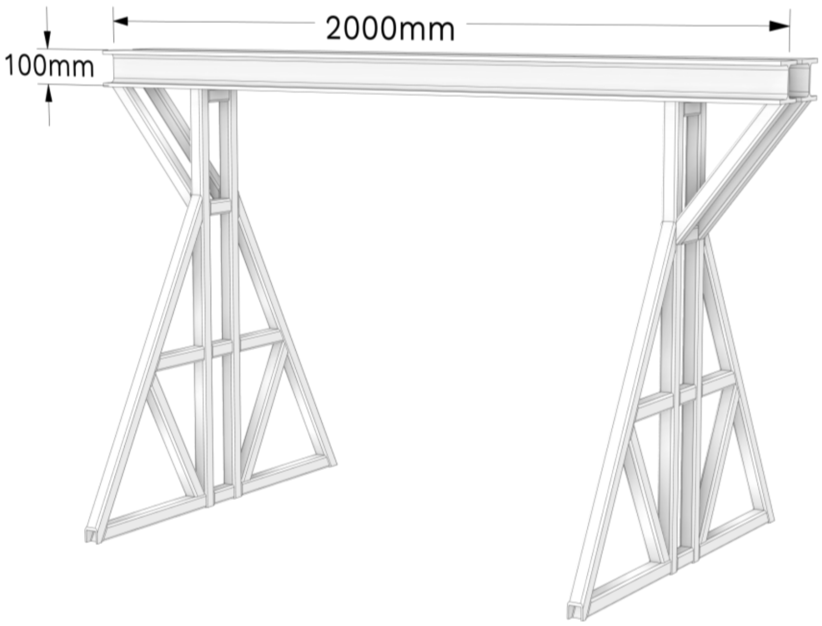


Figure 4 *Overhead of the supporting structure uses I-beams (also known as H-beam).*

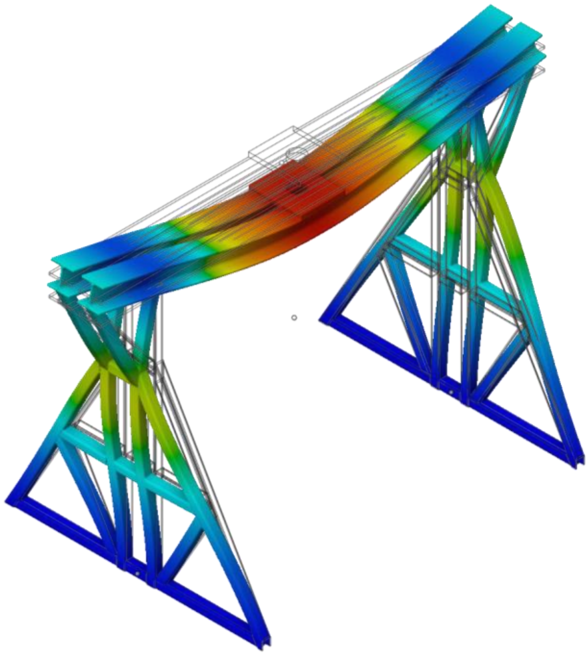


Figure 5 *Static stress and structural buckling analyses were performed to assure that the structure can support the loads and a safety margin has been added, allowing to adjust the I-beam size according to local material commercial availability.*

At the centre of the overhead, 20 mm thick metal plates, above and below the I-beams, are placed to support ball bearings that hold the shaft (Figure 6). The shaft is connected to the bearings with a keyed joint, consisted of a keyway and a keyset. In addition, to hold the shaft in place retaining rings are used. For simplicity, the keyed joints and the retaining rings are not shown in Figure 6, neither represented in the 3D CAD model.

