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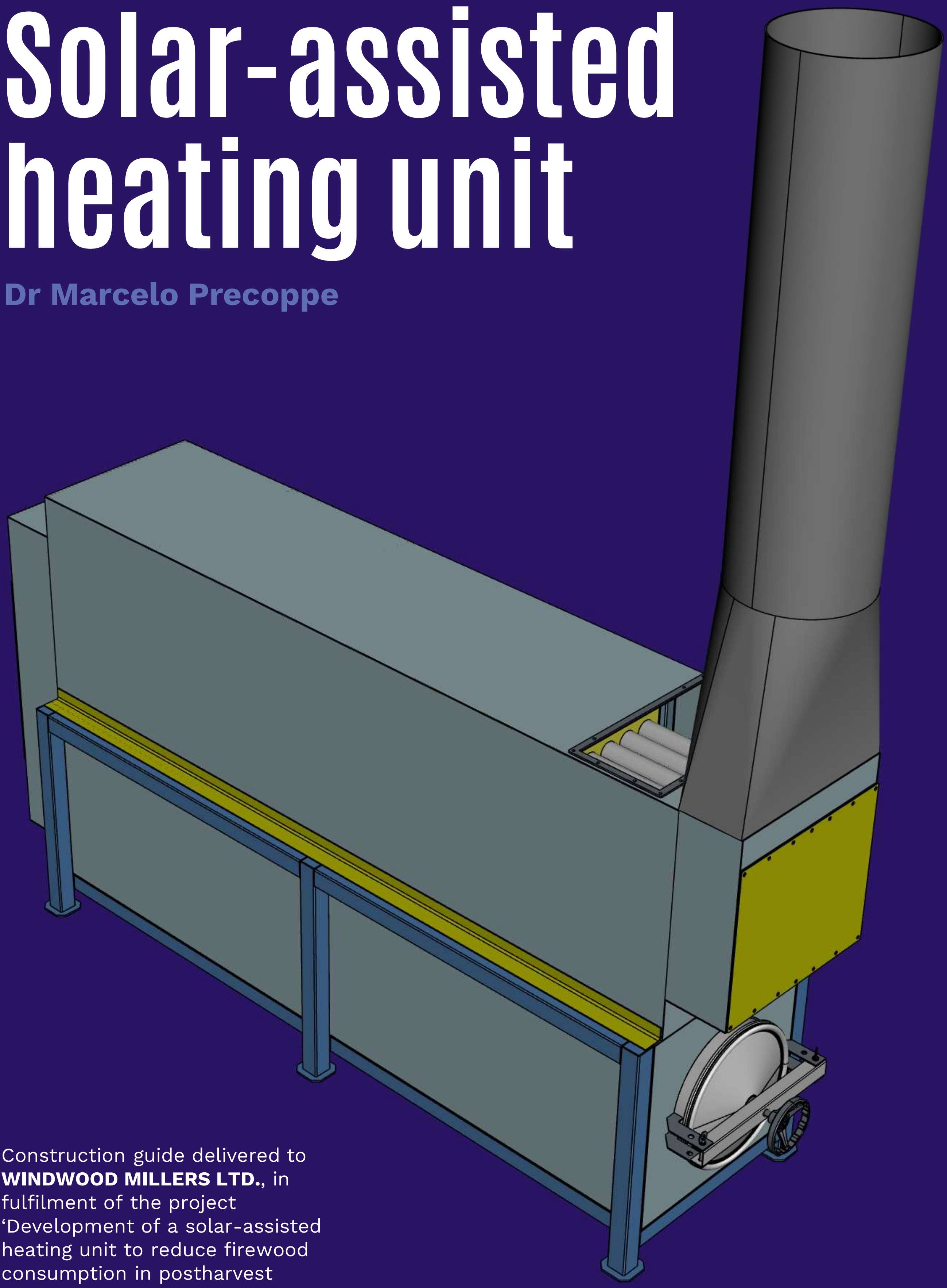
Solar-assisted heating unit

Dr Marcelo Precoppe

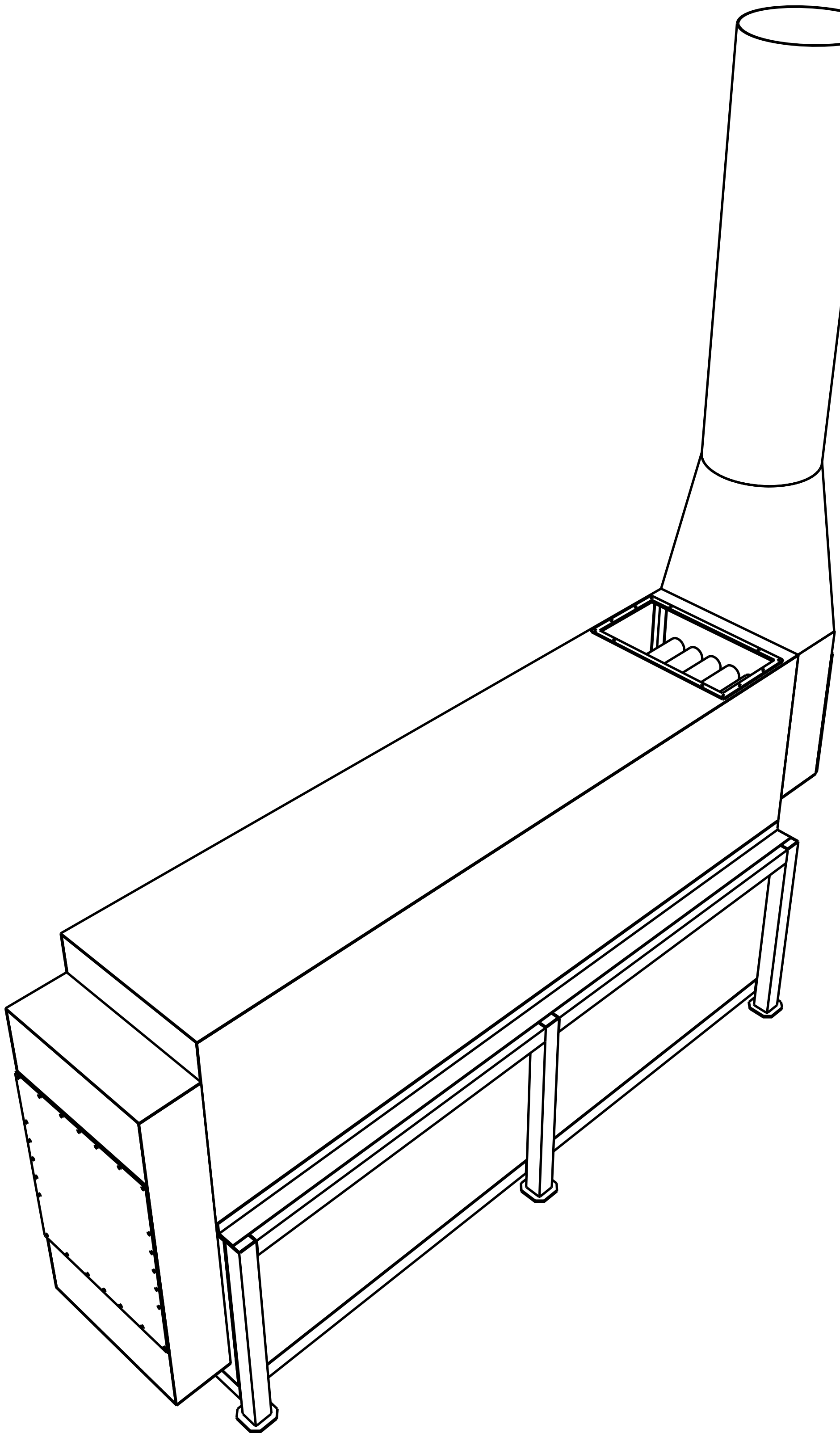


Construction guide delivered to **WINDWOOD MILLERS LTD.**, in fulfilment of the project 'Development of a solar-assisted heating unit to reduce firewood consumption in postharvest operations in developing countries' funded by HEIF 2020/2021

