

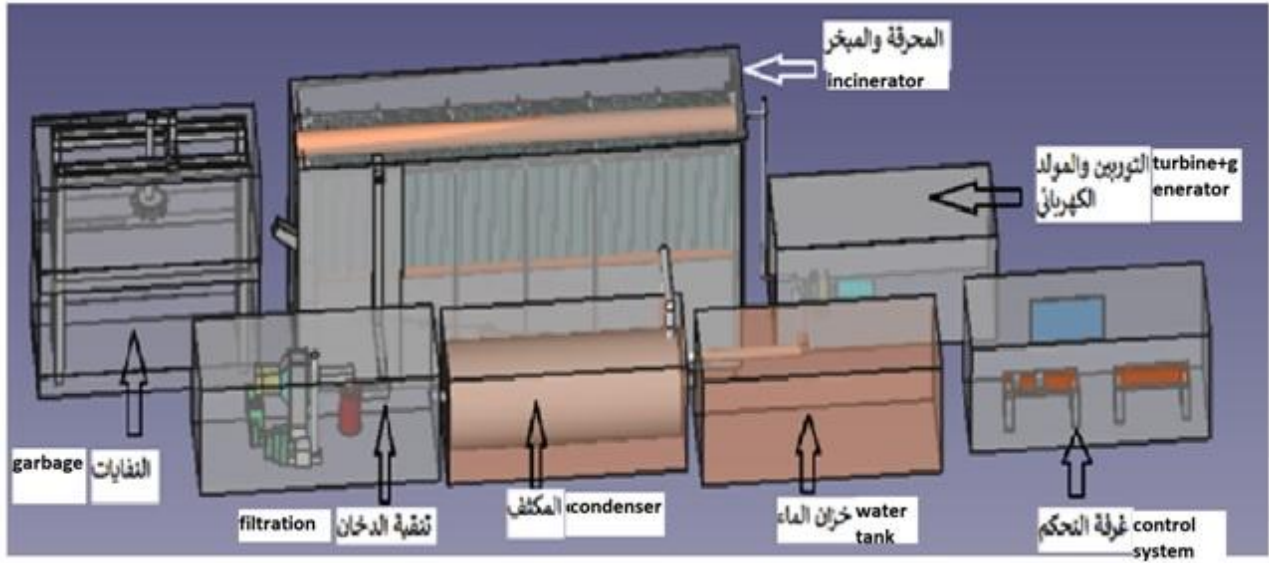
محطة طاقة كهربائية عن طريق حرق النفايات بحجم

1.5 MW

المواصفات الفنية

NLAP 1.5 MW Incineration Power Plant, Technical Specification

Last update: 6 Januar 2017



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Responsible for Document: Samir Mourad



طاقة الشمال

North Lebanon Alternative Power

www.nlap-lb.com

1.....	-مدخل	
2.....	الاحتياجات (Requirements)	1
2.....	مثال لوضع الاحتياجات	1.1
3.....	تصميم المنظومة (System design)	2
4.....	التوربين (Turbine)	3
4.....	تصميم في برنامج FreeCAD	3.1
4.....	Parts and costs of our 1.5 MW steam turbine	3.2
13.....	FreeCAD 2D Drawings of Turbine for manufacturing	3.3
13.....	Drawing a FreeCAD 3D object to 2D	3.3.1
19.....	2D drawings of our 1.5 MW turbine	3.3.2
23.....	Steam system parameters for a 2MW Turbine (14 bar, 195°C)	3.4
23.....	Calculation details	3.4.1
	Competetors: Backpressure Steam Turbines (500kW, 3 MW, 15 MW): Cost (\$/kW) and	3.5
24.....	Performance Characteristics	
25.....	Performance Losses	3.5.1
25.....	Maintenance	3.5.2
26.....	Steam Turbine Lubricating oil Characteristics	3.5.3
26.....	Background	3.5.3.1
27.....	Viscosity	3.5.4
27.....	Turbine bearing	3.6

27.....	Introduction	3.6.1
29.....	Materials needs and calculations	3.7
31.....	5D CNC machining	3.8
31.....	What is 5-Axis?	3.8.1
31.....	Basics of axis configuration	3.8.2
32.....	How a router works	3.8.3
32.....	3-axis routers vs. 5-axis routers	3.9
32.....	Thermal efficiency if the steam is superheated	3.10
34.....	Dynamo generator	3.11
35.....	المكثف (Condenser)	4
35.....	Condenser Specification	4.1
35.....	نموذج ببرنامج FreeCAD	4.2
35.....	Cooling of condenser	4.3
35.....	Sea water desalting unit for condenser cooling cycle (schema)	4.3.1
36.....	نموذج ببرنامج FreeCAD	4.3.2
37.....	Cost for cooling with fresh sea water cycle (only with piping to sea)	4.4
38.....	خزان المياه (Water tank)	5
39.....	مدخل النفايات	6
40.....	المحرقة والمبخر (Incinerator and vaporizer)	7
42.....	تنقية الدخان	8
43.....	ESP	8.1

43.....	Incineration Tests	8.2
46.....	الرماد بعد حرق النفايات المنزلية والاستفادة منه (Preparation of rost ash)	9
46.....	نظرة عامة	9.1
48.....	FLUREC/FLUWA	9.2
49.....	غرفة التحكم	10
50.....	ارقام مالية وايجابيات لمشروع بناء وتشغيل محطة طاقة 1.5MW عن طريق حرق النفايات	11
51.....	المواد الاولية التي نحتاجها لبناء محطة 1.5MW	12
52.....	Suppliers	13

مدخل

هذا المشروع يهدف الى تصنيع اول محطة صنع معظم الاجزاء من مؤسسة طاقة الشمال ومن ضمن ذلك التوريدين.