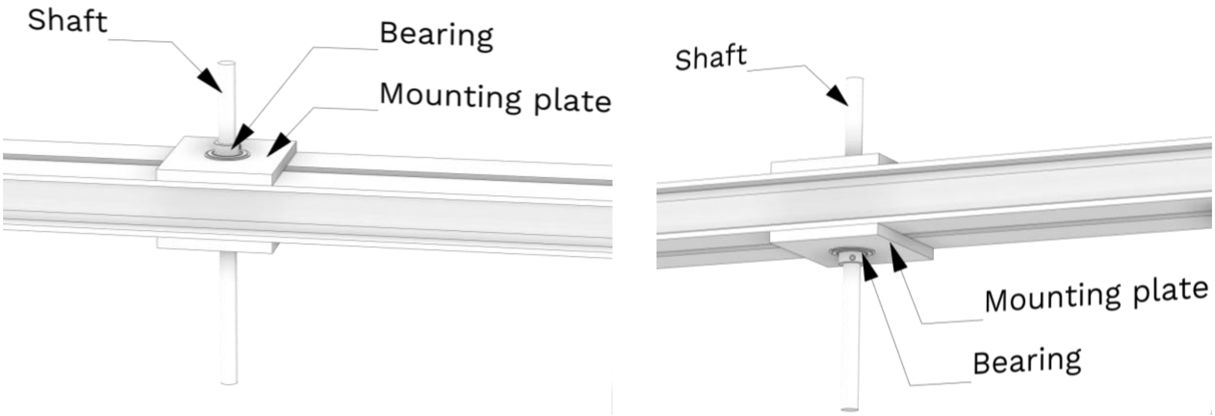


Figure 6 *Bearings on a mounting plate above and underneath the I-beams holds the shaft.*

Motor with reduction drive

The system is powered by a 2.2 kW (3 hp) motor coupled to a reduction drive. The reduction drive is a speed reducer that transmits motion at a 90° angle while decreasing speed and increasing torque. The design allows for any speed between 25 rpm and 125 rpm, depending on the local motors and reduction drives commercial availability.

System of spur gears

The shaft has a spur gear, that drives the gears of the beaters (Figure 7). At the shaft, as well as the beaters, the spur gear is secured with a keyed joint and retaining rings (not shown in Figures 7 nor represented in the 3D CAD model).

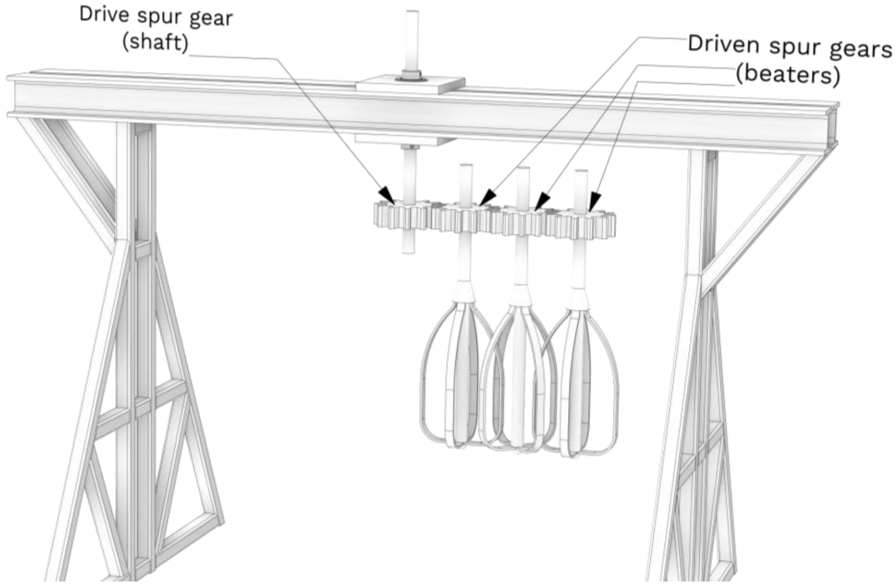


Figure 7 *A spur gear connected to the shaft drives the gears connected to the beaters.*

Gear-house

The gears are enclosed on a sealed gear-house, protecting the foodstuff underneath from contamination. The gear-house is a rectangular metal box built with 20 mm thick metal sheets, with reinforcement plates at the top and the bottom (Figure 8).