January 2021

Solar-assisted heating unit

Construction Guide: Part 1



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

This guide was delivered to **WINDWOOD MILLERS LTD.**, in fulfilment of the project *Development of a solar-assisted heating unit to reduce firewood consumption in postharvest operations in developing countries* funded by HEIF (2020/2021). It was prepared to instruct **Awiko Engineering Ltd.**, on how to build this novel solar-assisted heating unit. The guide is separate into 3 parts. Part 1 instructs the construction of the firewood-powered heating unit. Part 2 instructs the construction of the solar heater and Part 3 instructs on how to evaluate its performance.

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*) is a perennial root crop native to the central region of South America but nowadays cultivated throughout the humid tropics. Cassava is the main source of calories for many people living in Africa.

Cassava has a short shelf-life, and two days after being harvested becomes unsuitable for human consumption. For this reason, the roots are usually processed into flour, a dried product which can be used later as the basis for a variety of dishes. During the cassava flour production, the roots are peeled, grated, pressed, pulverized, dried, and milled, as shown in Figure 1.

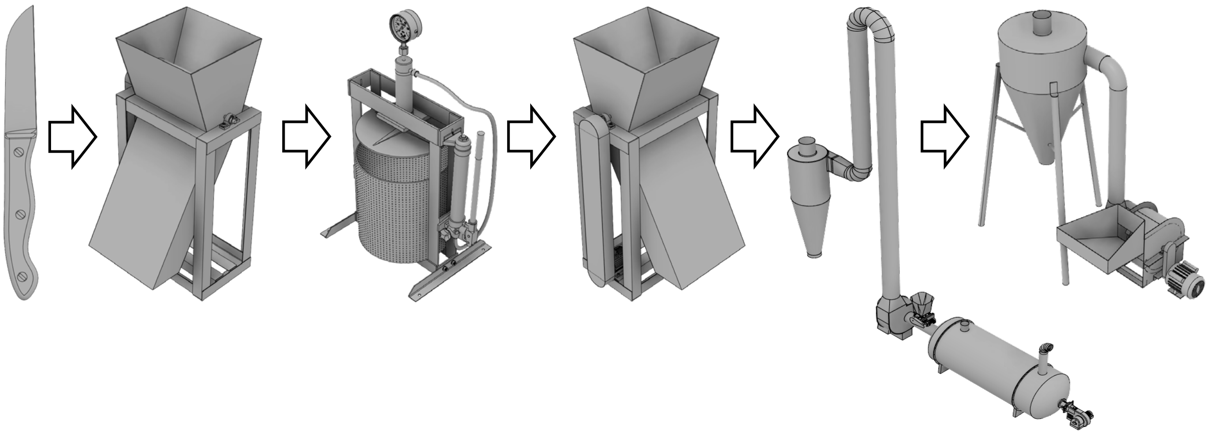


Figure 1 *Cassava processing requires peeling, grating, pressing, pulverizing, drying and milling.*

Firewood is still commonly used to dry cassava, a heating source that is often associated with deforestation, exposure to pollutants, and CO_2 emission. In the recent past, many projects aimed to develop drying technologies that use more sustainable heating sources such as solar energy, biogas, or bioethanol, but in developing countries, the adoption of those technologies has been limited, particularly by small-size enterprises. To makes matters worse, the firewood powered heating units, used by those enterprises, are highly inefficient. This project aims to develop a solar-assisted, highly efficient, firewood powered heating unit that can replace those inefficient ones. Firewood would still be used as the heating source, but the efficient design, combined with solar heating assistance, will reduce its consumption dramatically. A solar-assisted heating unit prototype will be built in Lira, Northern Uganda, at a cassava processing centre named Windwood Millers Ltd. The objective of this guide is to provide the instructions on how to build this highly efficient firewood-powered heating unit.

Overview of the firewood-powered heating unit

The heating unit has the function to warm-up the air. The unit consists of a combustion chamber, and on top of it, a heat exchanger (Figure 2).

