



طاقة الشمال

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مركز أبحاث تكنولوجيا العمليات الكيميائية

Institute for Chemical Process Technology (ICPT)
<http://aecenar.com/institutes/icpt>

ICPT - Electrolysis/Fuel Burner Unit, Project Report 1 (2020)

Detailed Design & Construction for:

- Electrolysis
- Fuel burner

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سامري.

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D:\AECENAR\ICPT\Electrolysis_sinceSep2019\18052020_ICPT-EFB_Report1_2020.docx

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1 Alkaline Electrolysis of Water Unit

1.1 Overview

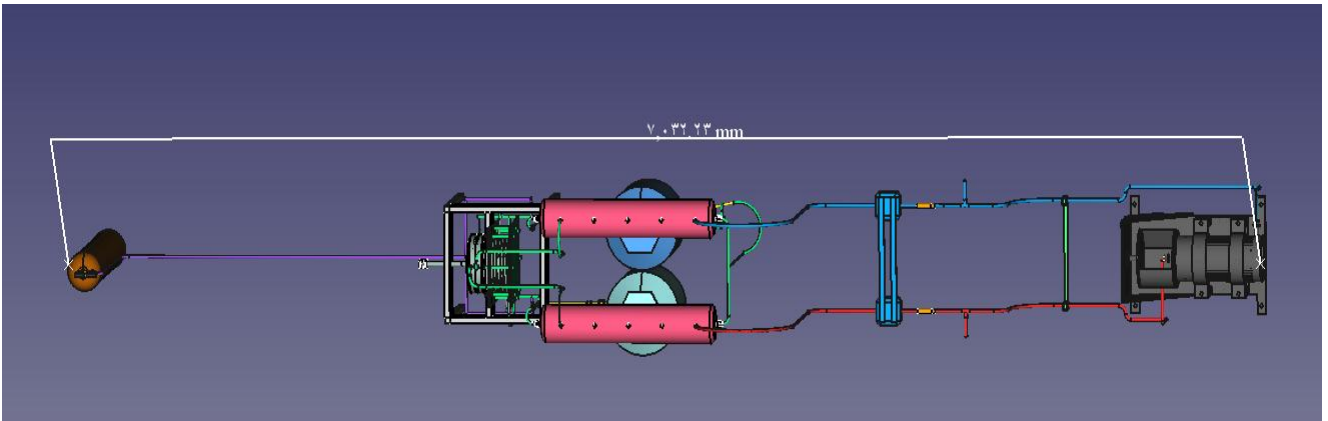


Figure 1 : Plant of electrolysis (FreeCAD)

Specification	
Voltage	4 volt
Current	150 Ampere
Power	0.6 KW
KOH	1.33 Kg
Gas flow rate Hydrogen all stacks	$2.27 L. min^{-1}$
Gas flow rate Oxygen all stacks	$1.13 L. min^{-1}$
Dimensions	Electrode (Radius: 15 cm / thickness: 2cm) Stainless 304 Stack (Radius: 15 cm/ Thickness: 16 cm)

Table 1: Specification of electrolysis

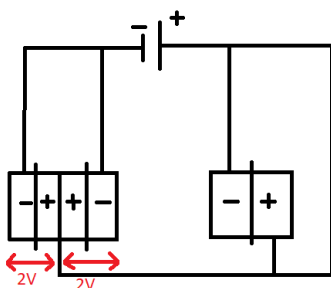


Figure 2 : Multistack Amperage/Voltage

Each stack has 2 serial cells ($2+2 = 4$ Volt / 75 Ampere)

2 stack parallel (4 Volt/ 75 Ampere * 2 = 150 Ampere)

- Each electrode has thickness 2 cm: 166.6 g (KOH)
We have 6 electrodes (2 cm) => $4 * 166.6 = 666.6$ g (KOH)
- Electrode has thickness 4 cm: 333.3 g (KOH)
We have 2 electrodes (4 cm) => $2 * 333.33 = 666.6$ g (KOH)