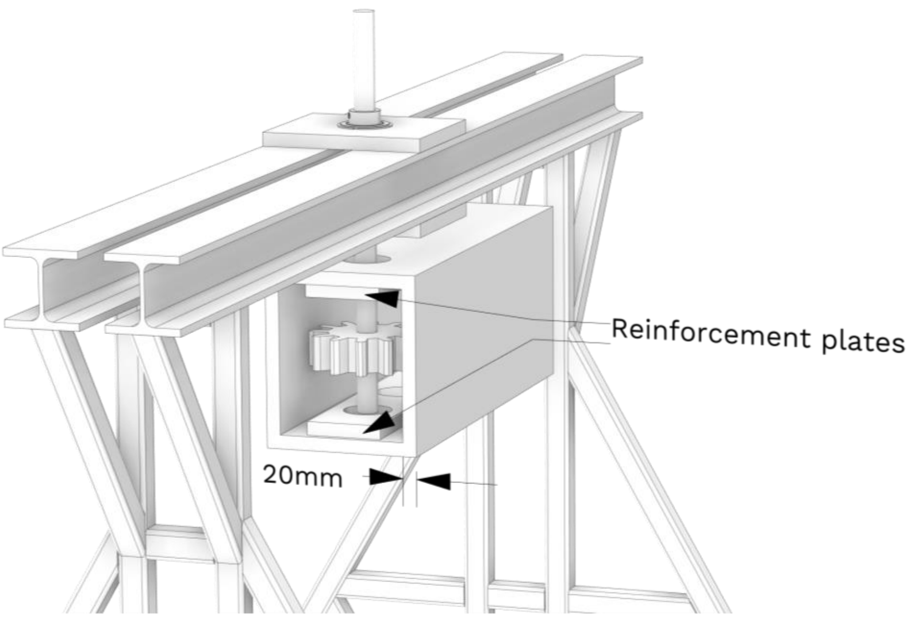


Figure 8 *A gear-house isolate the spur gear from the foodstuff underneath.*

The gear-house is supported by the shaft while bearings allow it to rotate (Figure 9). Keyed joints and retaining rings are used but not shown in Figures 9 nor represented in the 3D CAD model.

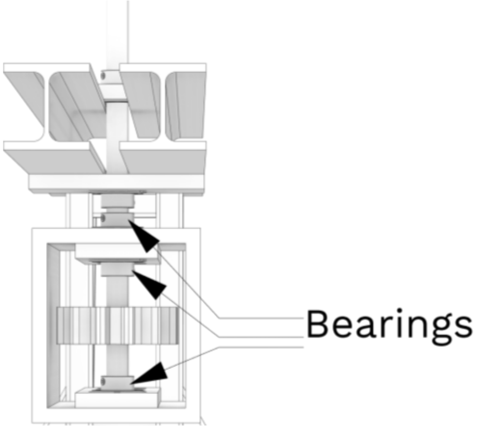


Figure 9 *The gear-house is supported by the shaft and bearings are used to allow it to rotate.*

The beaters are supported by the gear-house and bearings are used to allow it to rotate (Figure 10). The system is locked with keyed joint and retaining rings (not shown in Figures 10 nor represented in the 3D CAD model).