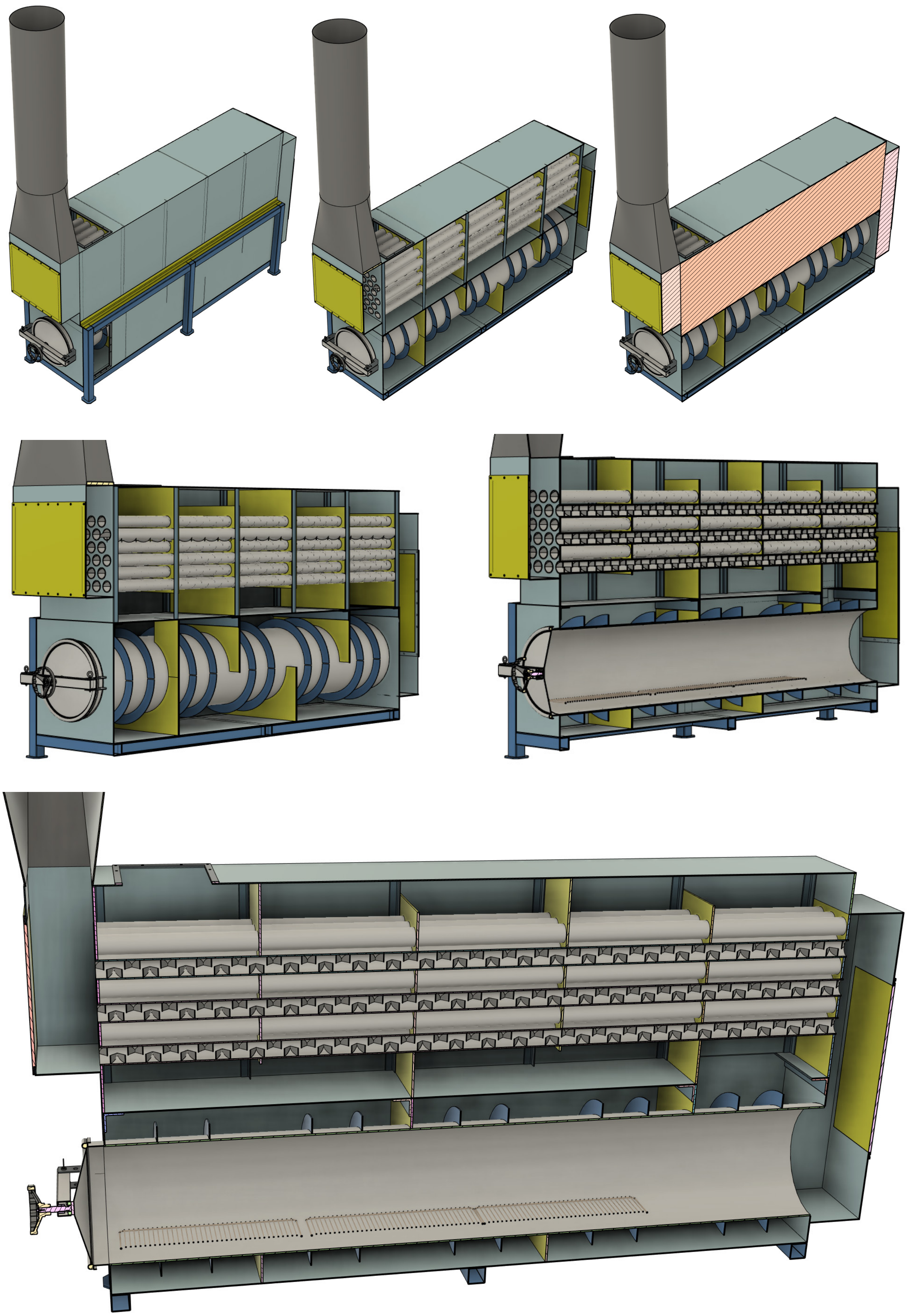


Figure 2 *Firewood powered heating unit with heat exchanger on top of the combustion chamber.*

Combustion chamber

The combustion chamber is a 2400 mm long cylinder with an internal diameter of 400 mm. It is made of 10 mm thick steel (Figure 3.)

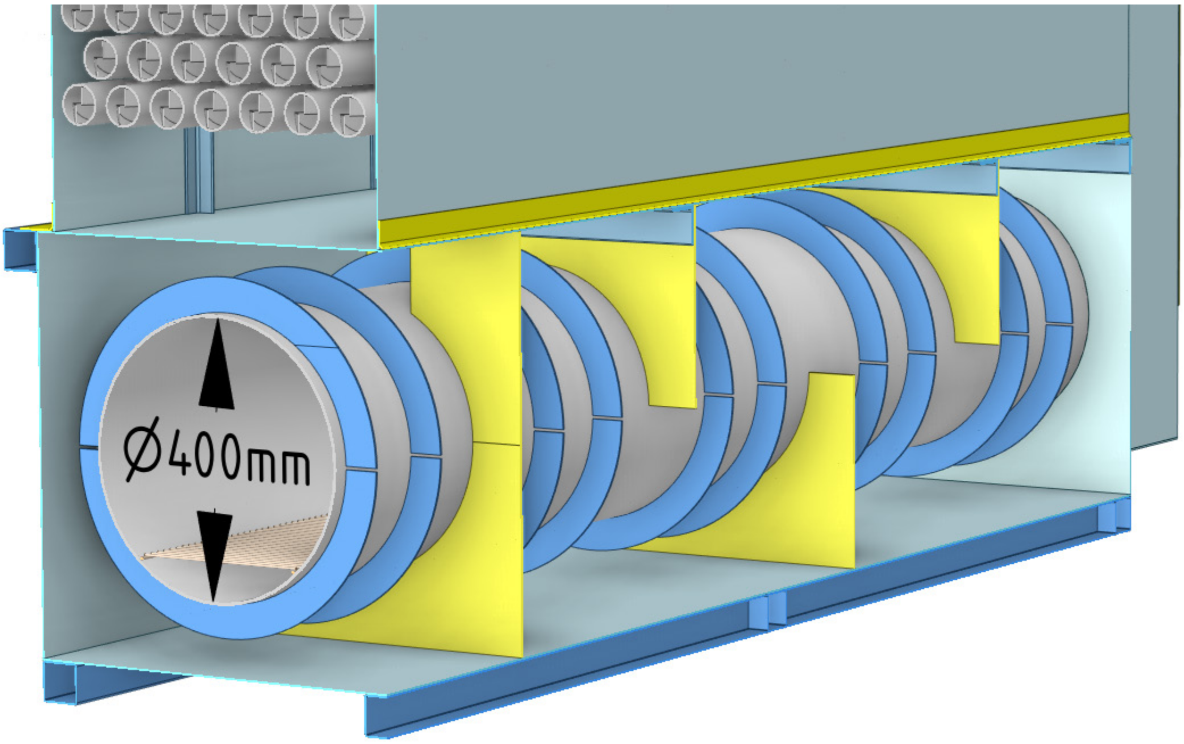


Figure 3 *The combustion chamber is a cylinder with an internal diameter of 400 mm.*

Baffles

Baffles are present at the external side of the combustion chamber to direct the flow and improve heat transfer. The baffles have also the function to hold the combustion chamber cylinder. The baffles at the combustion chamber are made of 6 mm thick sheet and they are 480 mm apart from each other (Figure 4).

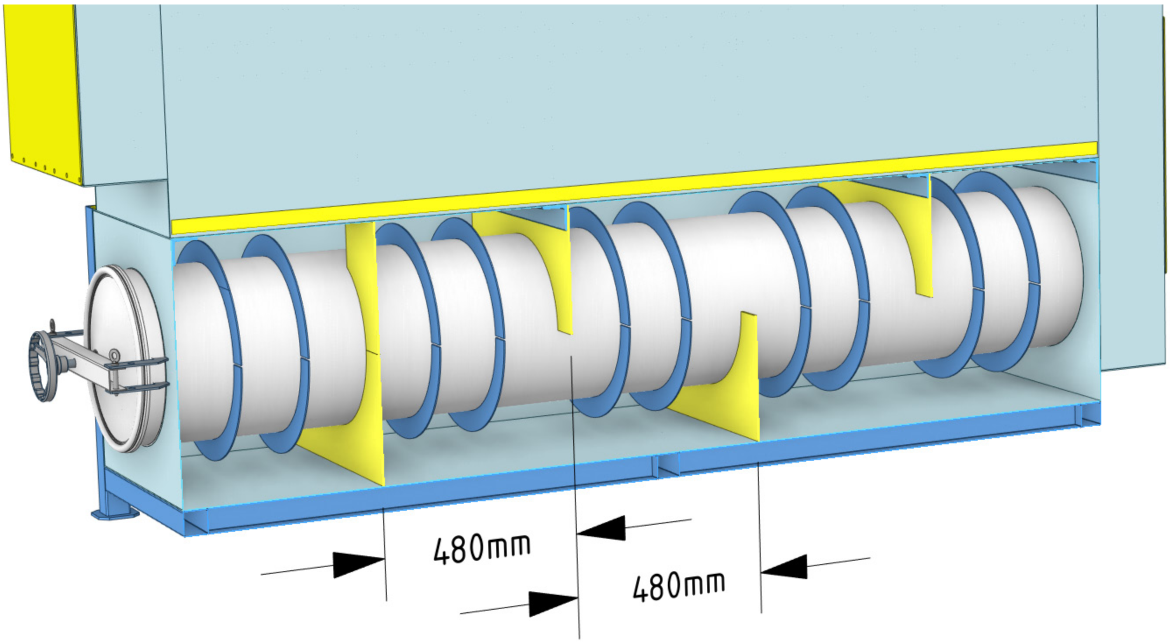


Figure 4 *Baffles, 6 mm thick, hold the combustion cylinder and direct the airflow.*

Fins

Fins are placed in between the baffles to increase surface area and induce turbulence. The fins are made of 3 mm thick steel and placed 160 mm apart (Figure 5.)