1 الاحتياجات (Requirements)

1.1 مثال لوضع الاحتياجات

REQVIEW-NEEDS: ReqView Business Needs

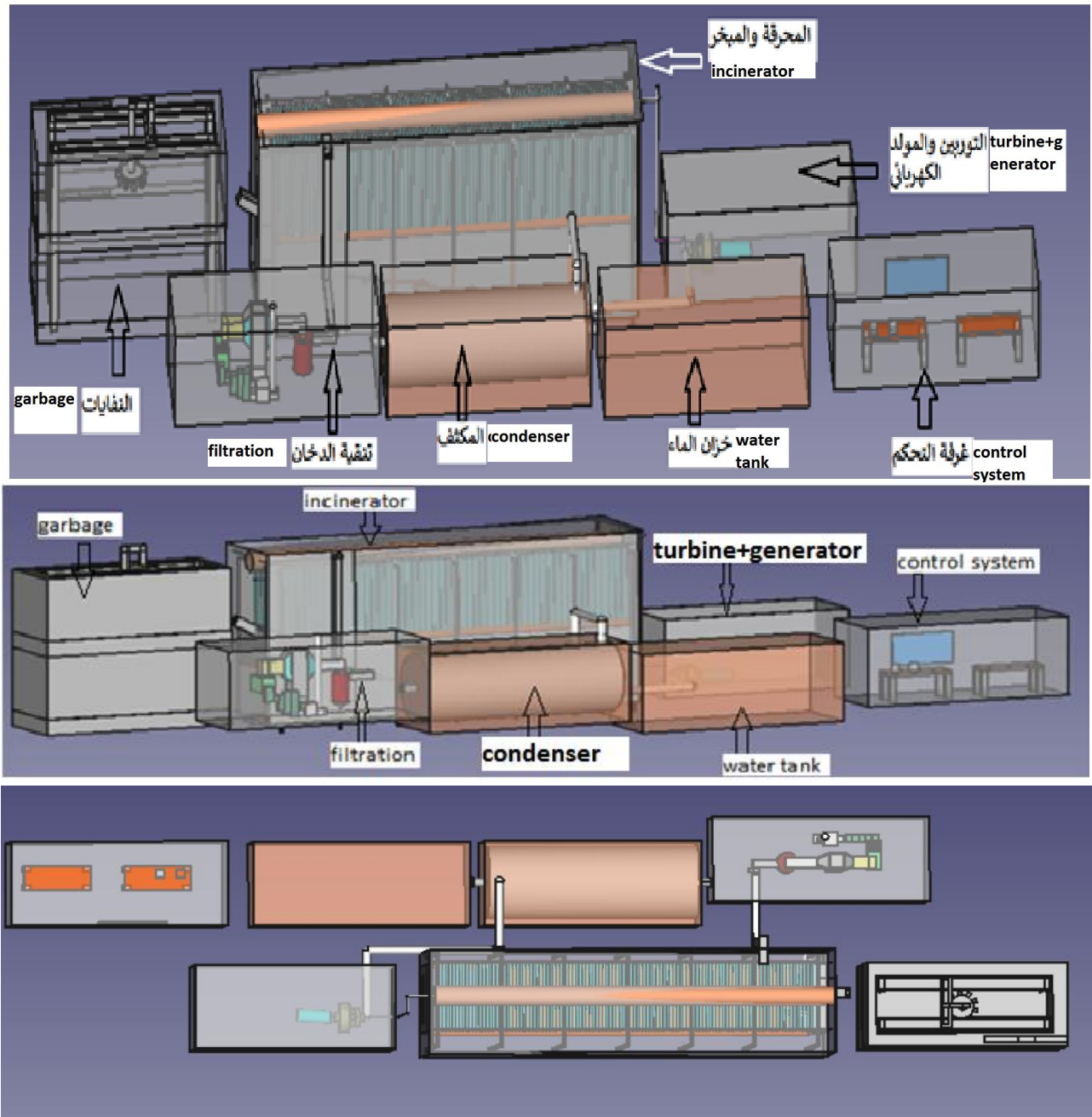
File Edit View Project Help

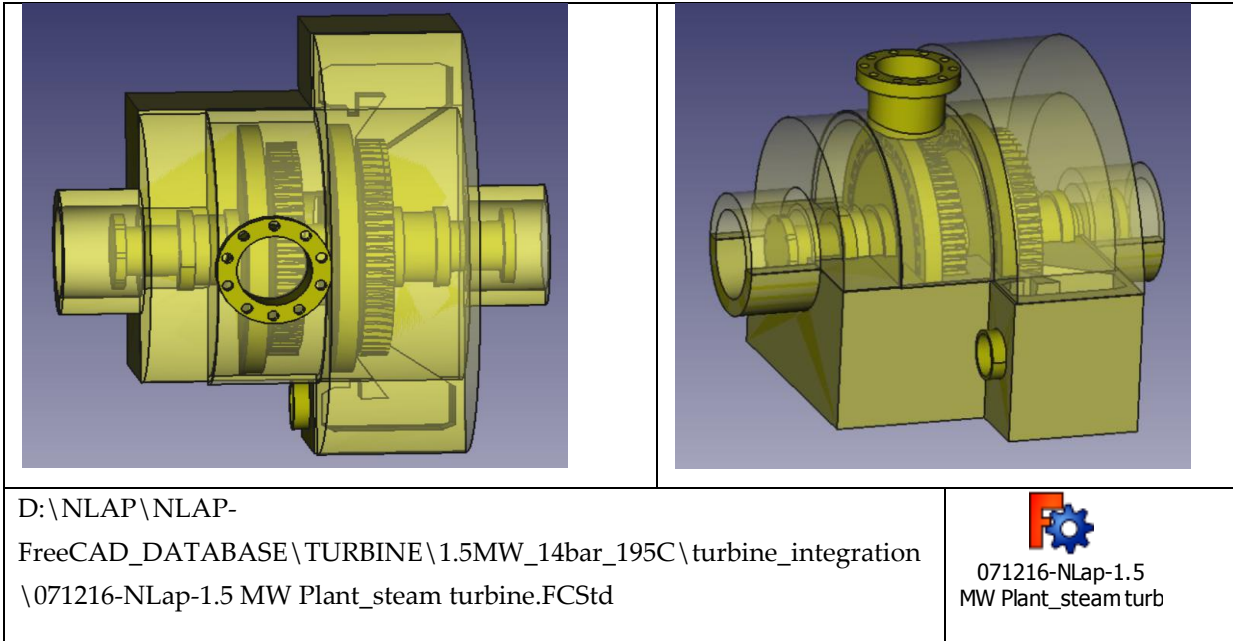
Filter

* ID	Description	As a(n)
NEEDS-2	1 Introduction	
NEEDS-46	1.1 Purpose This is a <i>demo document</i> describing business needs for development of ReqView Desktop tool. The document is not complete.	
NEEDS-49	1.2 Intended Audience and Reading Suggestions The target audience for this document are new ReqView users evaluating ReqView and learning how to gather and manage requirements in ReqView.	
NEEDS-1	2 User Roles	
NEEDS-5		