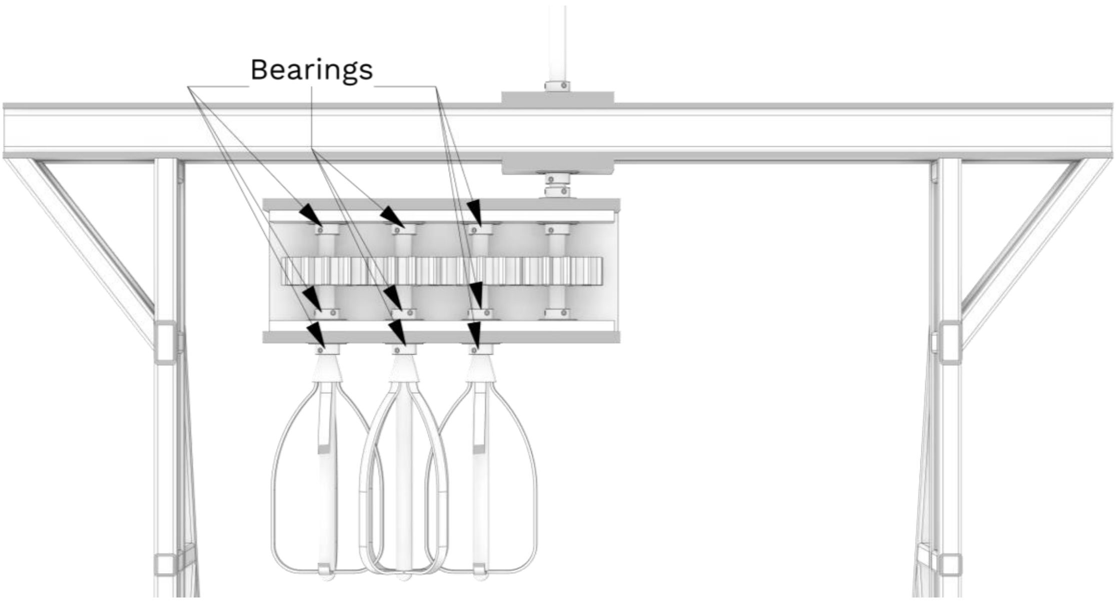


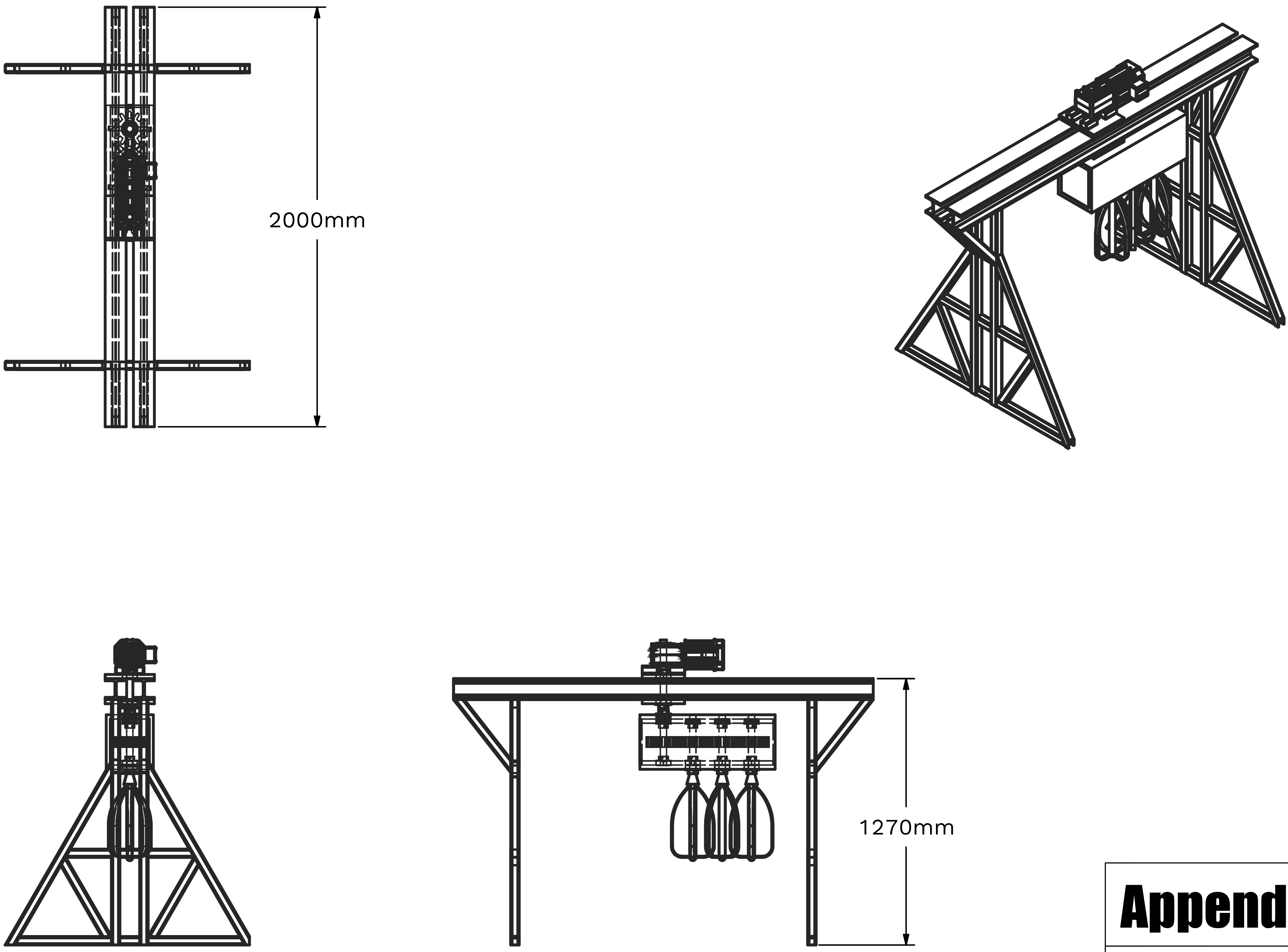
Figure 10 *The beaters are supported by the gear-house and bearings are used to allow it to rotate.*

Beaters

The beaters are the components that move and turn the material, enhancing the contact with the hot air and improving product uniformity. Because it comes in direct contact with the foodstuff it needs to be built with stainless steel.

Equipment dimensions

Appendix 1 to Appendix 5 shows the main dimensions of the stirrer. However, exact sizes should be obtained from the 3D CAD model available at https://a360.co/3ghSqyF.