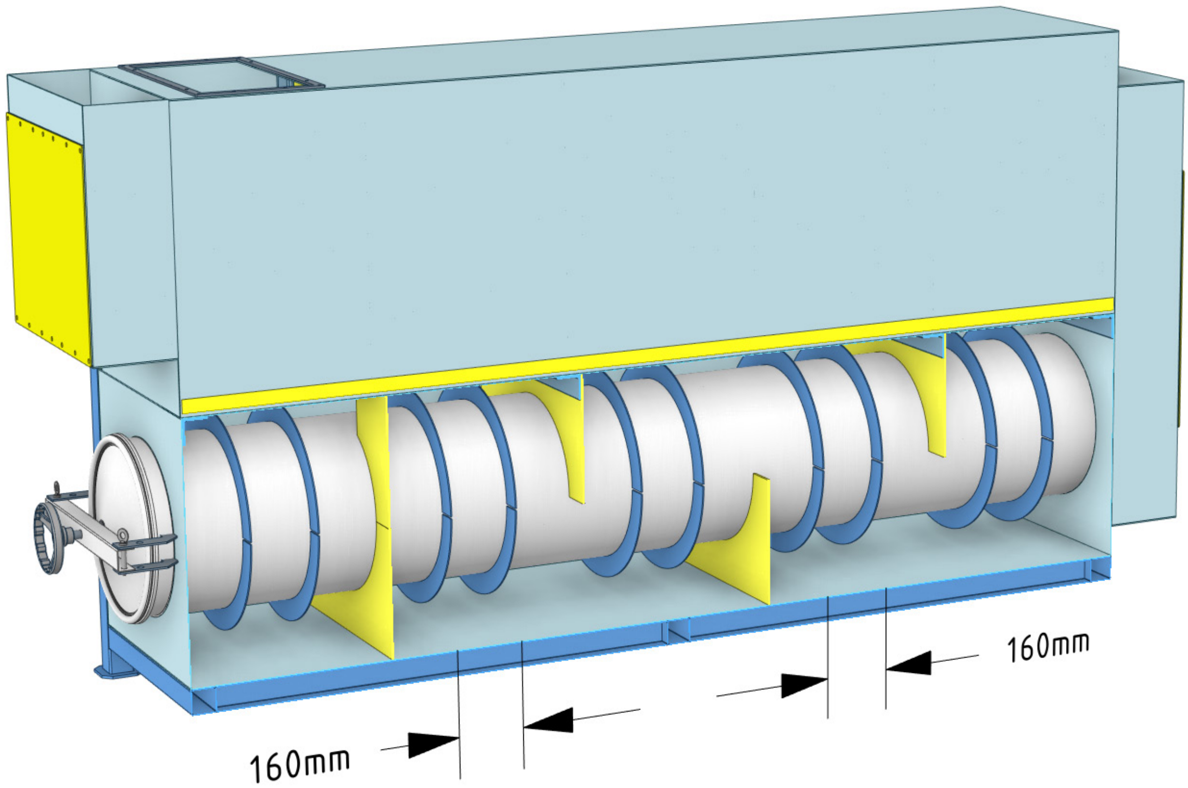


Figure 5 *Fins, placed 160 mm apart increase the surface area and induce turbulence.*

Block

The combustion chamber cylinder with its baffles and fins are enclosed in a squared shaped block, 610 mm heigh, 610 mm wide and 2400 mm long (Figure 6).

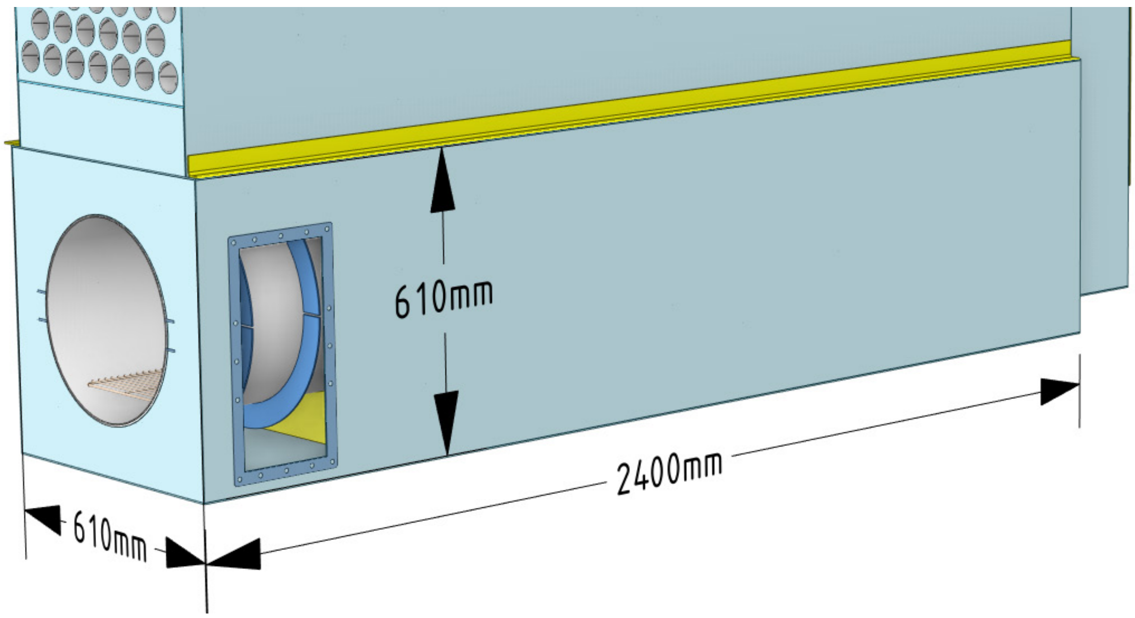


Figure 6 *A block, made of 3 mm thick steel, encloses the combustion cylinder.*

Intermediate zone

An intermediate zone connects the combustion chamber at the bottom with the heat exchanger at the top (Figure 7).

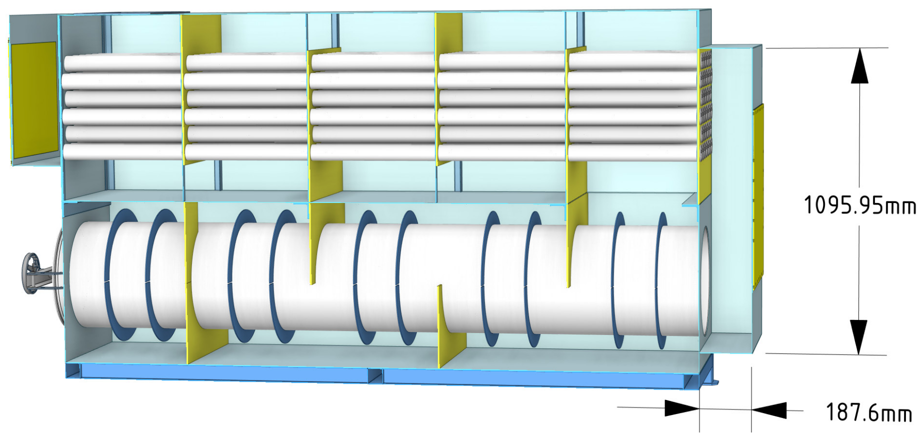


Figure 7 *Intermediate zone connecting the combustion chamber to the heat exchanger.*

Heat exchanger

Heat exchangers are devices that transfer heat between two fluids. In the context of convective drying, heat exchangers are used to transferring the heat from the combustion gases to the drying air. Several types of heat exchangers are used in food processing, but the most common type is the shell-and-tube type, because of its large heat transfer surface and consequently higher efficiency. Shell-and-tube heat exchangers contain a bundle of parallel tubes enclosed in a shell. Inside each tube, a turbulator is placed to increase heat transfer. Like in the combustion chamber, baffles are also used to guide the flow and to support the tubes.