1.2 FreeCad Design

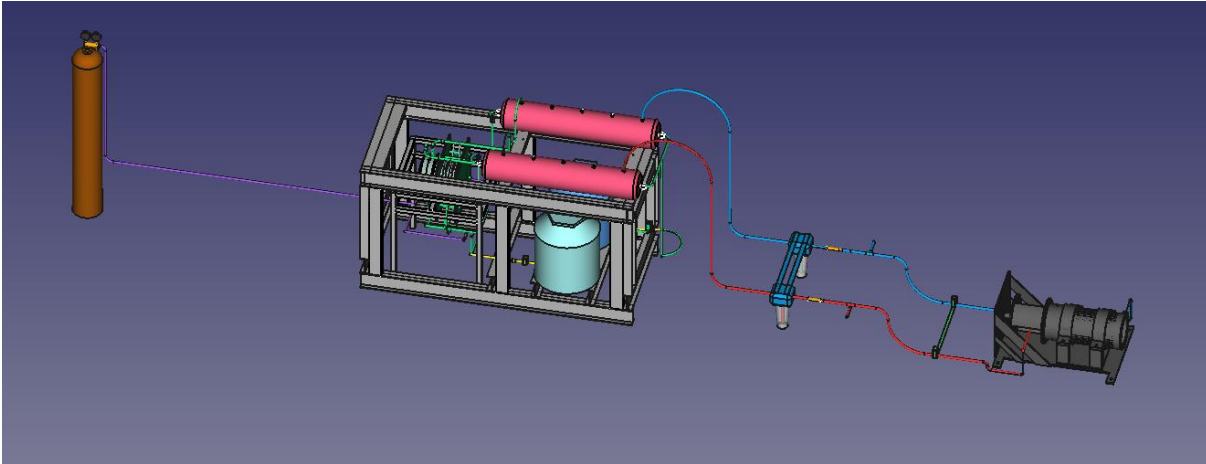


Figure 3



electrolyser+fuel burnner 010120.FCStd

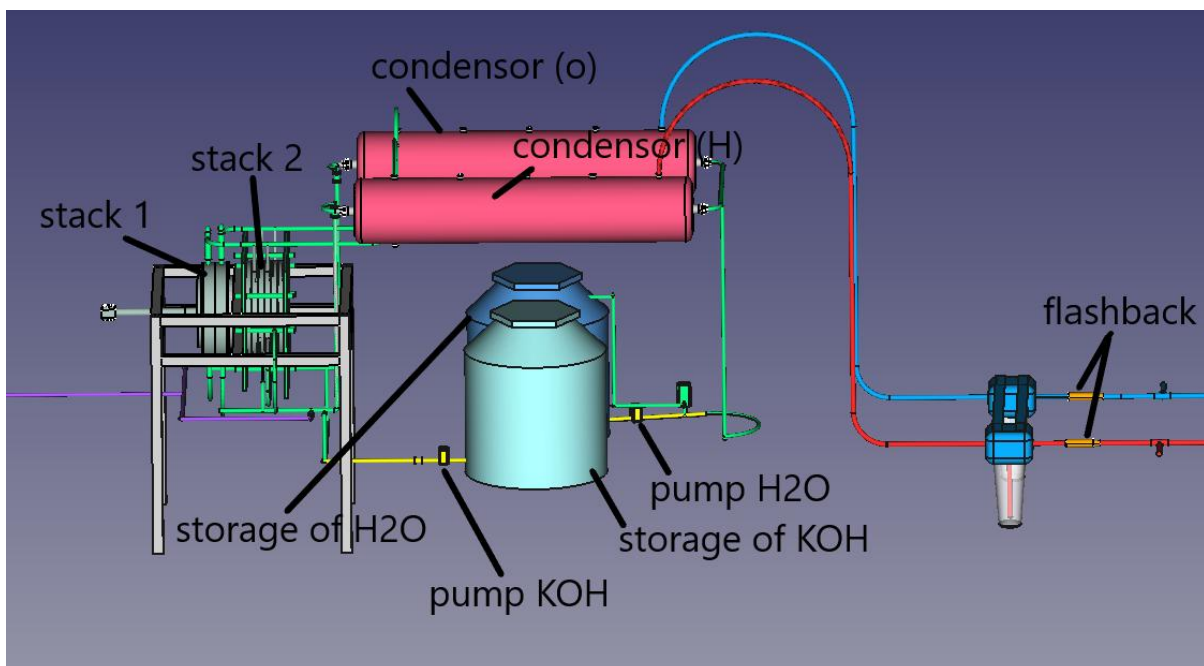


Figure 4

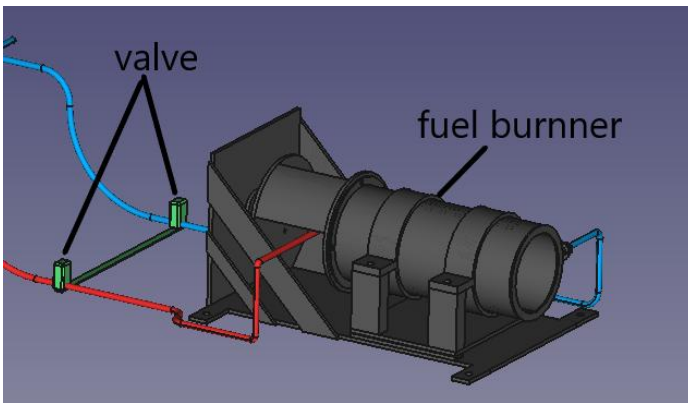


Figure 5

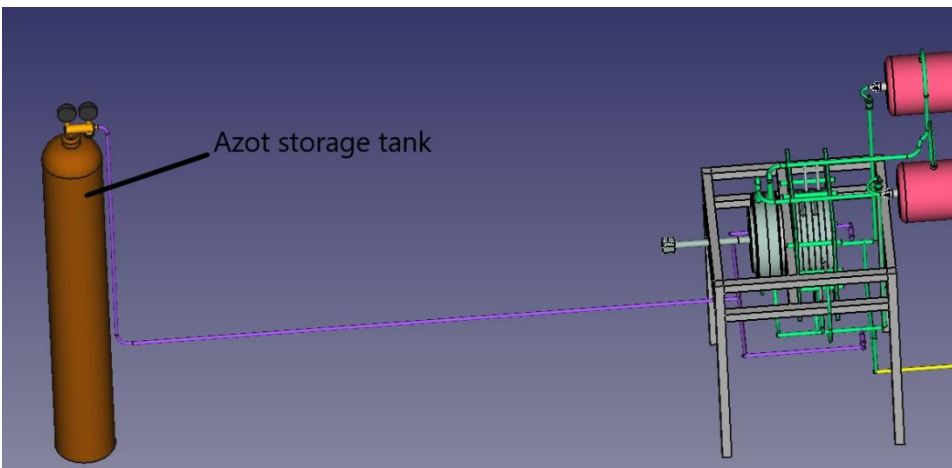


Figure 6

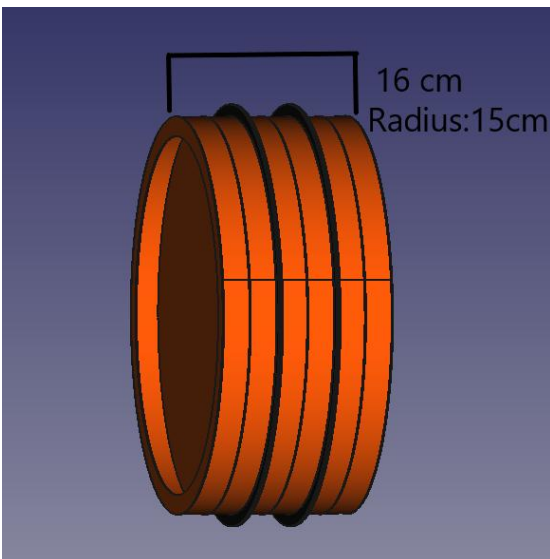


Figure 7: Serial stack



180319_Stack_electrol
ysis.FCStd

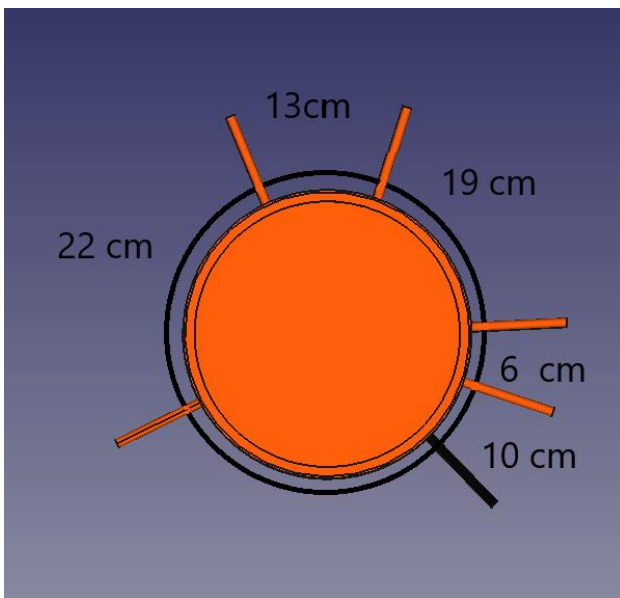


Figure 8

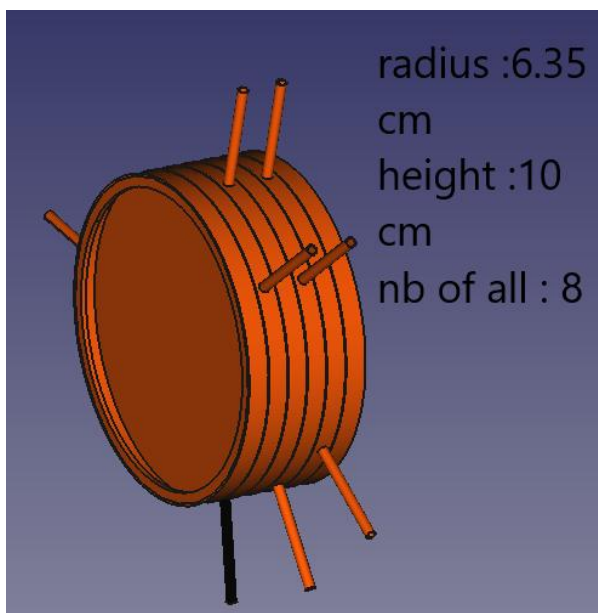


Figure 9



original electroluser.FCStd

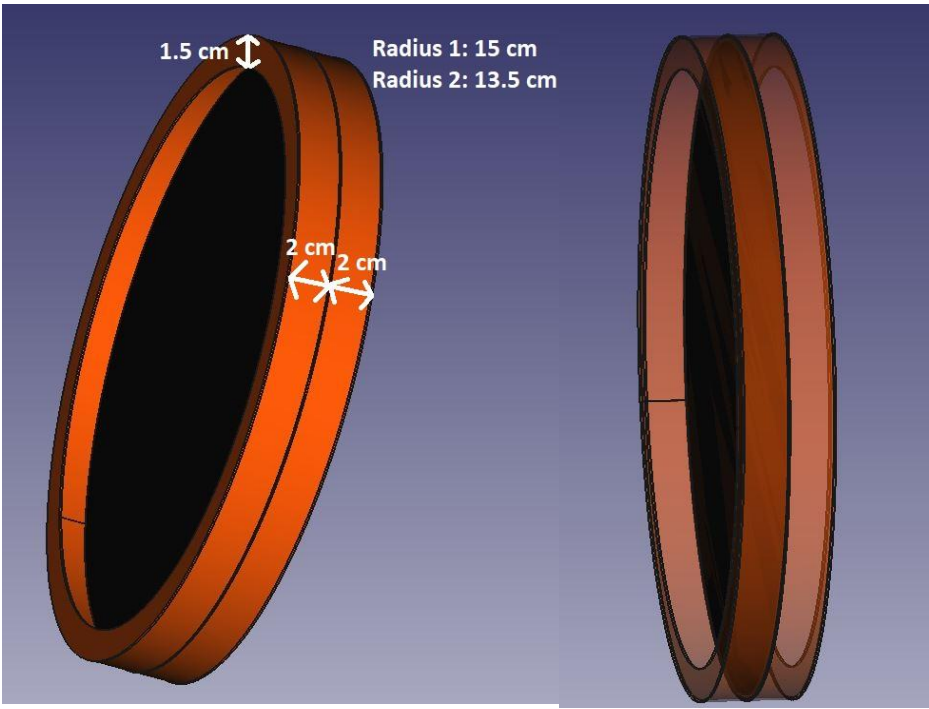


Figure 10

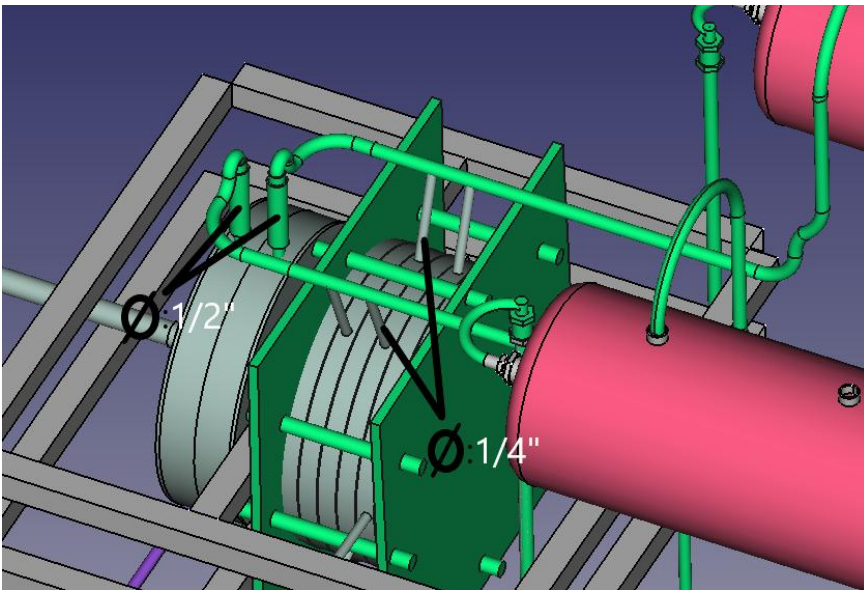
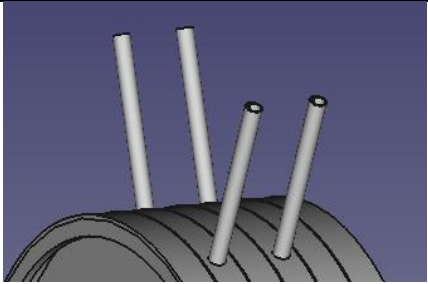