Appendix 1

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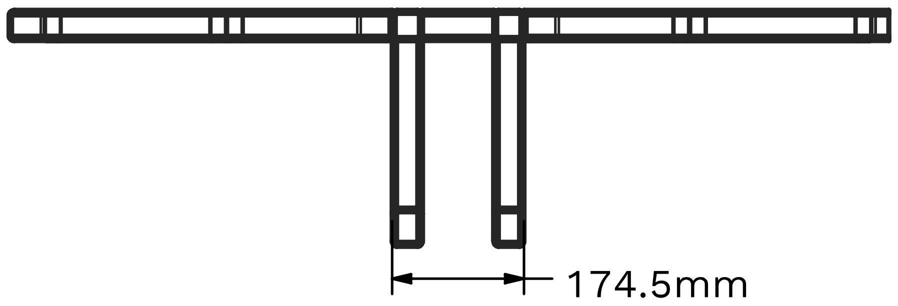

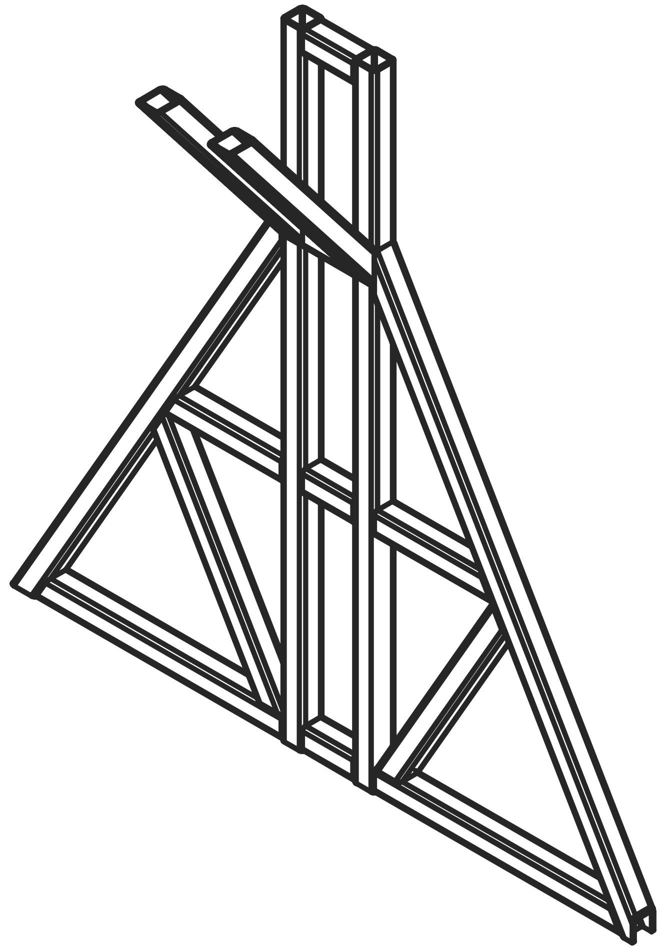