Tubes

The heat exchanger uses 39 tubes arranged in 6 rows. Each tube is 2400 mm long with an inner diameter of 53 mm and an outer diameter of 60.3 mm (Figure 8)

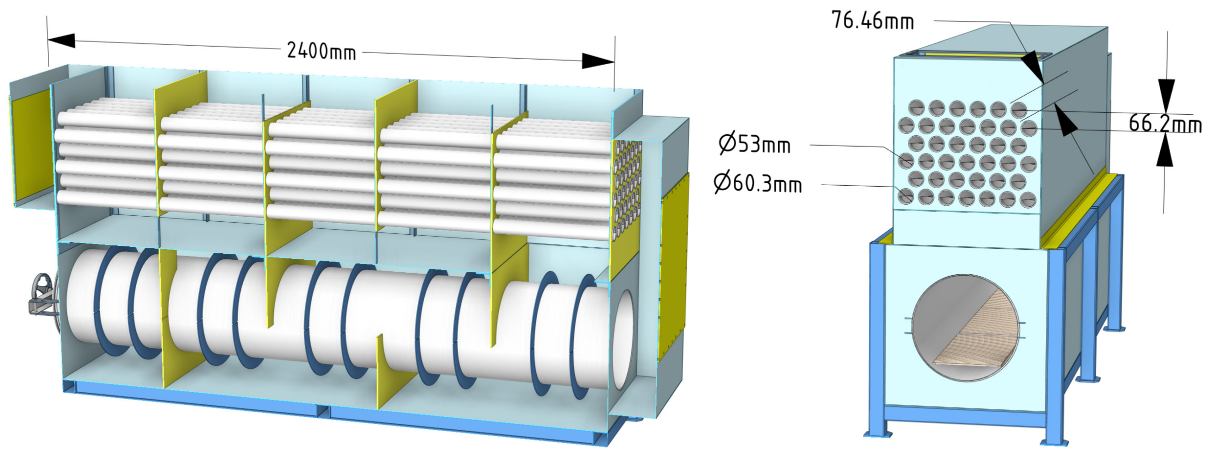


Figure 8 *Bundle of 39 tubes, 66.2 mm apart from each other are used in the heat exchanger.*

Turbulators

Turbulators are inserted inside each tube to increase heat transfer surface and thus efficiency (Figure 9).

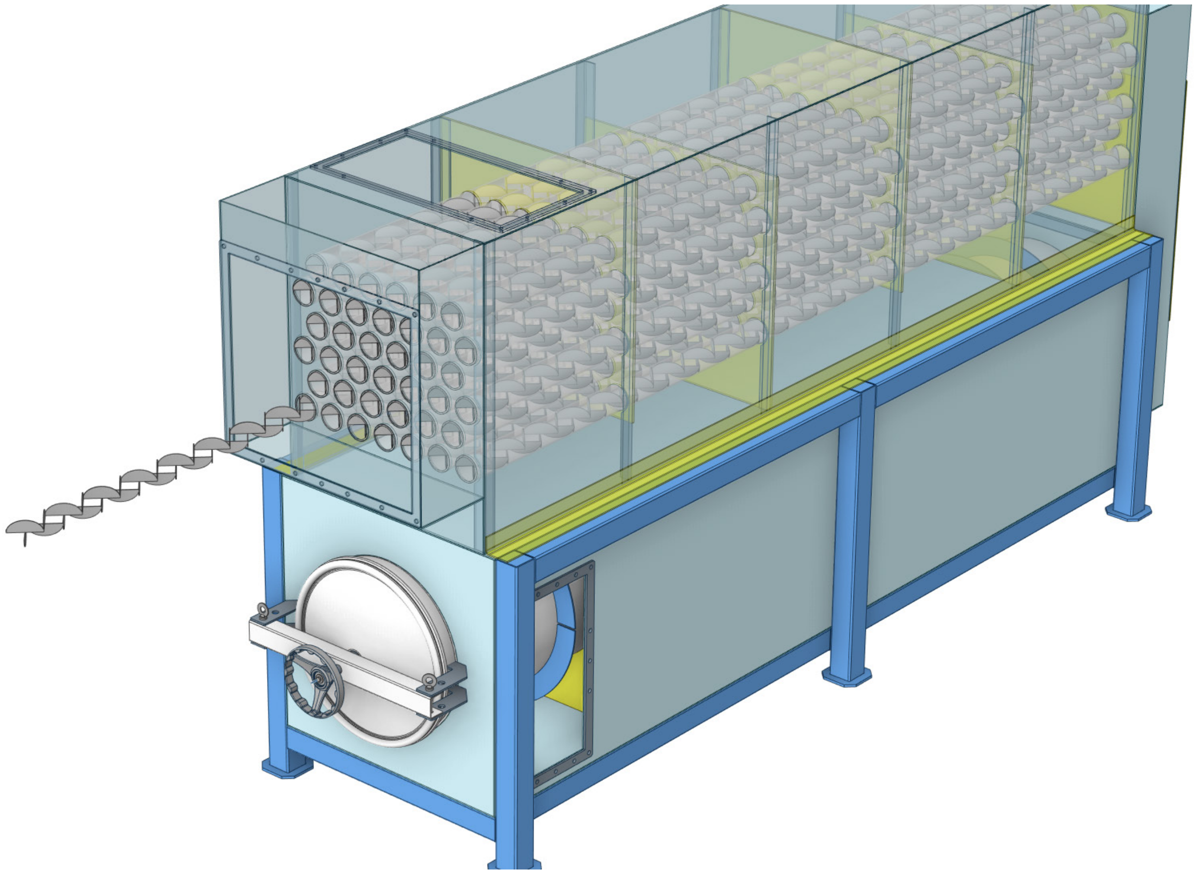


Figure 9 *Turbulators are made by cutting and bending 1 mm thick metal sheets.*

Baffles

Baffles, made of 6 mm thick metal sheet are 480 mm apart (Figure 10)