Figure 11

الشكل	المقاس	عدد	مواد
	قطر: 1/4" طول 10 سنتيمتر	8	قسطل

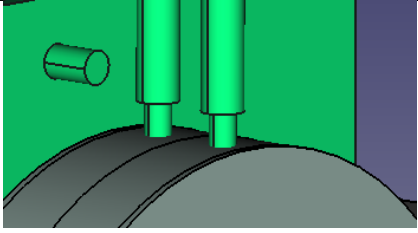
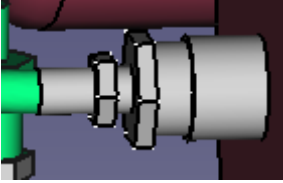
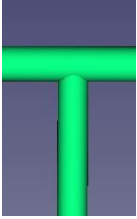
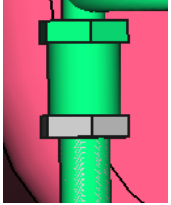
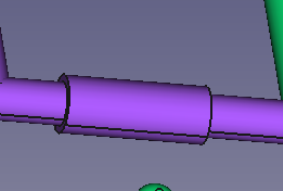
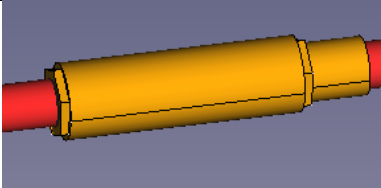
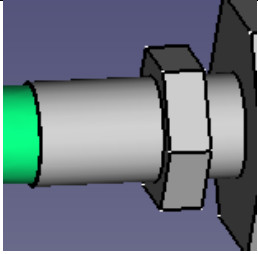
	قطر: 1/2" طول 10 سنتيمتر	4	قسطل
	من 1" الى 1/2"	4	محول
	1/4"	16	T (بلاستيك)
	1/2"	3	صباغ عدم رجوع (ماء)
	Ø:16 mm	2	صباغ عدم رجوع (azot)
	Ø:16 mm	2	صباغ عدم رجوع (Hyd,Oxy)
	1/2"	8	شريط بعزقة
	20 mm	43	حبسة حجم صغير
	40 mm	35	حبسة حجم كبير

Table 2

1.3 Calculation of the amount of water and KOH

$$V = \pi \cdot R^2 \cdot h$$

Radius: 15 cm

$H_1 : 4 \text{ cm}$ $H_2 = 2 \text{ cm}$

$$V_1 = \pi \cdot R^2 \cdot h_1$$

$$= \pi \cdot 0.15^2 \cdot 0.04$$

$$= 2.82 \cdot 10^{-3} \text{ m}^3$$

$$= 2.82 \cdot 10^{-3} \cdot 10^6 \text{ cm}^3$$

$$= 2.82 \cdot 10^3 \text{ cm}^3$$

$$= 2.82 \text{ liter}$$

$$V_2 = \pi \cdot R^2 \cdot h_2$$

$$= \pi \cdot 0.15^2 \cdot 0.02$$

$$= 1.41 \cdot 10^{-3} \text{ m}^3$$

$$= 1.41 \cdot 10^{-3} \cdot 10^6 \text{ cm}^3$$

$$= 1.41 \cdot 10^3 \text{ cm}^3$$

$$= 1.41 \text{ liter}$$

The cell can contain 2.82 liter and 1.41 liter but in reality we want full cell a) 1 liter and b) 0.5 liter respectively

KOH

A. The electrolysis need 25 % KOH in 1000 ml so 75 % is water

250 g \rightarrow 750 ml

?? \leftarrow 1000 ml

$$\text{Amount of KOH in one cell end plate electrode} = \frac{1000 \text{ ml} \cdot 250 \text{ g}}{750 \text{ ml}} = 333.33 \text{ g}$$

We have 2 electrodes end plate: $2 \cdot 333.3 \text{ g} = 666.6 \text{ g}$

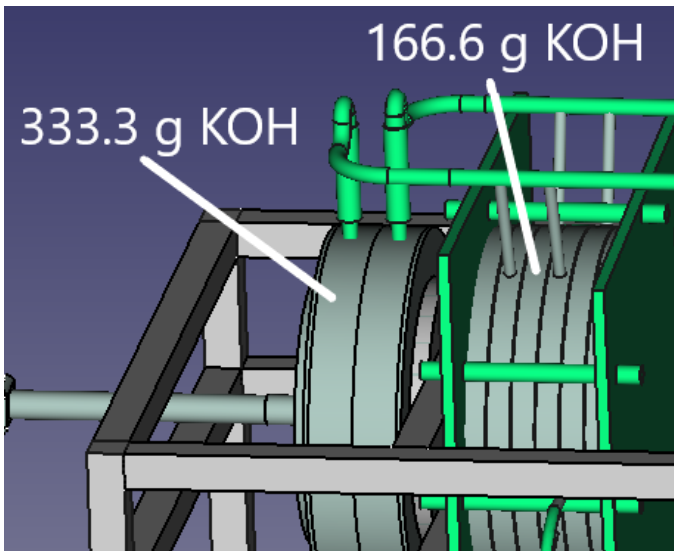


Figure 12: Amount of KOH

B. The electrolysis need 25 % KOH in 500 ml so 75 % is water

125 g \rightarrow 375 ml

?? \leftarrow 500 ml

Amount of KOH in one cell base plate = $\frac{500 \text{ ml} * 125 \text{ g}}{375 \text{ ml}} = 166.66 \text{ g}$

We have 4 electrodes base plate: $4 * 166.66 \text{ g} = 666.6 \text{ g}$

1.4 Calculation of gas flow rate

The maximum cell current value of 75 A is selected for the calculation. Faraday constant ($F = 96485 \text{ C.mol}^{-1}$ or C: coulomb ($1\text{C} = 1\text{A.s}$)). Moreover, Eq. 1 is used to calculate the number of hydrogen moles as follows.

$$n_{(H_2)} = \frac{I * t}{2F} = \frac{75 \text{ (A)} * 60 \text{ (s)}}{2(\text{electrons}) * 96485 \text{ C.mol}^{-1}} = 0.0233 \text{ mol/min}$$

Considering Eq. 2, assuming the pressure of 1 atm and the operating temperature of 25°C, the theoretical $V_{H_2(g)}$ can be determined as,

$$V_{H_2(g)} = \frac{n_{H_2} RT}{P} = \frac{0.0233 \text{ mol/min} * 0.082 \text{ Latm K}^{-1} \text{mol}^{-1} * 298 \text{ K}}{1 \text{ atm}}$$

$$V_{H_2} = 0.569 \text{ L. min}^{-1}$$

Each stack produce $0.569 \text{ L. min}^{-1} \Rightarrow$ 4 stack produce = $0.569 \text{ L. min}^{-1} * 2 \text{ (stack)} = 1.138 \text{ L.min}^{-1}$

For oxygen:

The amount of substance for $O_2(g)$ can be determined by using either Eq. 5.1 or the electrochemical reaction of the alkaline electrolysis cell. According to the electrochemical reaction, the number of $O_2(g)$ moles should be half of $H_2(g)$ moles. Hence, the number of $O_2(g)$ moles can be easily determined as in Eq.

$$n_{O_2} = \frac{n_{H_2}}{2}$$

$$n_{O_2} = 0.0116 \text{ mol/min}$$

$$V_{O_2(g)} = \frac{n_{O_2}RT}{P} = \frac{0.0116 \text{ mol/min} * 0.082 \text{ Latm K}^{-1}\text{mol}^{-1} * 298 \text{ K}}{1 \text{ atm}}$$

$$V_{O_2} = 0.284 \text{ L} \cdot \text{min}^{-1}$$

Each stack produce $0.284 \text{ L} \cdot \text{min}^{-1} \Rightarrow 2 \text{ stacks produce} = 0.284 \text{ L} \cdot \text{min}^{-1} * 2 \text{ (stacks)} = 0.568 \text{ L} \cdot \text{min}^{-1}$

Other https://www.editions-petiteelisabeth.fr/calculs_electrolyse_3.php

1.5 Power supply

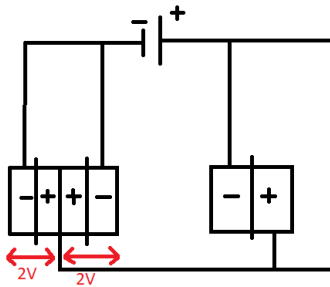


Figure 13

- Density current for electrolysis: $0.2 - 0.4 \text{ A/cm}^2$
- Our cell contains $0.5 \text{ liter} = 250 \text{ cm}^3$
- Current apply for each cell $= \frac{250 \text{ cm}^3 * 0.3 \text{ A/cm}^2}{1 \text{ cm}^2} = 75 \text{ A}$
- Voltage apply for each cell is 2 V
- Each stack has 2 serial cell \Rightarrow voltage $= 2 * 2 = 4 \text{ V}$
Current $= 75 \text{ A}$
- The total is 2 parallel stack \Rightarrow voltage $= 8 \text{ V}$
Current $= 2 * 75 = 150 \text{ A}$
- Power apply: Power $=$ voltage \times Current $= 4 \text{ Volt} \times 150 \text{ Ampere} = 0.6 \text{ KW}$