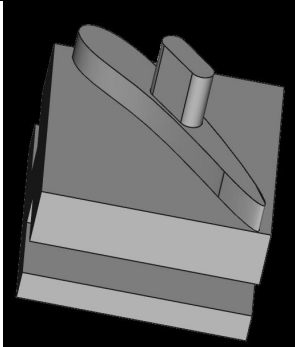
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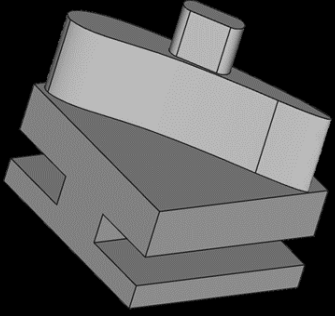
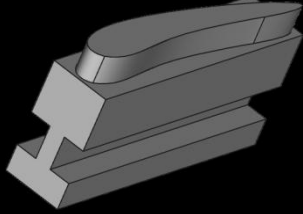
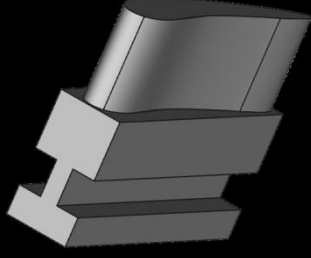
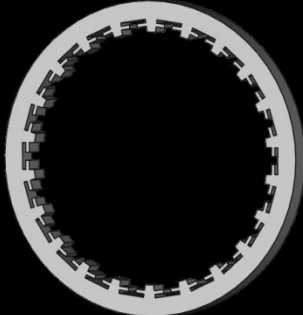
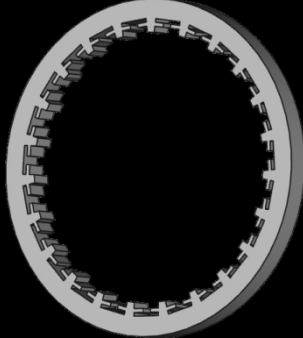




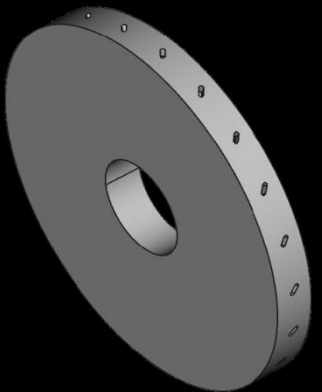
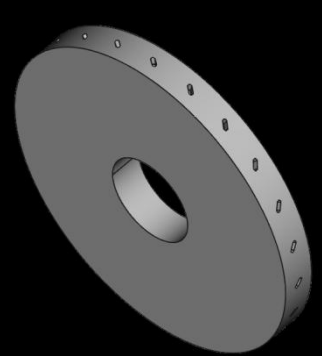
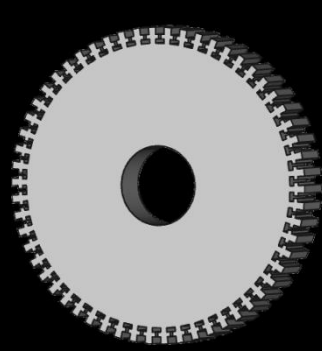
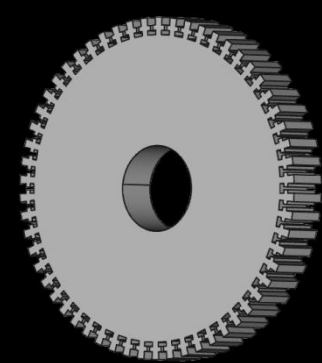
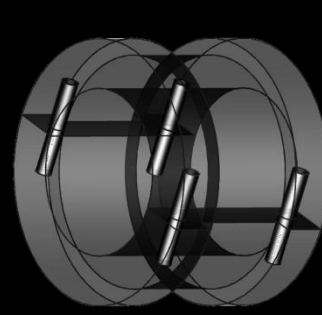
3.2 Parts and costs of our 1.5 MW steam turbine

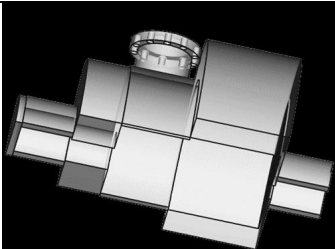
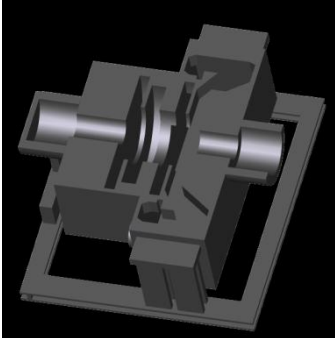
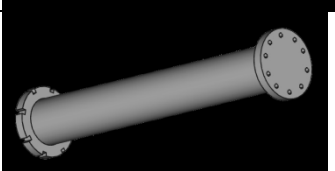
Name	3D design	عدد القطع المطلوبة #pieces	كيفية الصناعة How it is manufactured	Material	سعر القطعة الواحدة
FB-FS ¹	Figure 1 	22	CNC machine	Stainless steel	50\$

• ¹ FB-FS: Fixed blades for the first stage.

FB-SS ²	Figure 2		23	CNC machine	Stainless steel	50\$
MB-FS ³	Figure 3		58	CNC machine	Stainless steel	50\$
MB-SS ⁴	Figure 4		58	CNC machine	Stainless steel	50\$
Outer cylinder for FB-FS	Figure 5		1	CNC machine		
Outer cylinder for FB-SS	Figure 6		1	CNC machine		

- ² FB-SS: Fixed blades for the second stage.
- ³ MB-FS: Moving blades for the first stage.
- ⁴ MB-SS: Moving blades for the second stage.

<p>Inner cylinder for FB-FS</p>	<p>Figure 7</p>		<p>1</p>	<p>CNC machine</p>		
<p>Inner cylinder for FB-SS</p>	<p>Figure 8</p>		<p>1</p>	<p>CNC machine</p>		
<p>Cylinder for MB-FS</p>	<p>Figure 9</p>		<p>1</p>	<p>CNC machine</p>		
<p>Cylinder for MB-SS</p>	<p>Figure 10</p>		<p>1</p>	<p>CNC machine</p>		
<p>Bearings</p>	<p>Figure 11</p>		<p>2</p>	<p>CNC machine</p>		

Case (upside)	Figure 12		1	CNC machine		
Case (down side)	Figure 13		1	CNC machine		
Shaft	Figure 14		1	CNC machine		

Note: that cost is without the material only for the CNC machining.