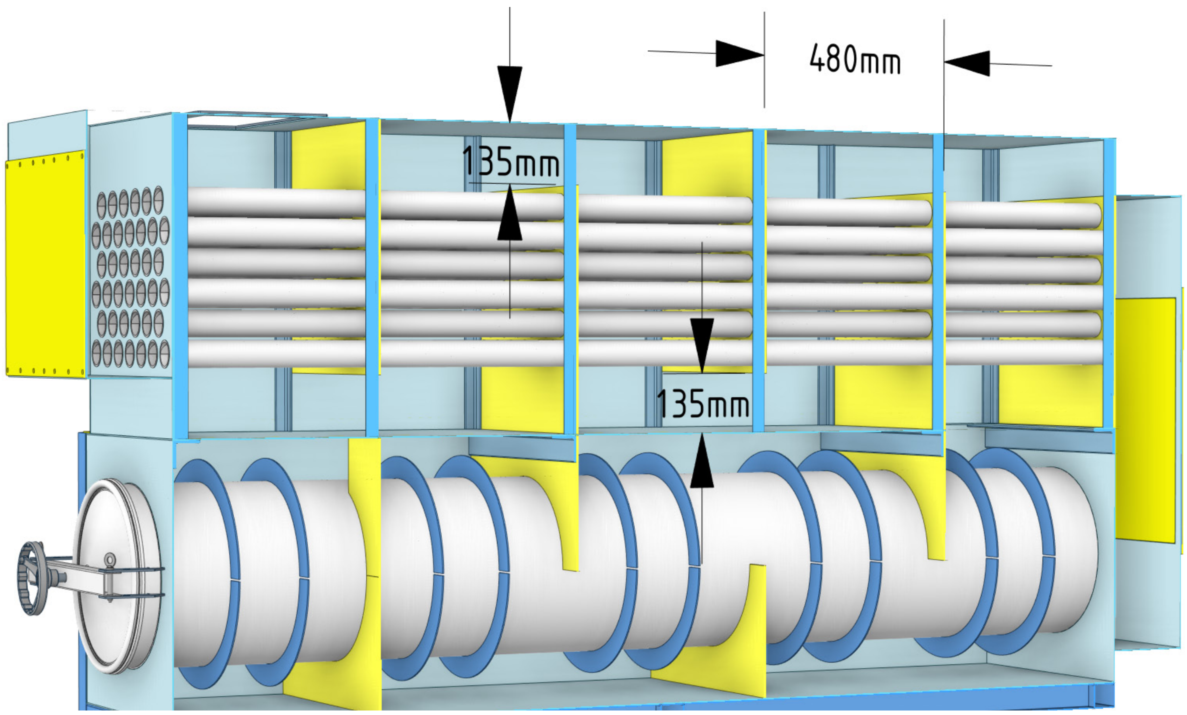


Figure 10 *Baffles hold the tubes and guide the airflow*

Shell

The tubes and the baffles are enclosed in a shell that has a rectangular shape as shown in figure 11.

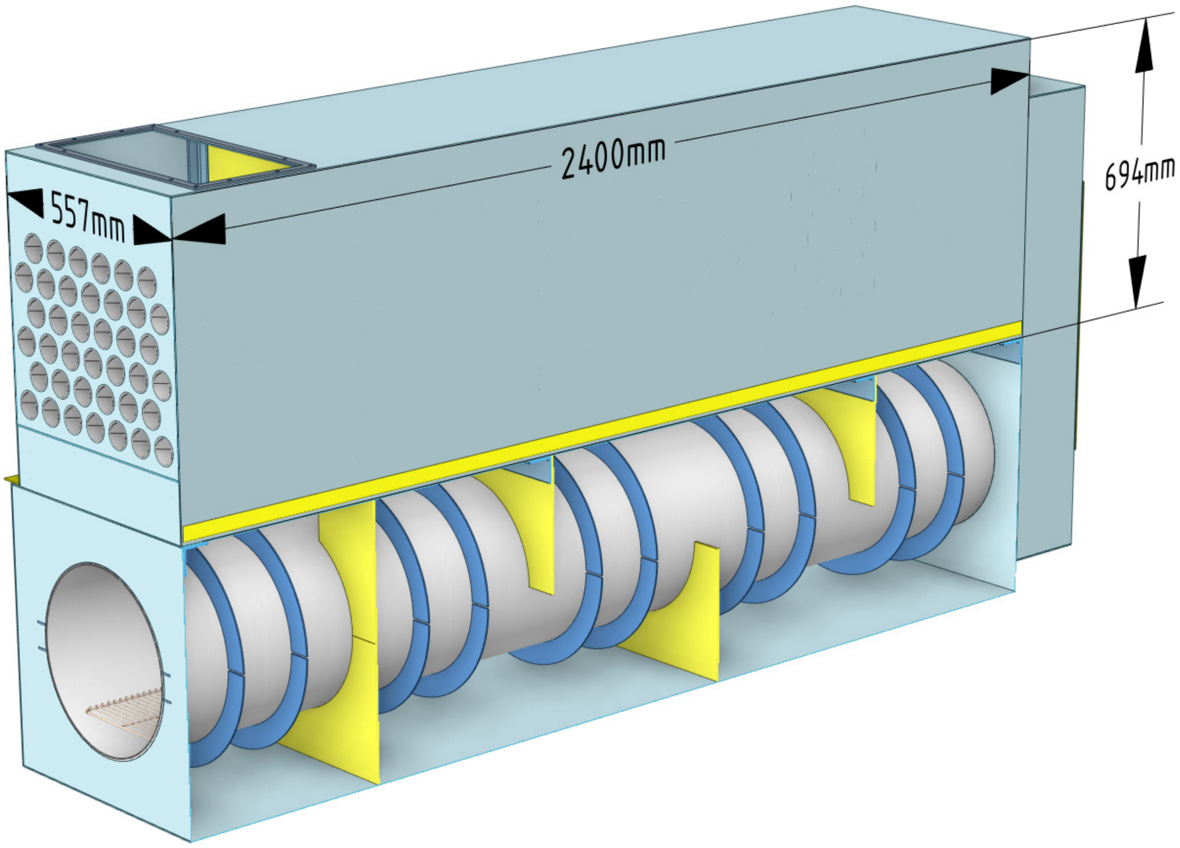


Figure 11 Rectangular shaped heat exchanger shell, encloses tubes and baffles.

Exhaust zone

The exhaust zone guides the combustion gases to the chimney (Figure 12).

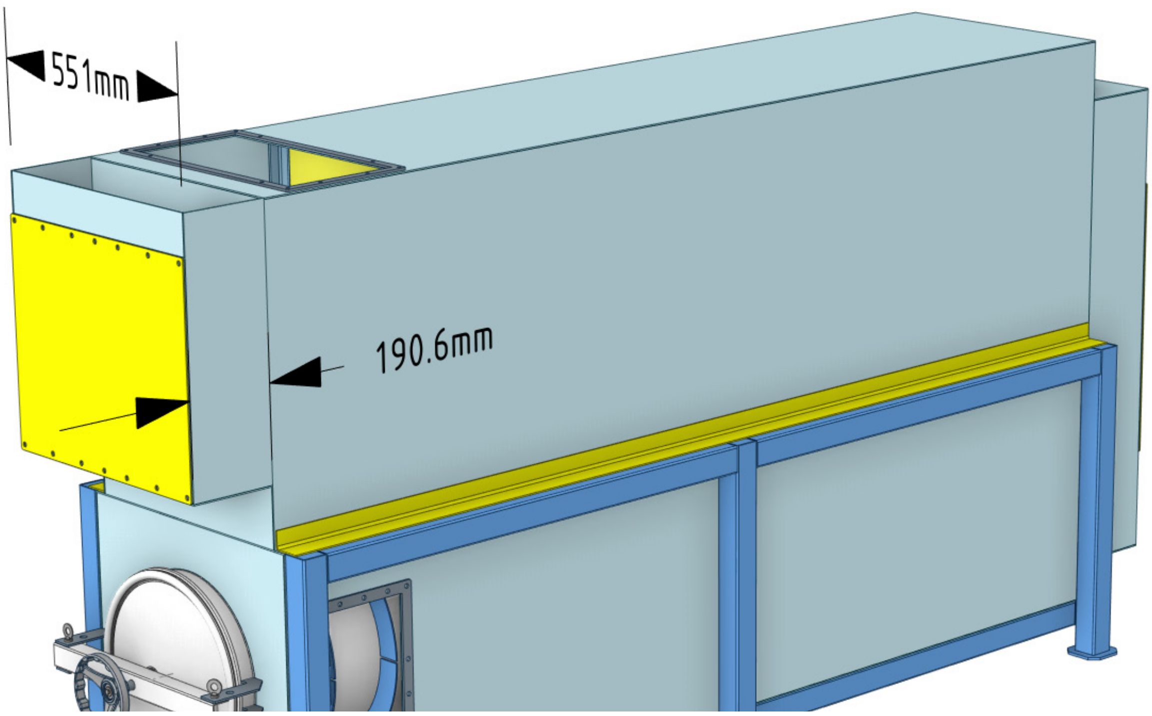


Figure 12 Exhaust zone, from where the exhaust gases leave the equipment to a chimney.