1.6 Compact Design¹

1.6.1 Level Control System

tubes=12.5mm,6mm

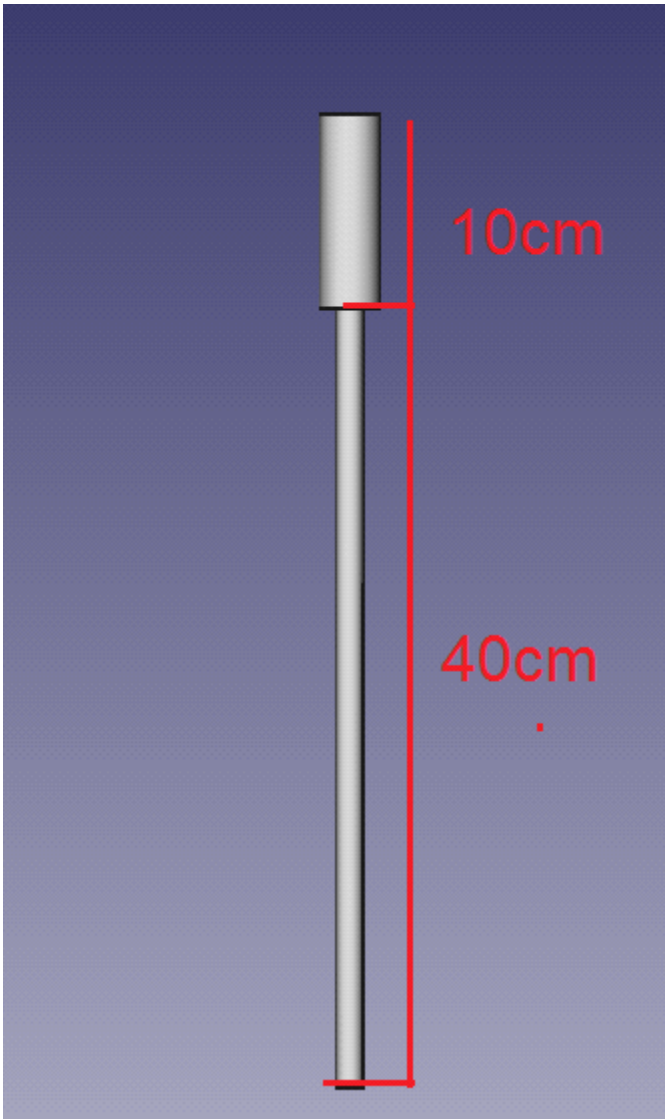


Figure 14

¹ Samer Youssef, July/Aug 2019

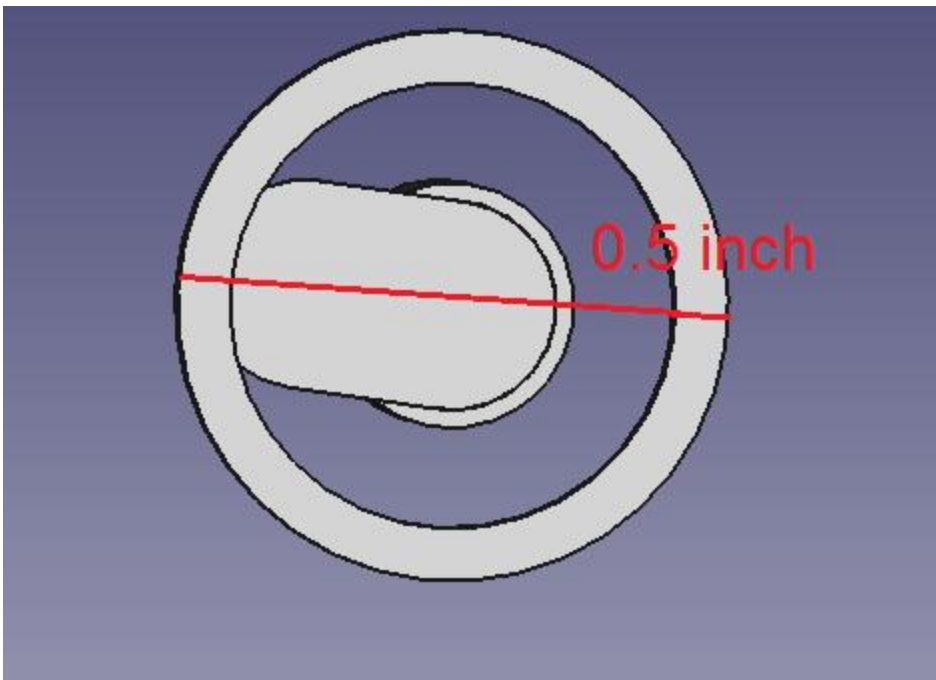


Figure 15

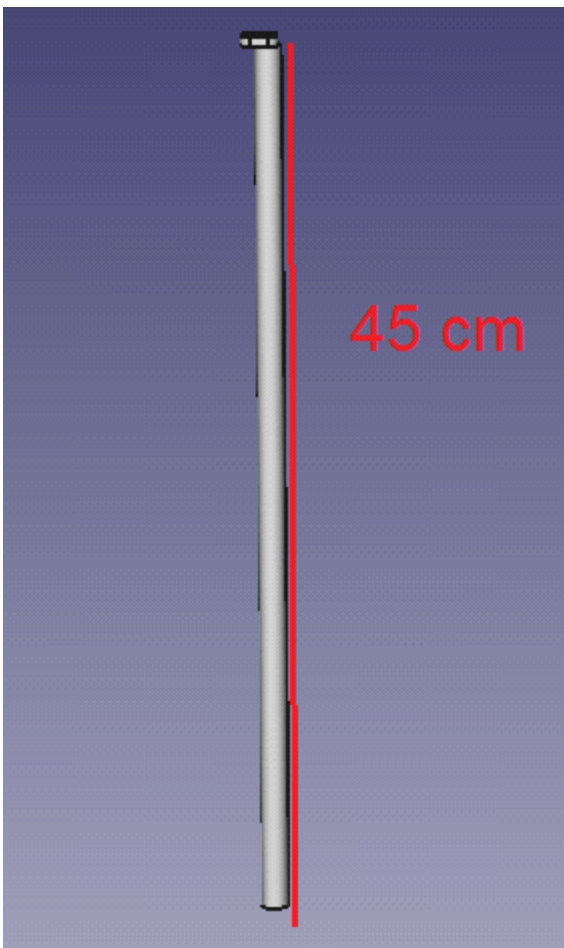


Figure 16

1.6.2 Electrolyser Container

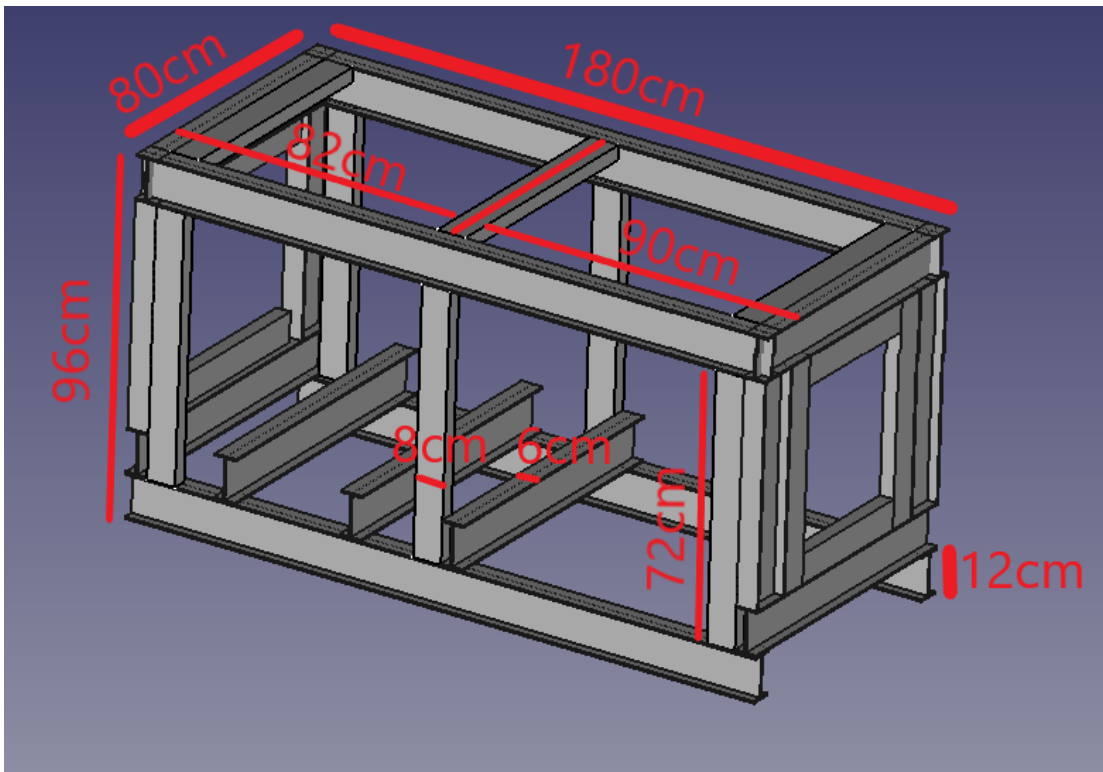


Figure 17