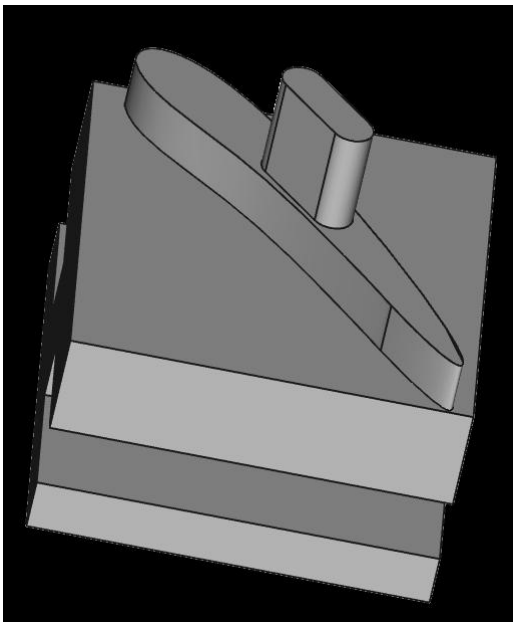


Figure 1

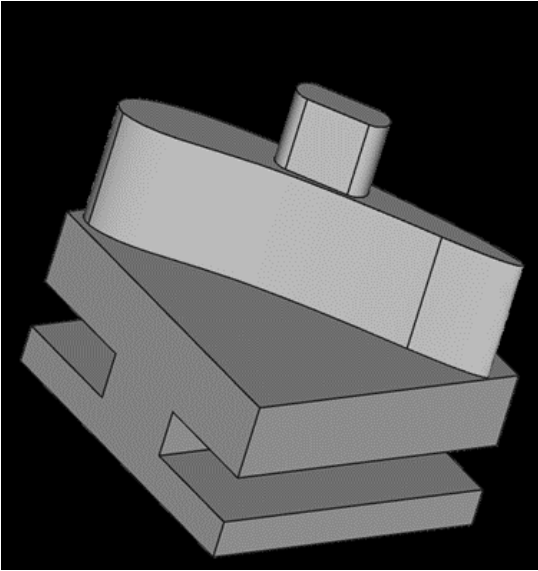


Figure 2

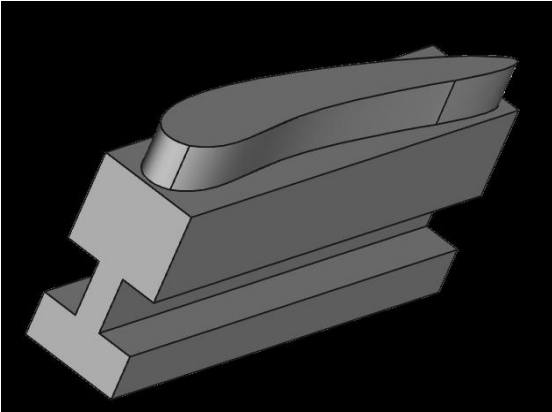


Figure 3

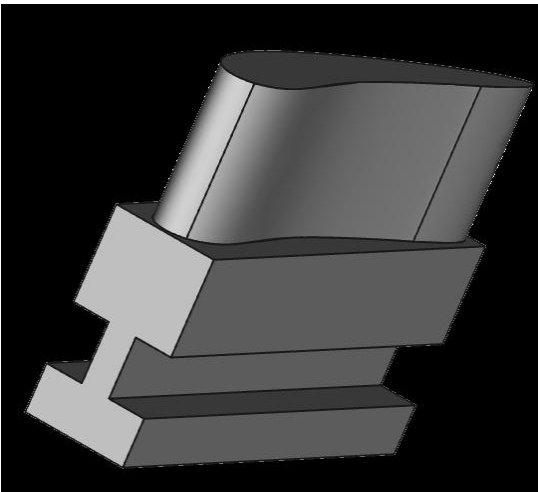


Figure 4

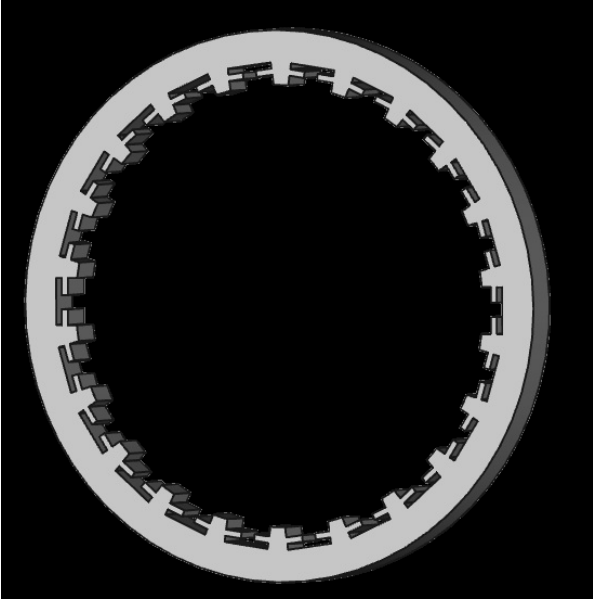


Figure 5