Equipment dimensions

Appendix 1 contains drawing sheets of the heating unit, but exact dimensions should be obtained from the 3D CAD file available at https://a360.co/39cfjiW or https://adobe.ly/2Xt3hfx.

Finances

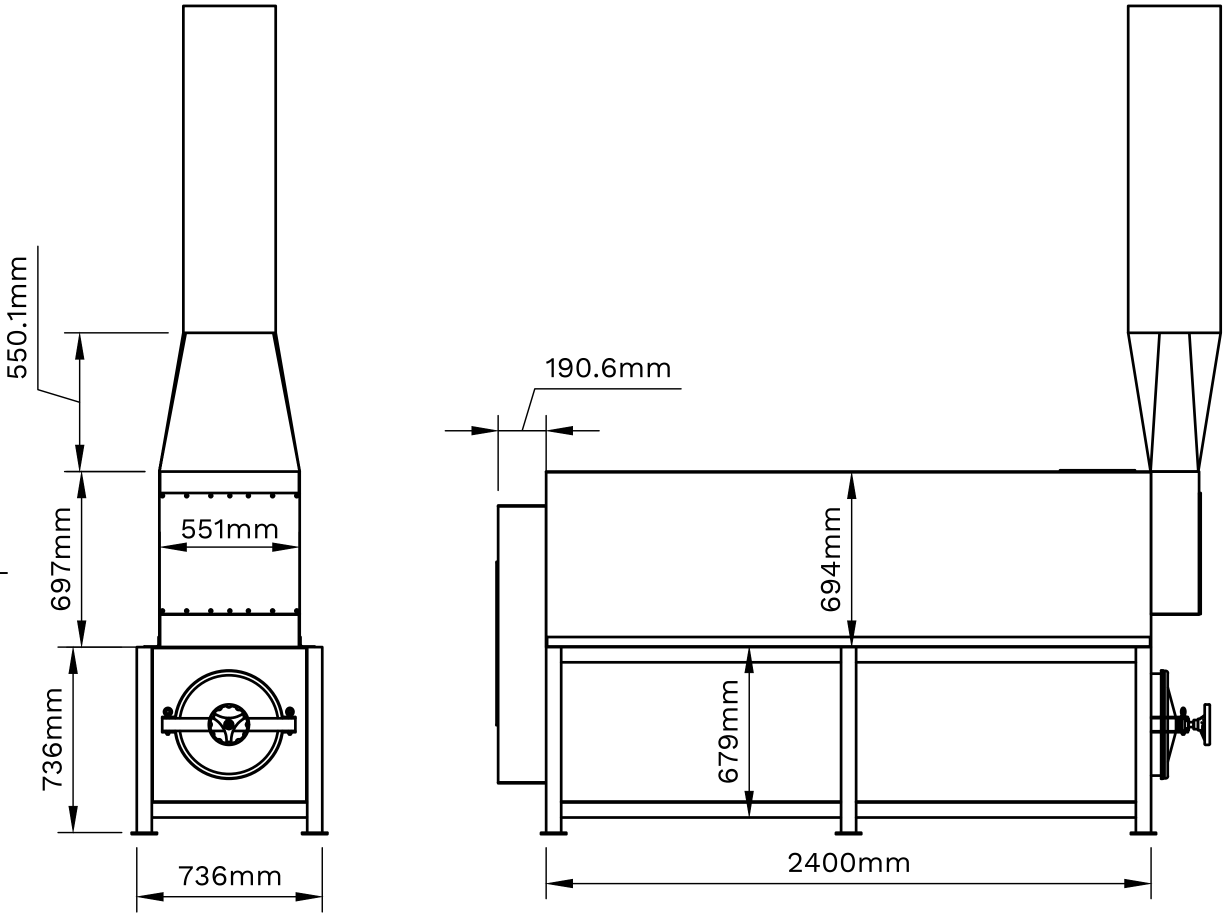
The construction of this equipment will be covered by this project funded by HEIF 2020/2021. Payments will be made via international bank transfer, from the University of Greenwich, directly to Awiko Engineering Ltd., who will build the equipment. However, Windwood Millers is who will organize its construction and assure the equipment is built according to the specifications. Payment will be done in two instalments, one at the beginning and one at completion. Once authorized, payments might take up to 28 days to reach Awiko Engineering bank account.

Follow-up activities

The heating unit must be built and installed at Windwood Millers' processing centre latest by the end of February, to allow testing and troubleshooting in March. Windwood Miller will negotiate the price of its construction and installation with Awiko Engineering and send a quote to University of Greenwich. Table 1 shows the work schedule.

Table 1 Work schedule of the follow-up activities.

Tasks	Responsible	Jan	Feb	Mar
Obtain a quote for construction and installation	Windwood Millers	■		
Construction and installation	Awiko Engineering		■	
Test and troubleshooting	University of Greenwich			■



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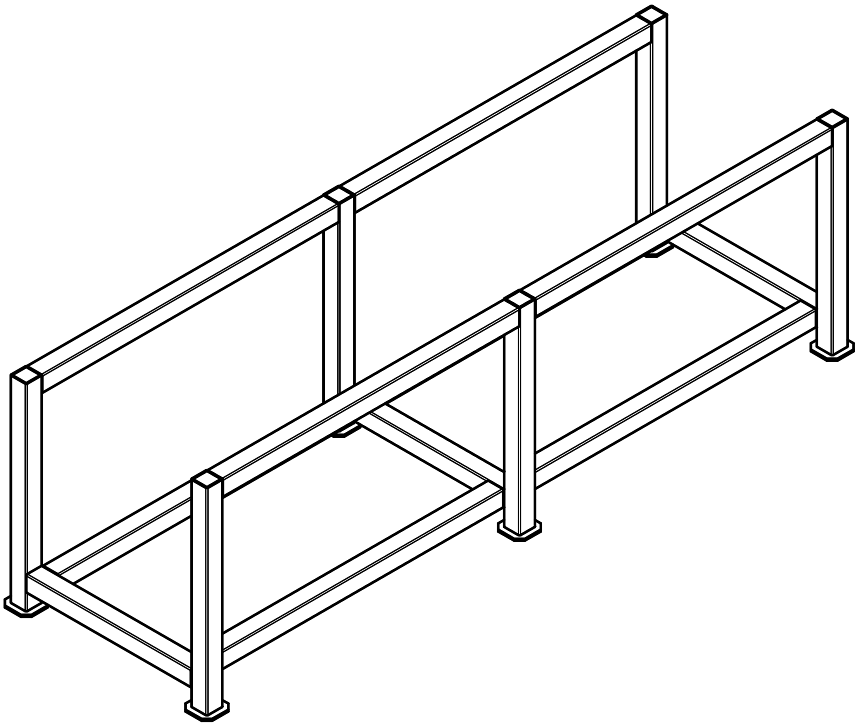