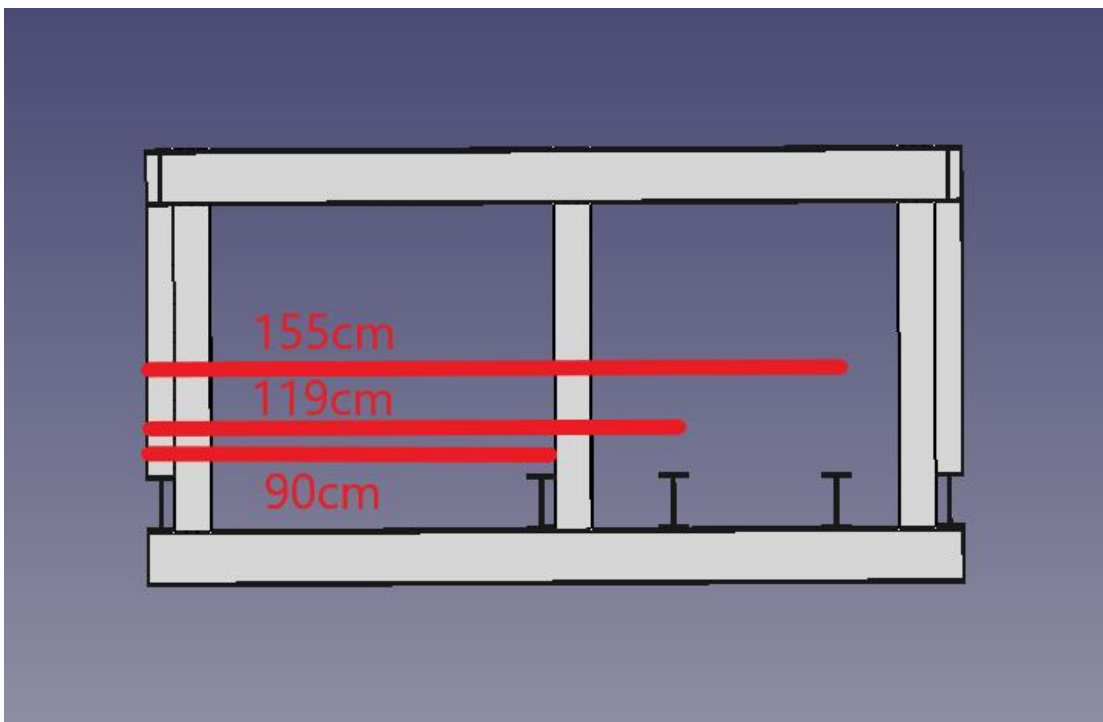


Figure 18

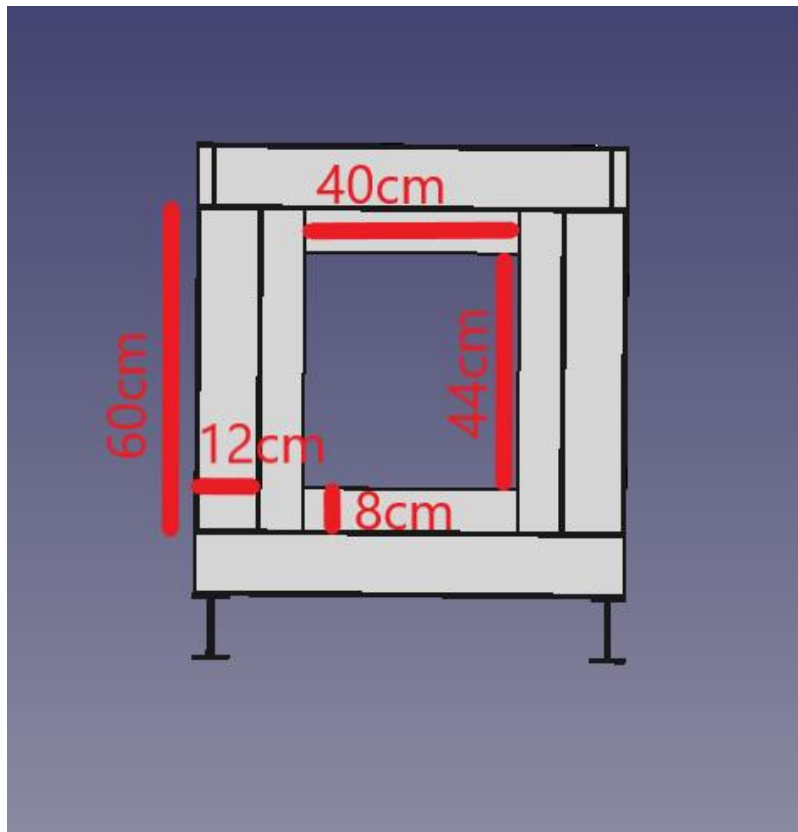


Figure 19

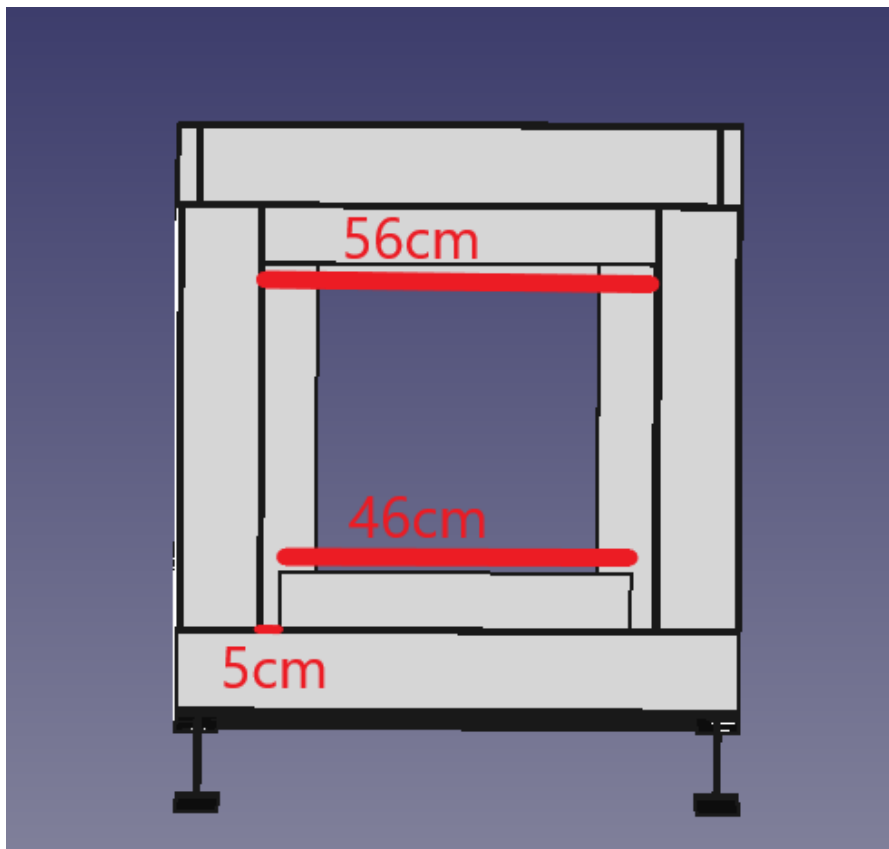


Figure 20

numbers of columns : 4-(180)cm

6-(72) cm

5-(80) cm

5-(68) cm

6-(60) cm

2-(40) cm

1-(56) cm

1-(46) cm.

1.6.3 Integration

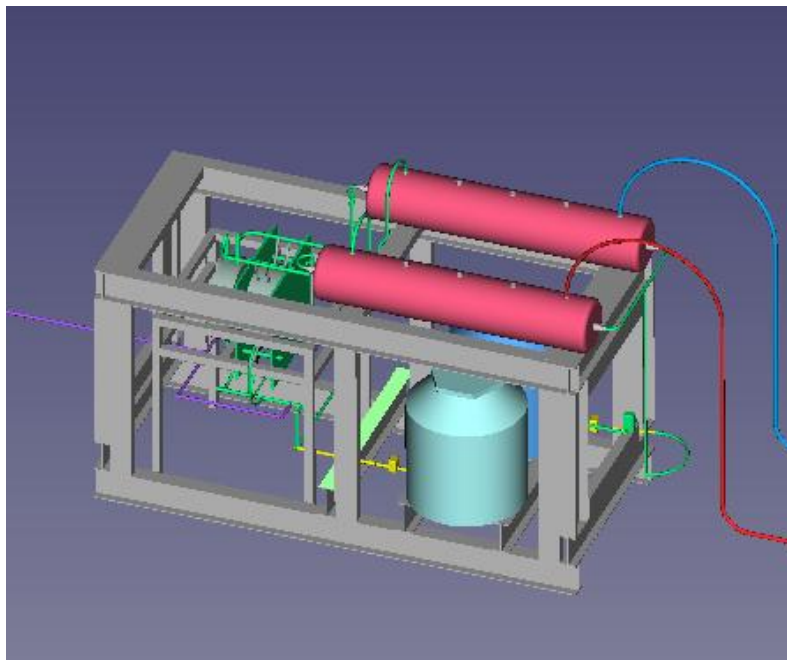
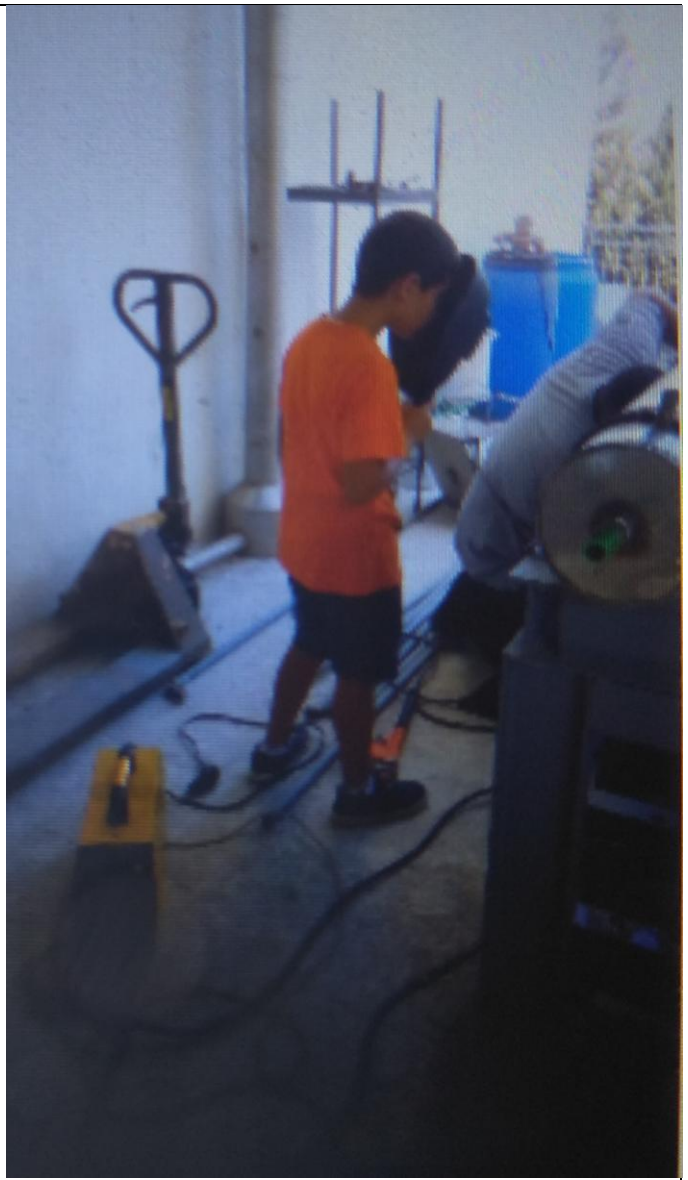