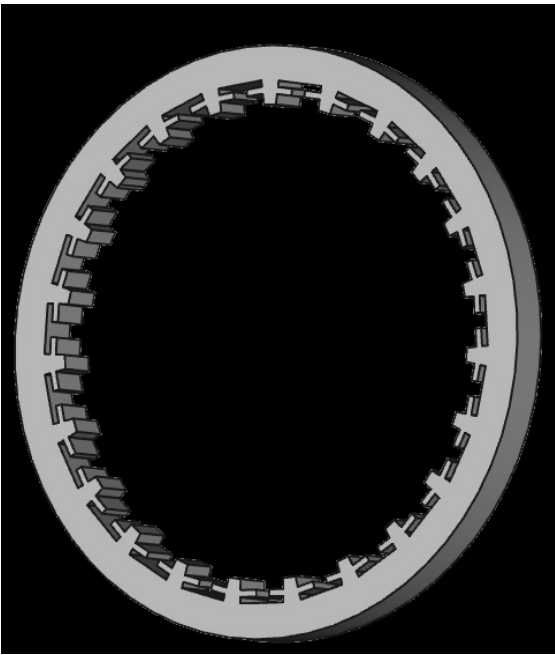


Figure 6

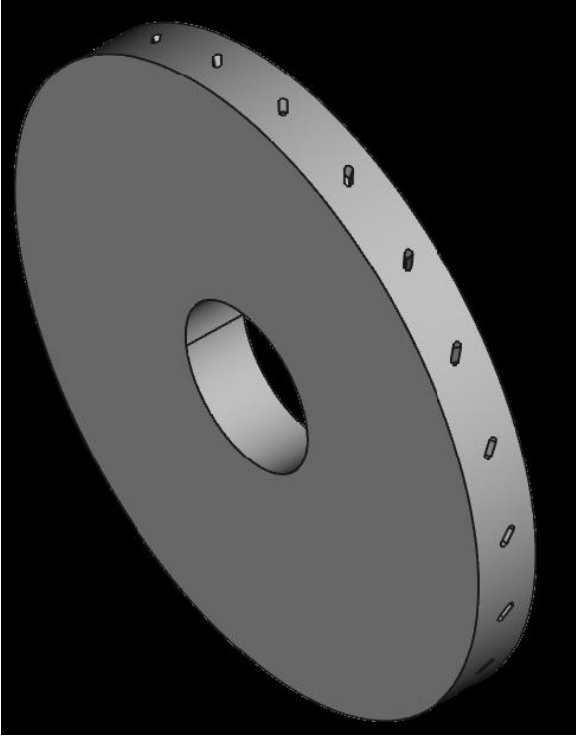


Figure 7

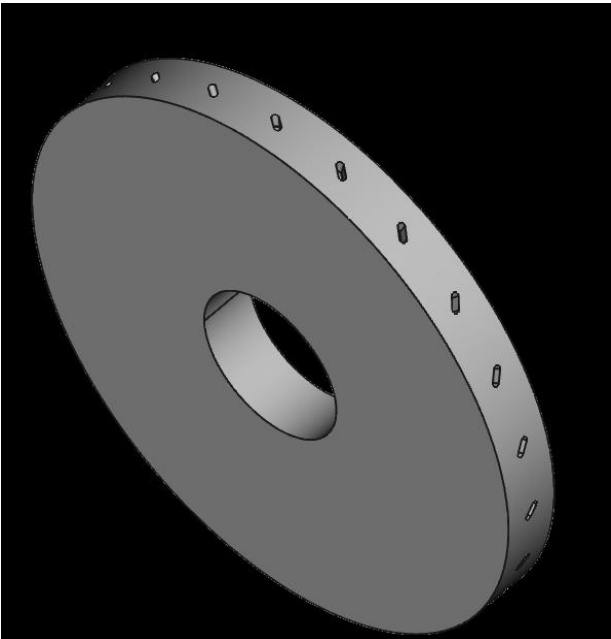


Figure 8

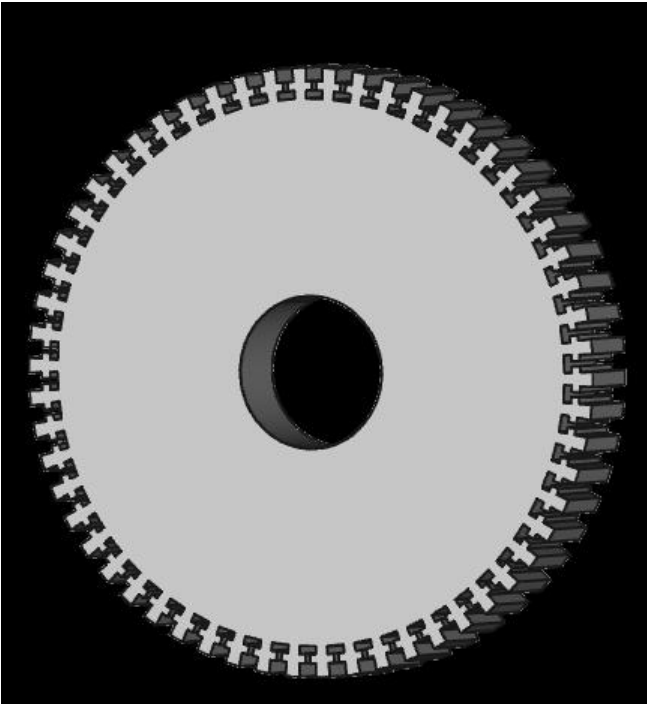


Figure 9

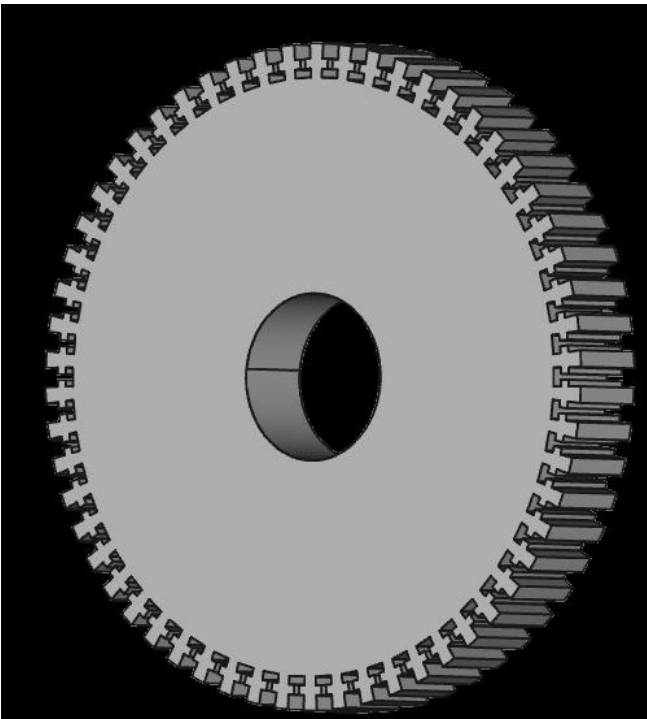


Figure 10

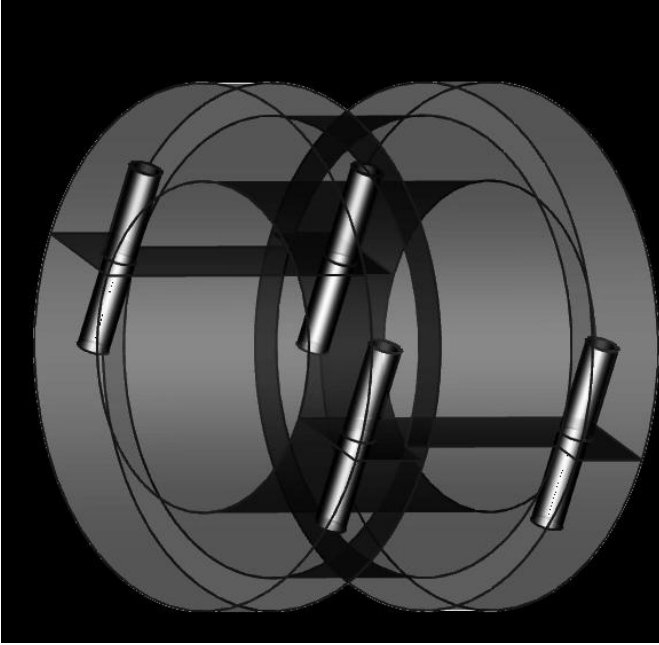