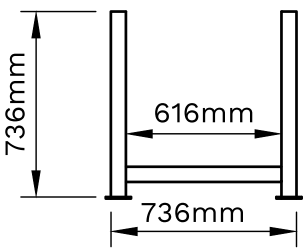

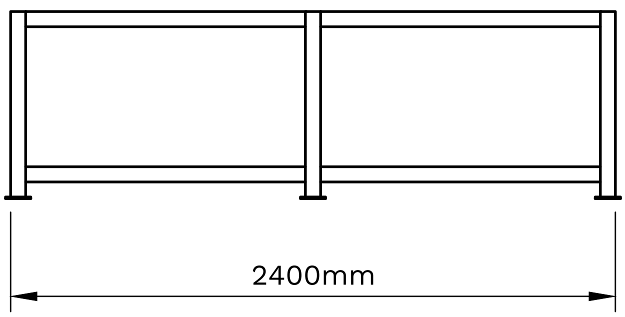

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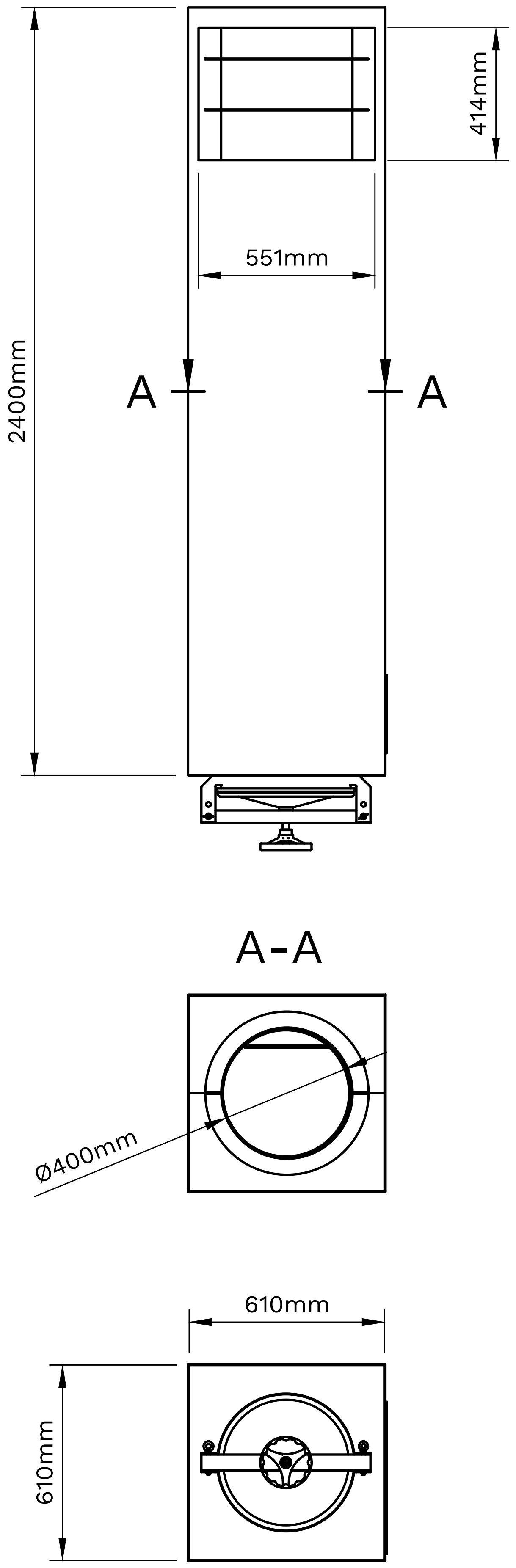

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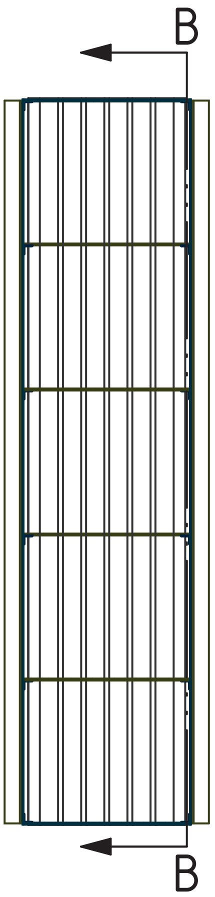
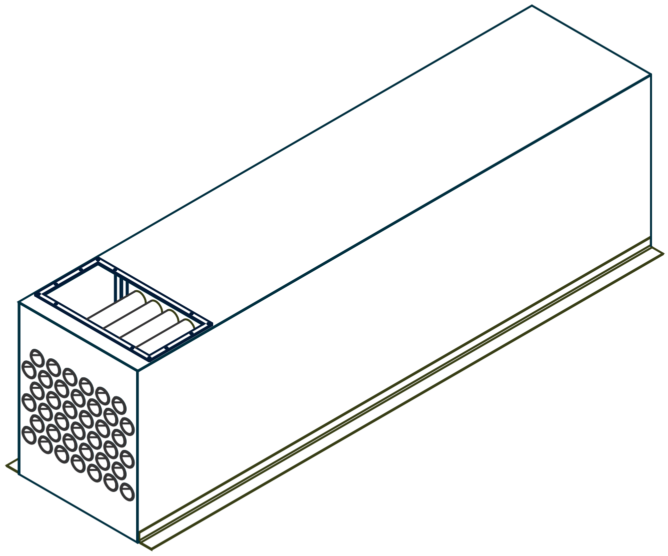
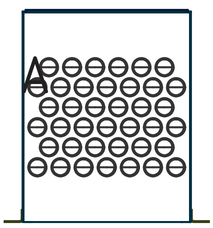
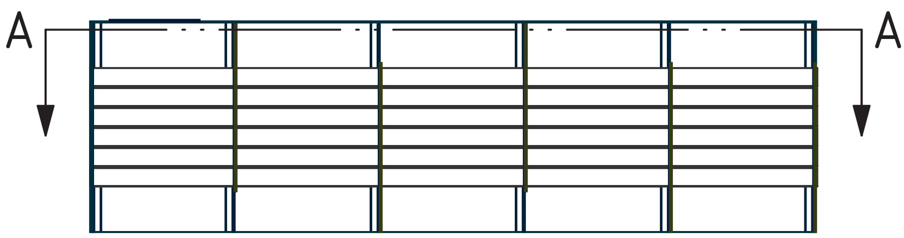


SECTION A-A







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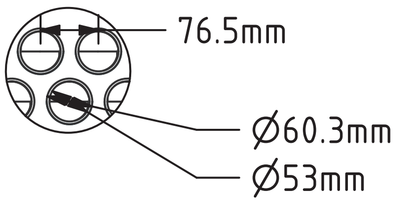

DETAIL A
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