Figure 21



electrolyser+fuel burner 010120.FCStd





2 Fuel burner unit

2.1 Fuel burner

2.1.1 FreeCAD Design

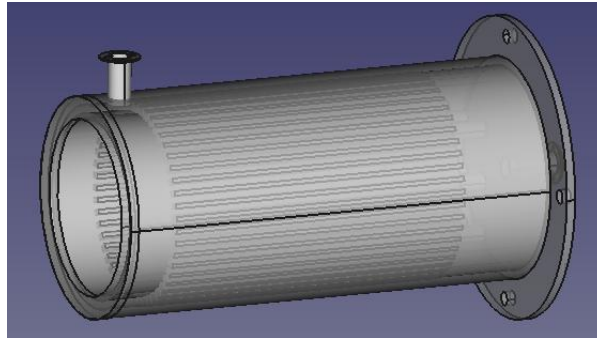


Figure 22

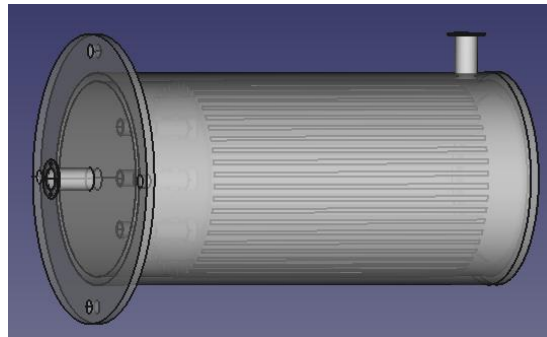
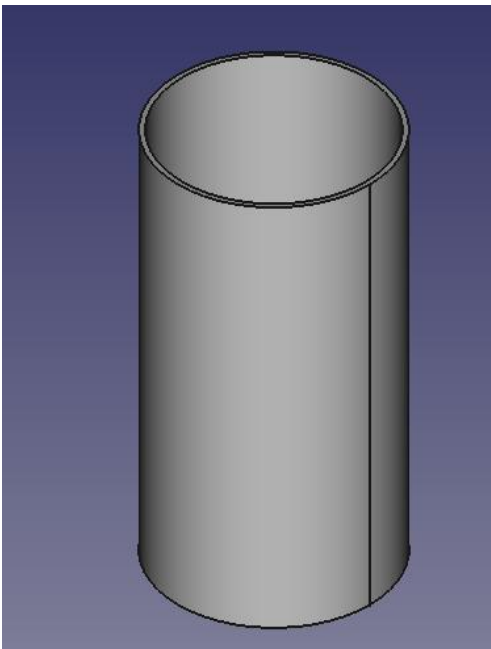


Figure 23

Figure 24

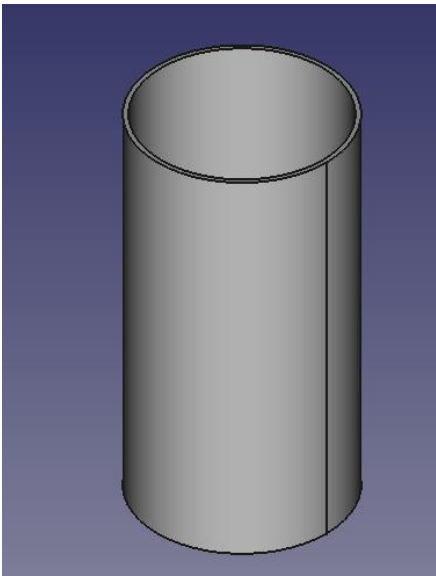


Int diameter: 23 cm ,

Ext diameter: 25cm ,

Length: 50 cm .

Figure 25



Int diameter : 17 cm,

Ext diameter: 20 cm,

Length : 40 cm .

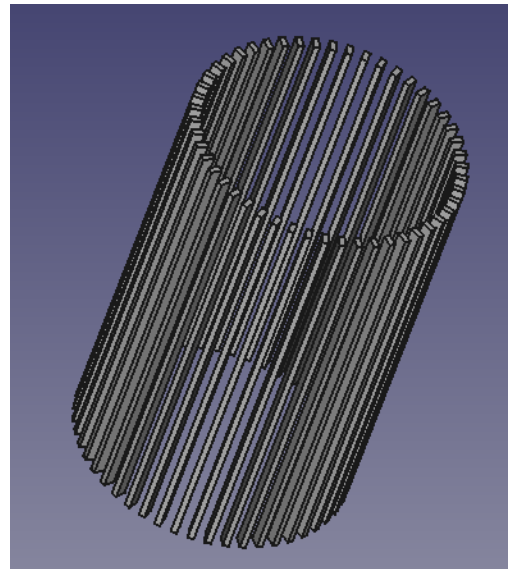


Figure 26

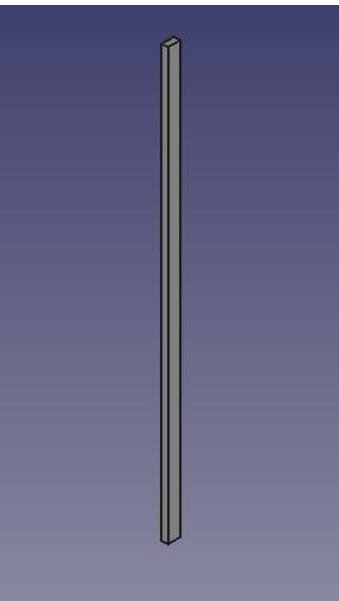
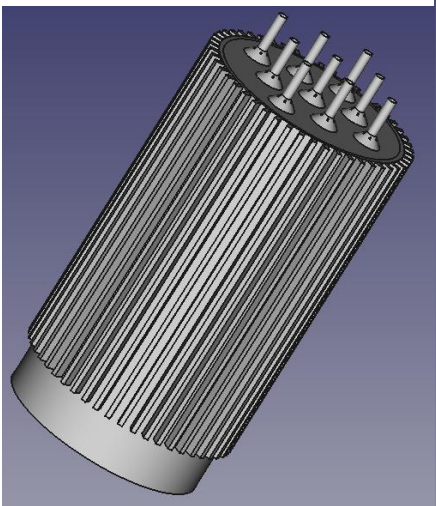