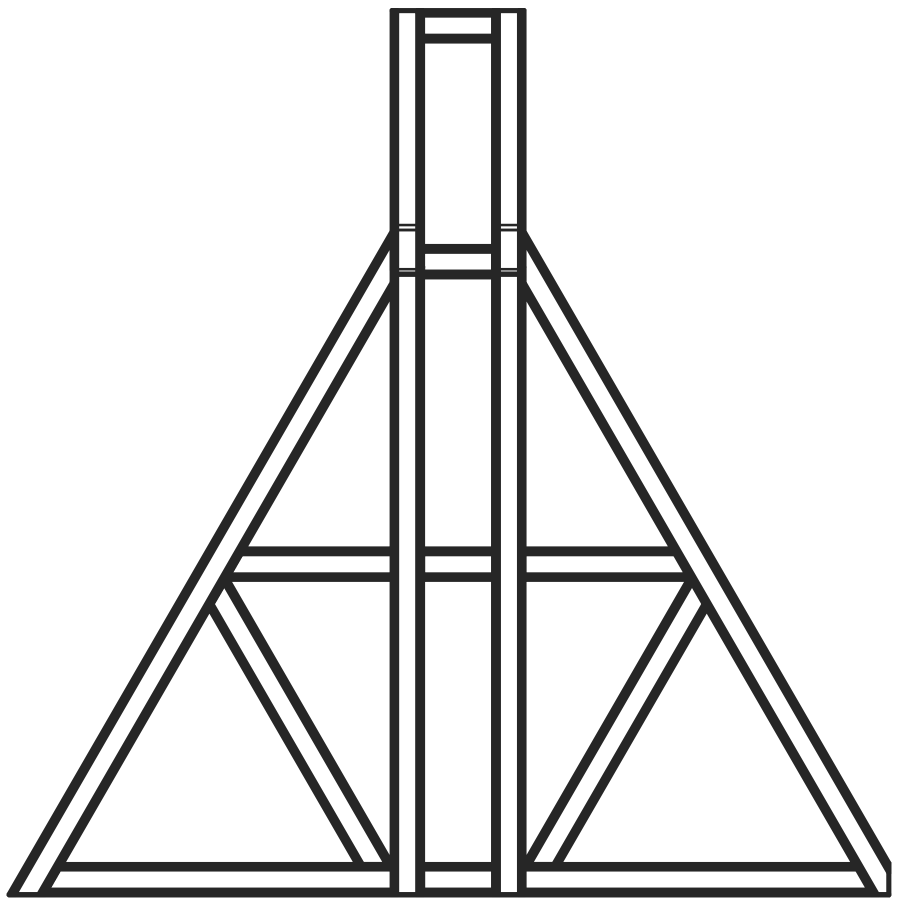

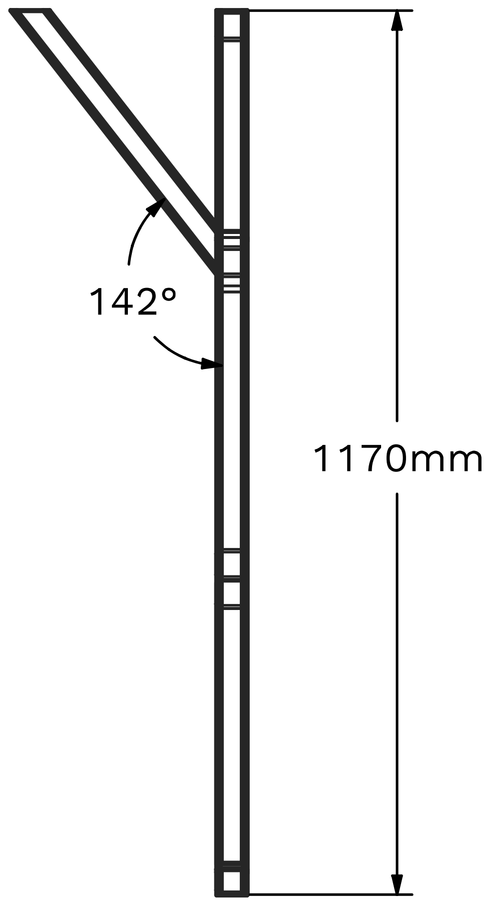

Appendix 2

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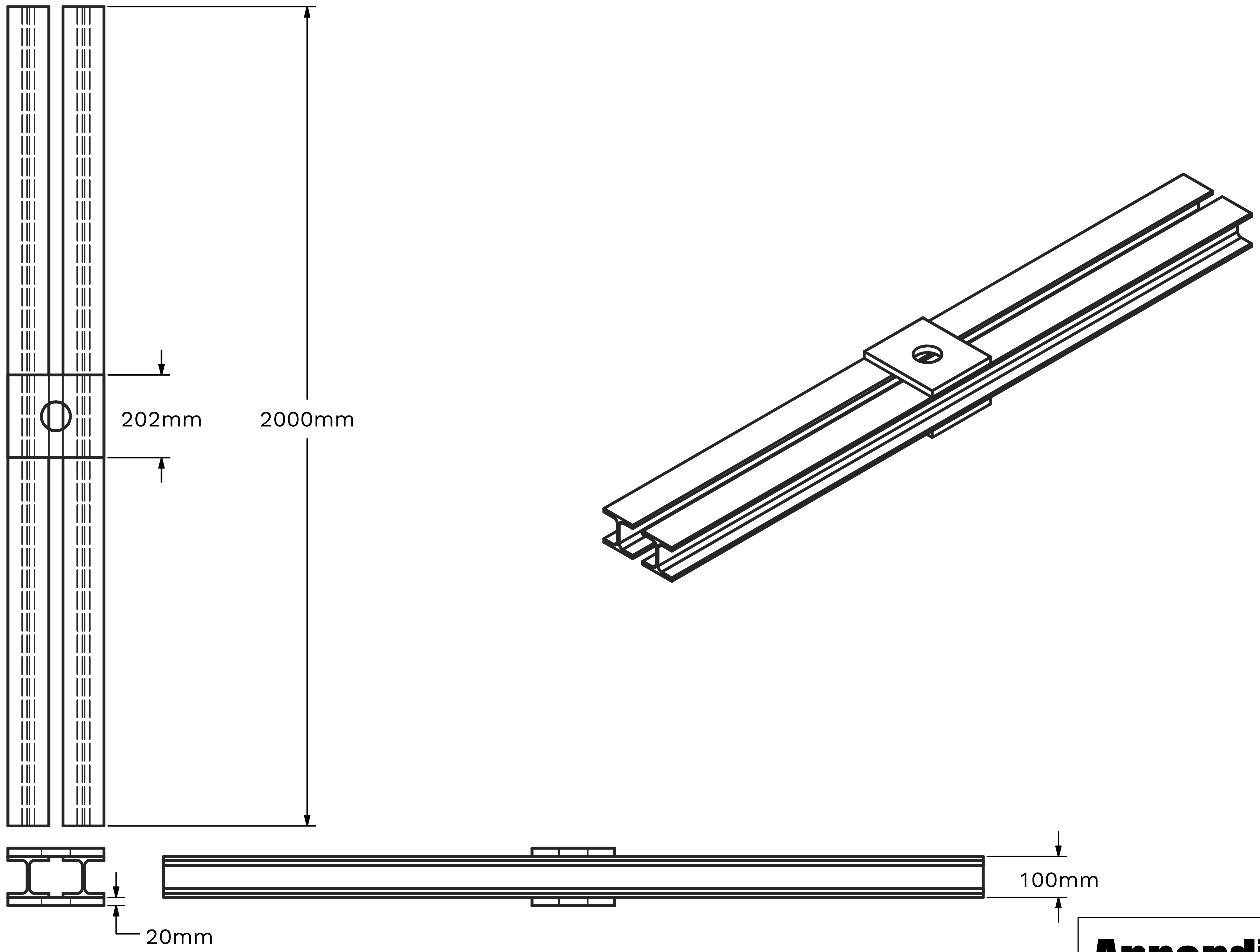