Figure 11

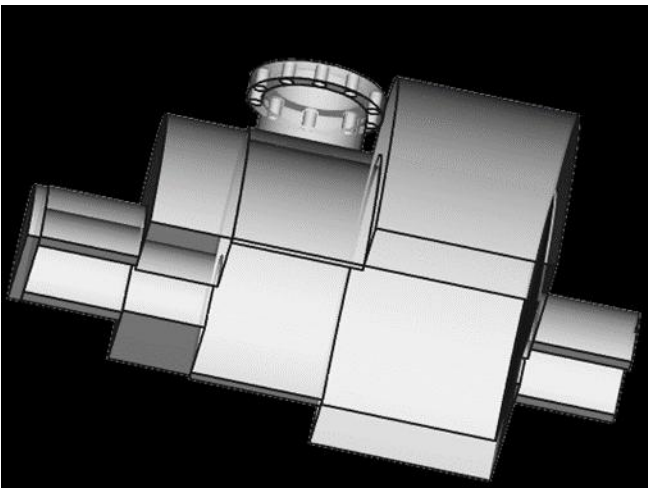


Figure 12

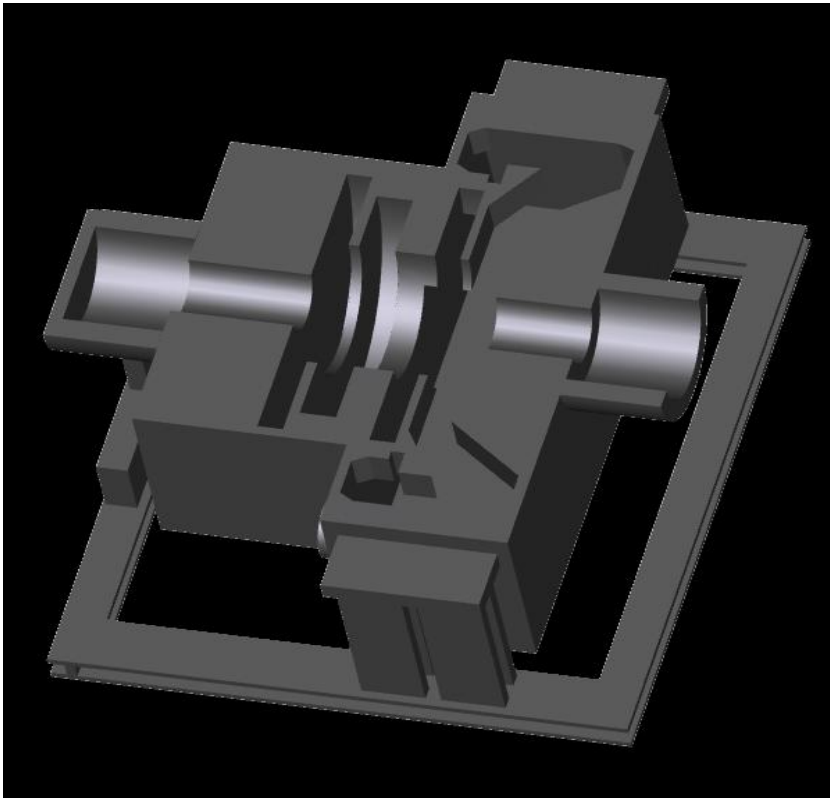


Figure 13

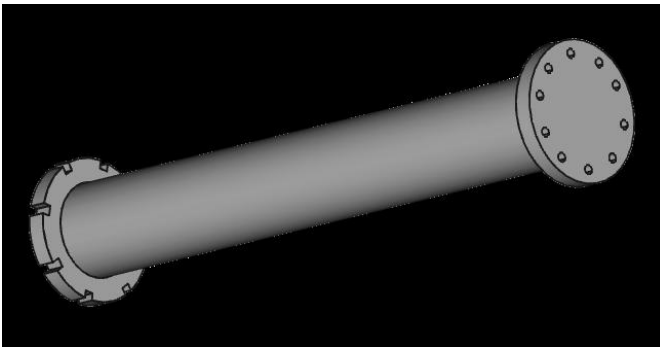


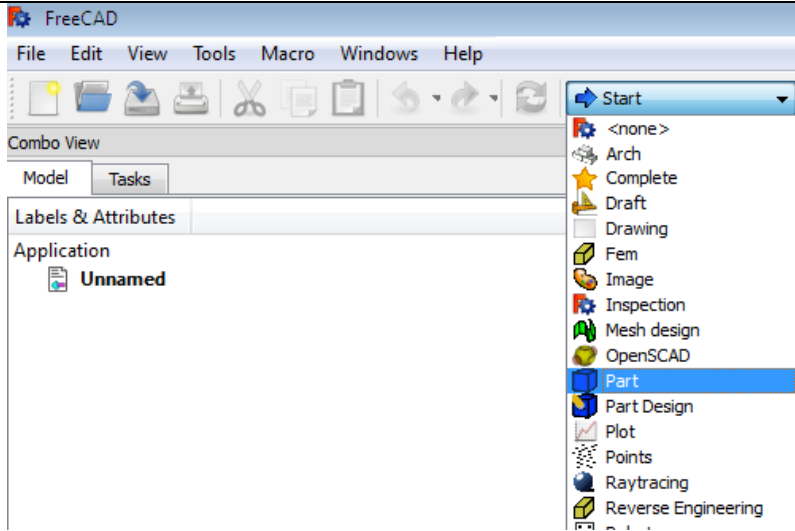
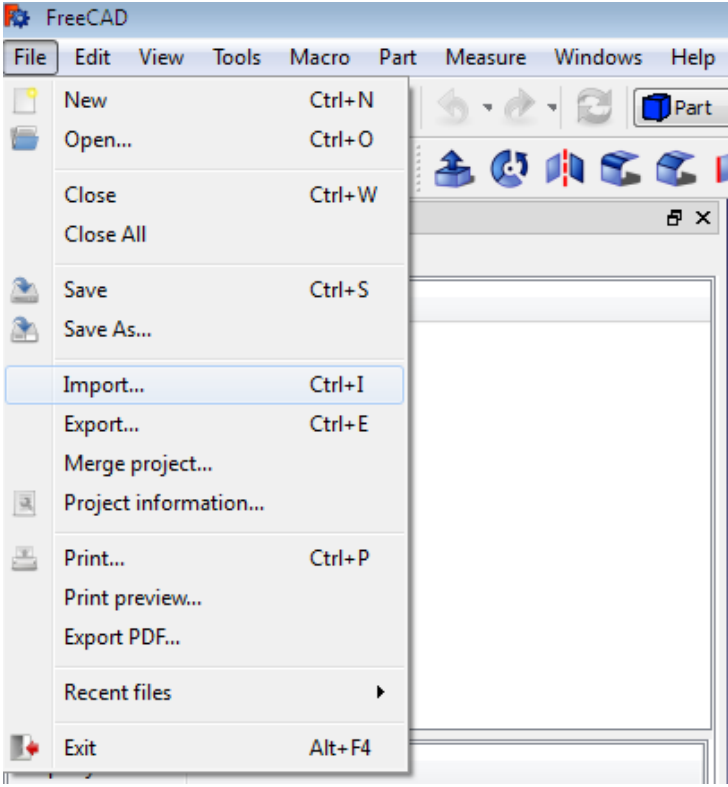
Figure 14