Figure 27

length: 1 cm

width : 5mm

height : 35 cm

Nb of bars: 50

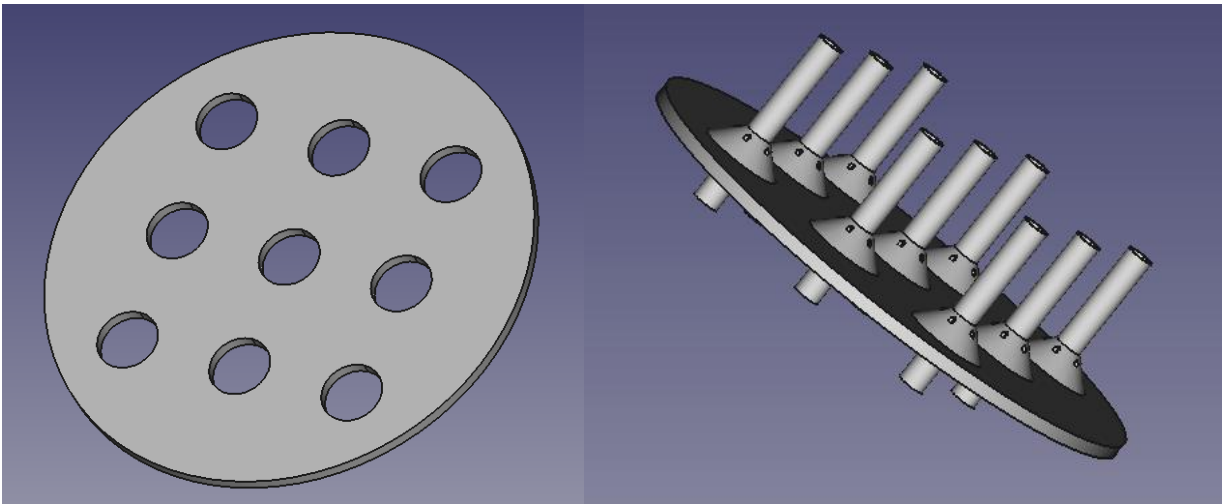


Figure 28

Figure 29

Dimetre of plate : 17 cm

Thickness : 5mm

Diameter of holes : 25 mm

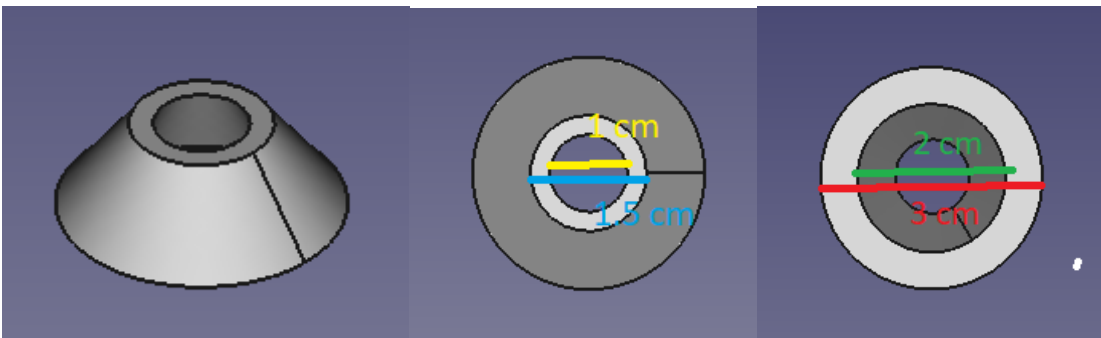
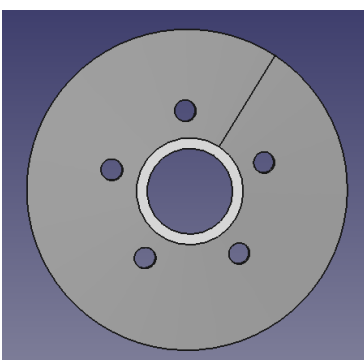