Appendix 3

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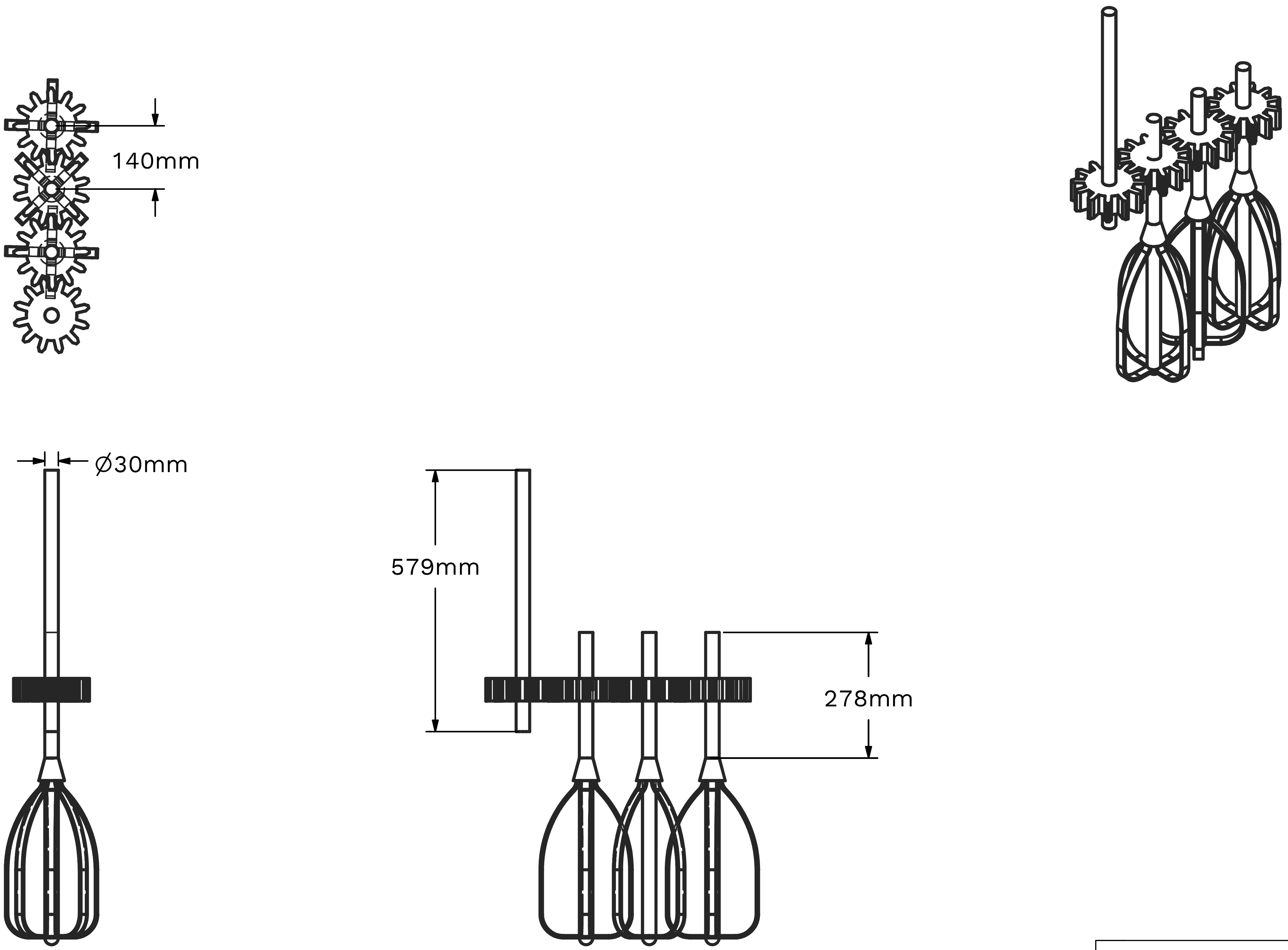