Figure 30



Height of cone: 1cm

Diametre of holes : 2 mm

Figure 31



Figure 32

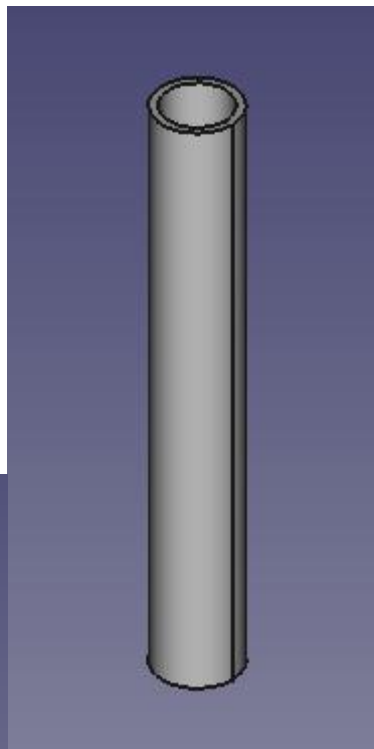


Figure 33

Height: 7 cm
Int diameter: 8 mm
Ext diameter: 10 mm



fuel_burner_261218.FCStd

2.1.2 Manufacturing



Table 3



Table 4



Table 5



Table 6



Table 7



Table 8



Table 9

2.2 Holder of fuel burner

2.2.1 Free Cad Design

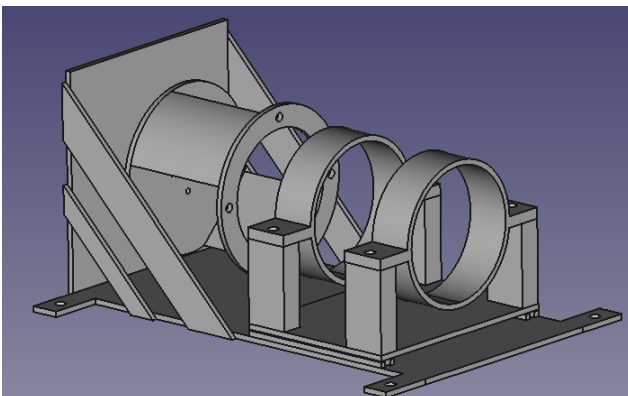


Figure 34: FreeCad holder of fuel burner Figure

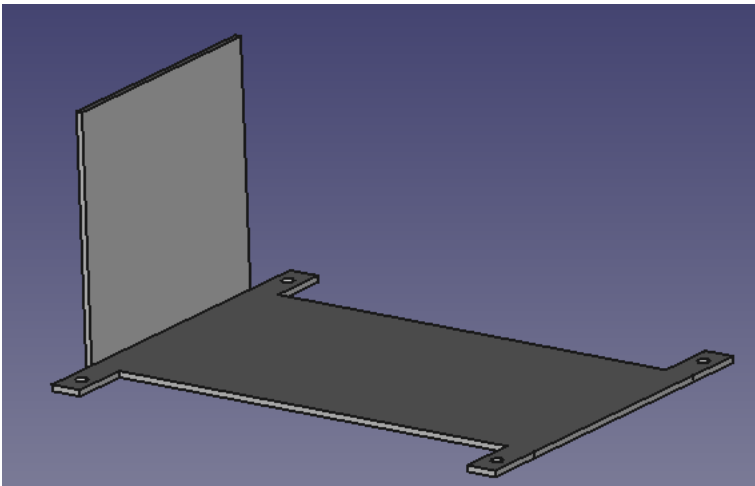


Figure 35

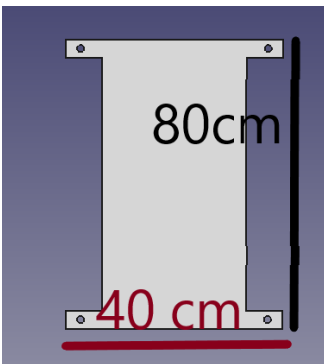


Figure 36

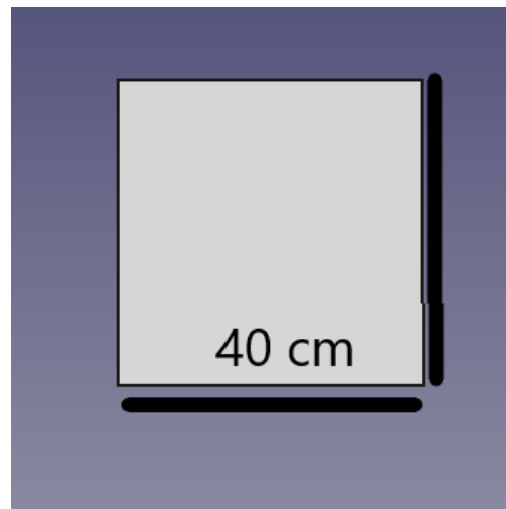


Figure 37

Thickness: 10 mm

Diameter of holes: 20 mm

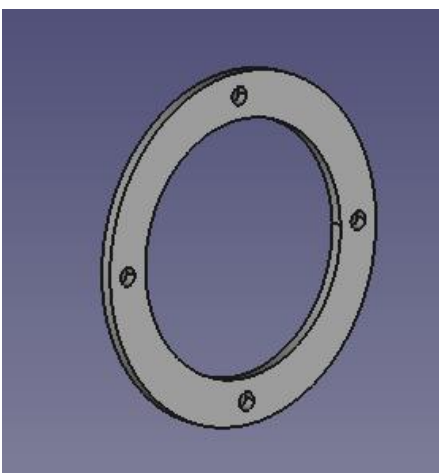


Figure 38

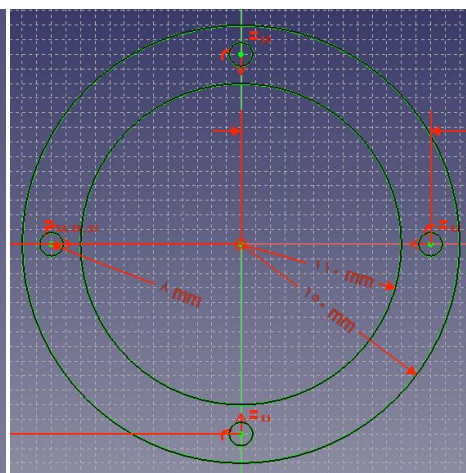


Figure 39

Int diameter: 22 cm

Ext diameter: 30 cm

Diameter of holes: 16 mm

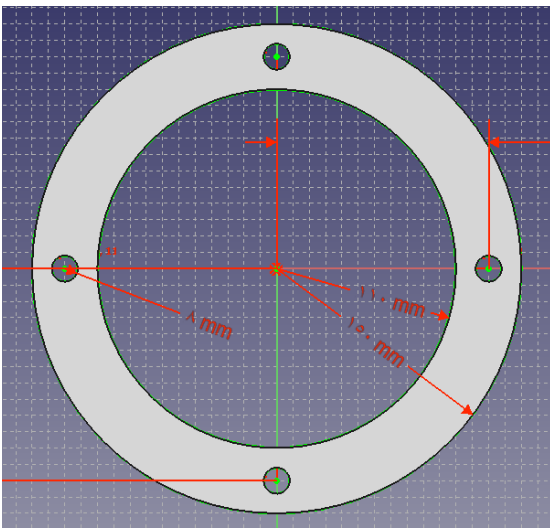


Figure 40

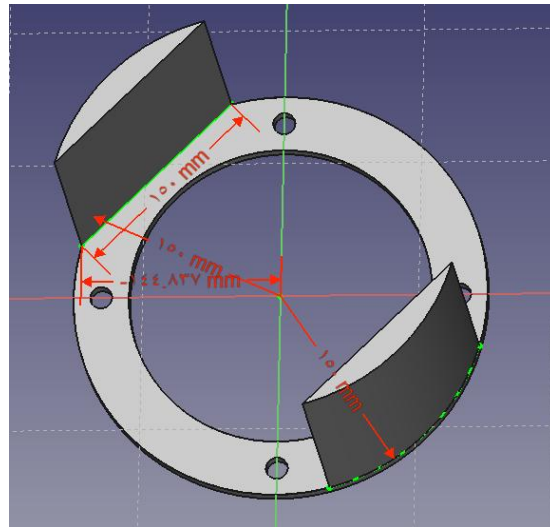


Figure 41

Thickness : 10 mm

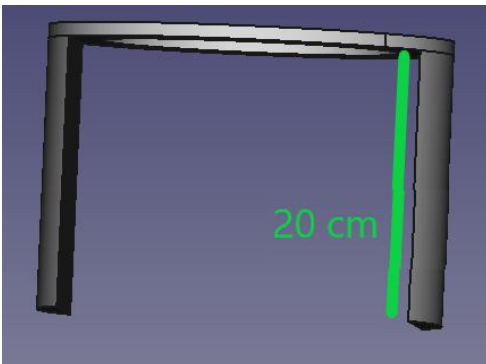


Figure 42

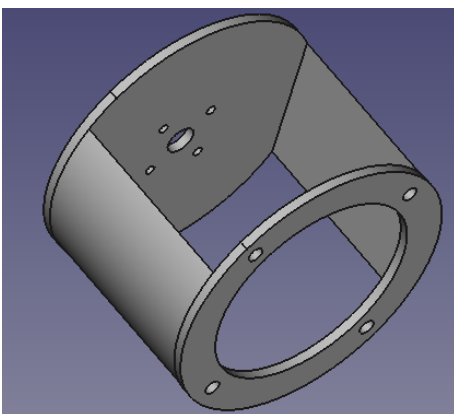


Figure 43

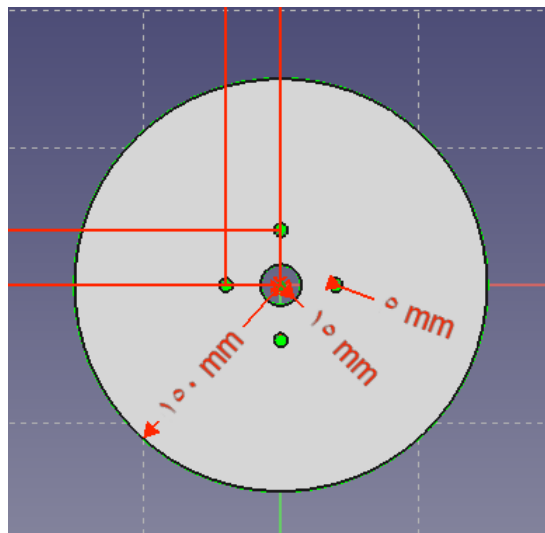


Figure 44

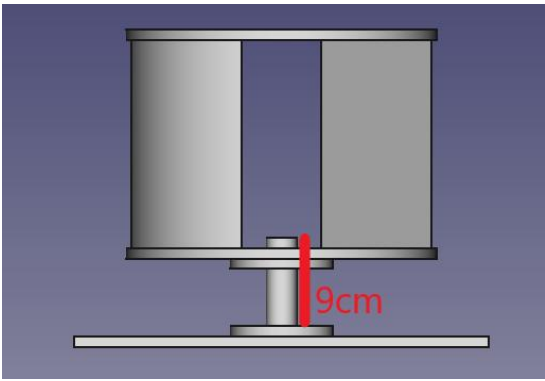


Figure 45

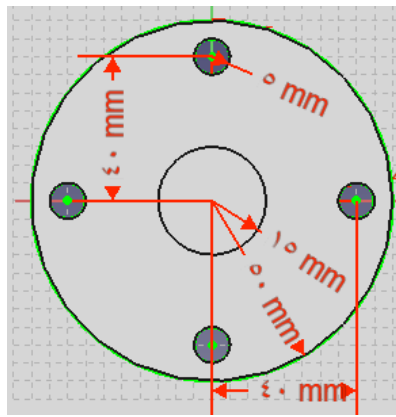


Figure 46

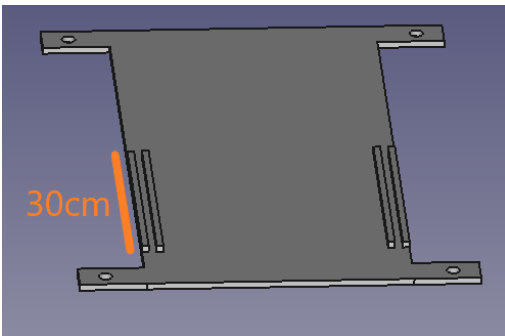


Figure 47

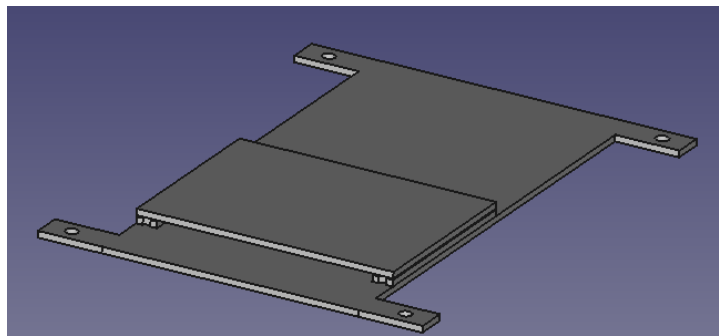


Figure 48

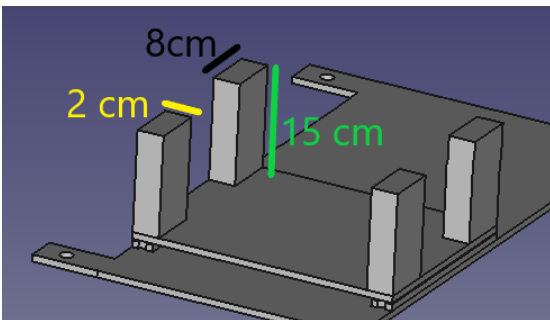


Figure 49

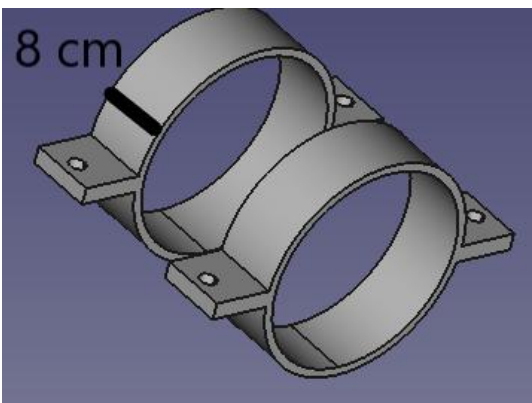


Figure 50

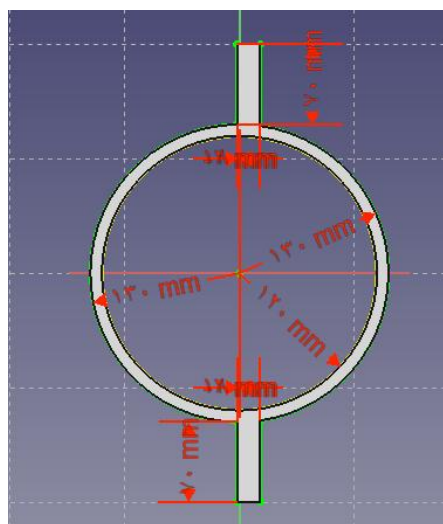


Figure 51

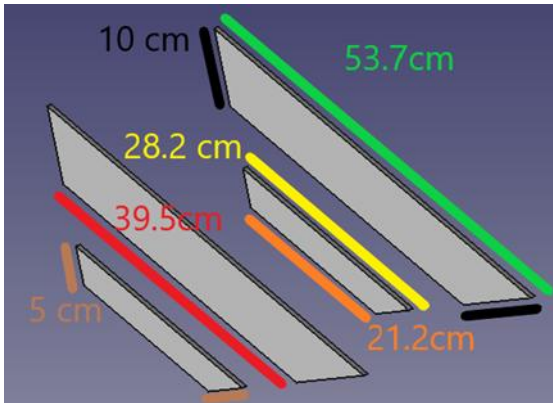


Figure 52

2.2.2 Manufacturing



Table 10



Table 10



Table 11



Table 12

2.3 Integration



Table 13