Appendix 4

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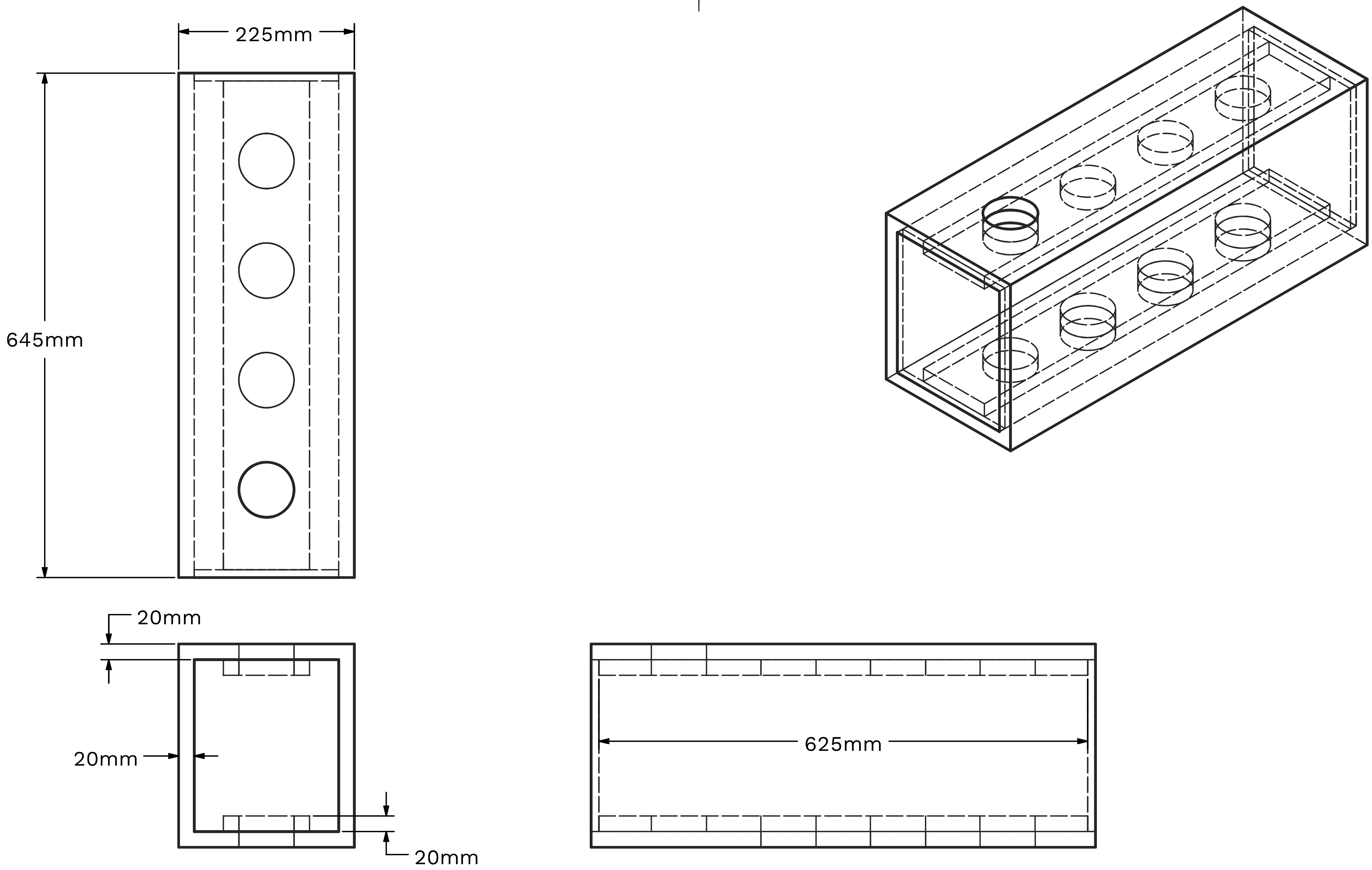

Appendix 5

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