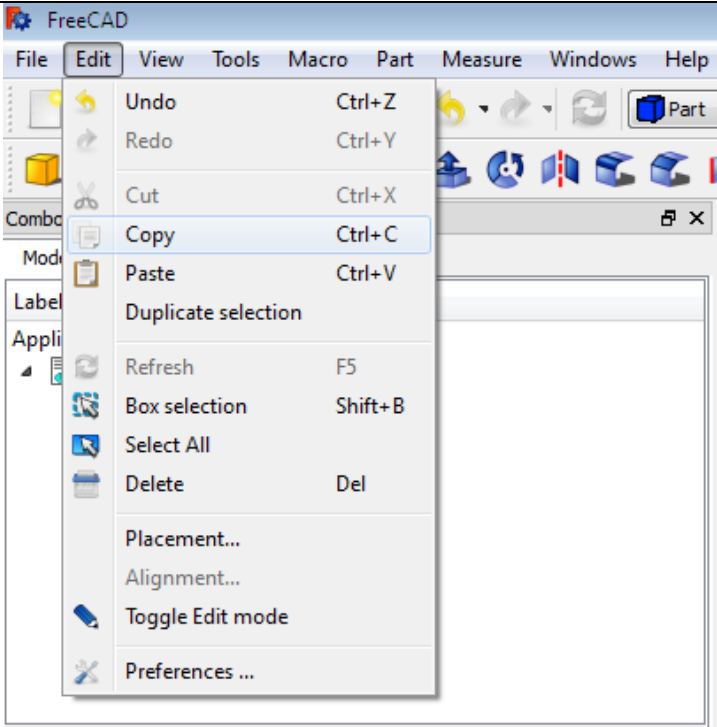
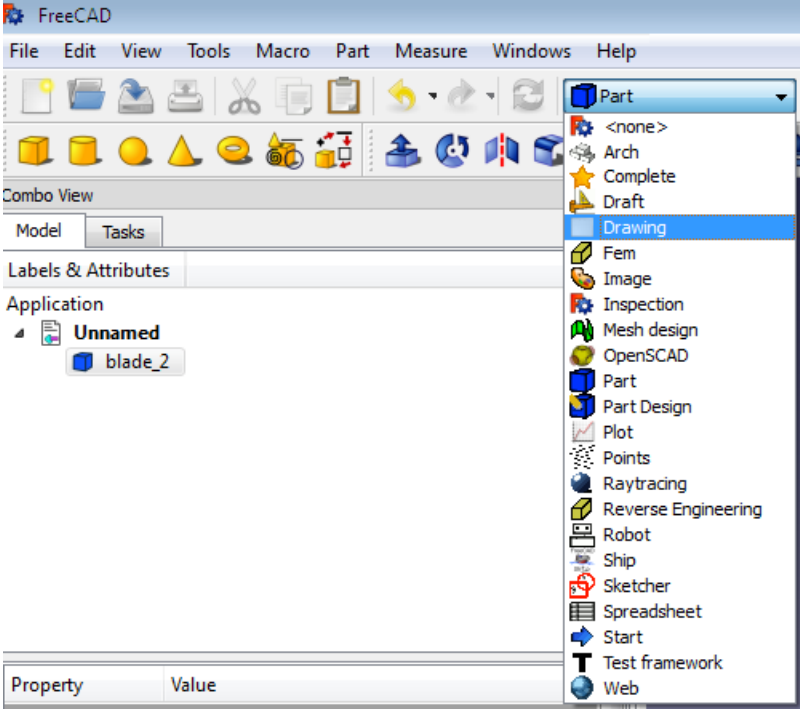
3.3 FreeCAD 2D Drawings of Turbine for manufacturing

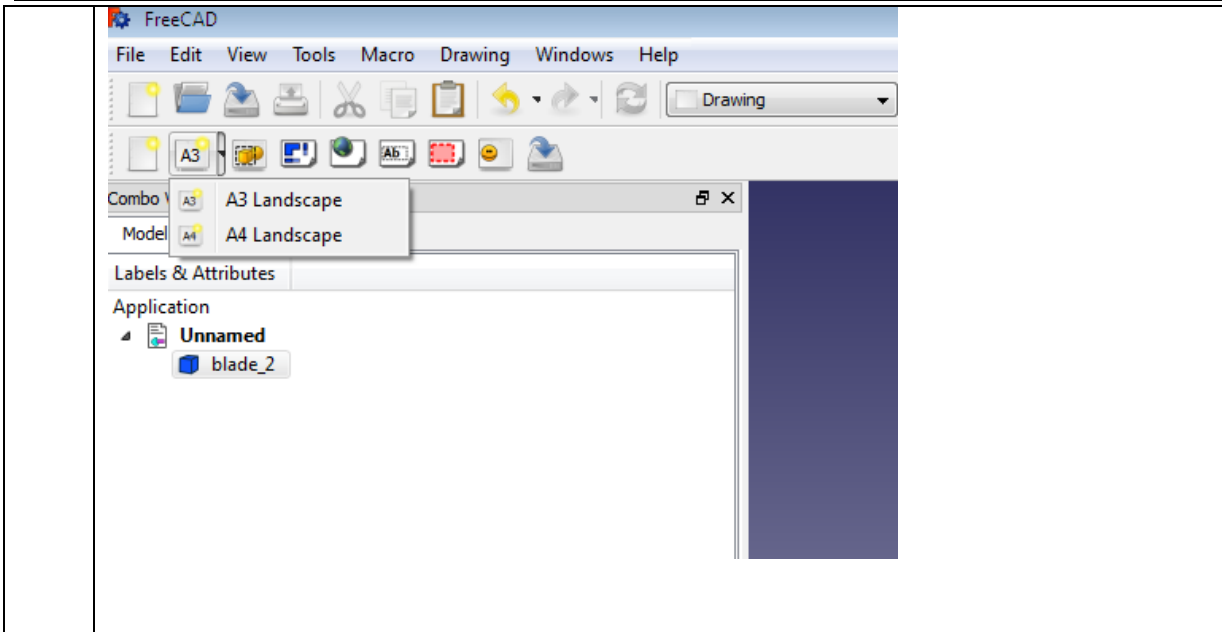
3.3.1 Drawing a FreeCAD 3D object to 2D

Follow those step to obtain it:

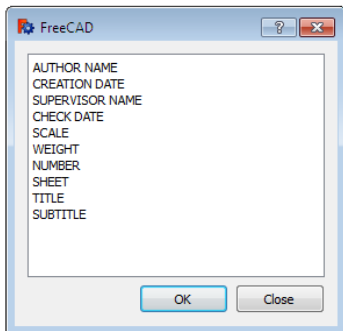
1	Select in "Start "menu, the part section.
---	---

	 <p>A screenshot of the FreeCAD application window. The 'Start' menu is open, showing a list of workbench options. The 'Part' workbench is highlighted in blue. Other options include <none>, Arch, Complete, Draft, Drawing, Fem, Image, Inspection, Mesh design, OpenSCAD, Part Design, Plot, Points, Raytracing, and Reverse Engineering.</p>
2	<p>Create simple copy of the object that was designed, or import an exported file of a Free CAD.</p>  <p>A screenshot of the FreeCAD application window with the 'File' menu open. The 'Import...' option is highlighted in blue. Other menu items include New (Ctrl+N), Open... (Ctrl+O), Close (Ctrl+W), Close All, Save (Ctrl+S), Save As..., Export... (Ctrl+E), Merge project..., Project information..., Print... (Ctrl+P), Print preview..., Export PDF..., Recent files, and Exit (Alt+F4).</p>
3	<p>Select "Edit" in the toolbar, copy then paste. (After selecting of the object).</p>

	 <p>A screenshot of the FreeCAD software interface. The 'Edit' menu is open, showing various options with their respective keyboard shortcuts. The options include: Undo (Ctrl+Z), Redo (Ctrl+Y), Cut (Ctrl+X), Copy (Ctrl+C), Paste (Ctrl+V), Duplicate selection, Refresh (F5), Box selection (Shift+B), Select All, Delete (Del), Placement..., Alignment..., Toggle Edit mode, and Preferences ...</p>
<p>4</p>	<p>Select in Start menu, the “drawing” section.</p>  <p>A screenshot of the FreeCAD software interface showing the 'Start' menu. The 'Start' menu is open, displaying a list of categories. The 'Drawing' category is highlighted in blue. Other categories visible include: <none>, Arch, Complete, Draft, Fem, Image, Inspection, Mesh design, OpenSCAD, Part, Part Design, Plot, Points, Raytracing, Reverse Engineering, Robot, Ship, Sketcher, Spreadsheet, Test framework, and Web.</p>
<p>5</p>	<p>Select “A3” then “A3 Landscape”.</p>



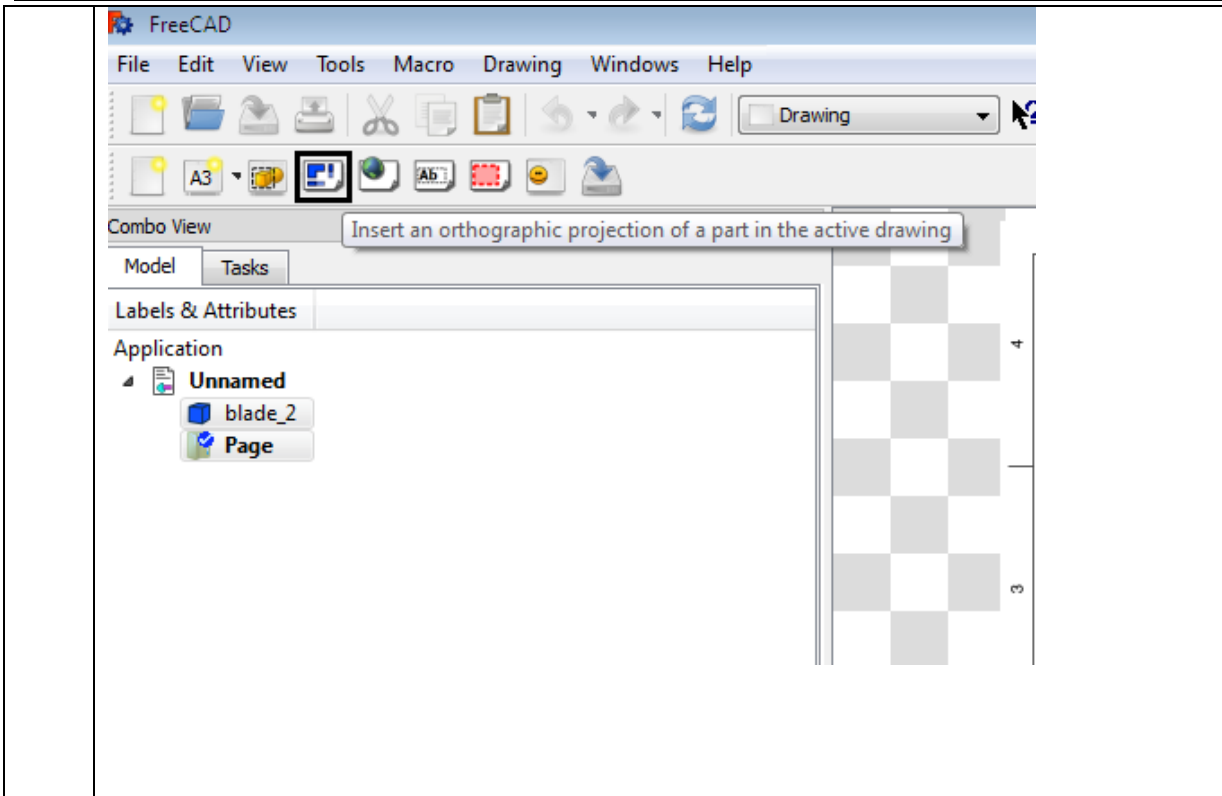
6 Double click on the folder named “page” in the left, → “data” in down, → 3 points in left of “Editable Texts” then you can change texts in the option pane. (Then it is changed in the rectangle down).



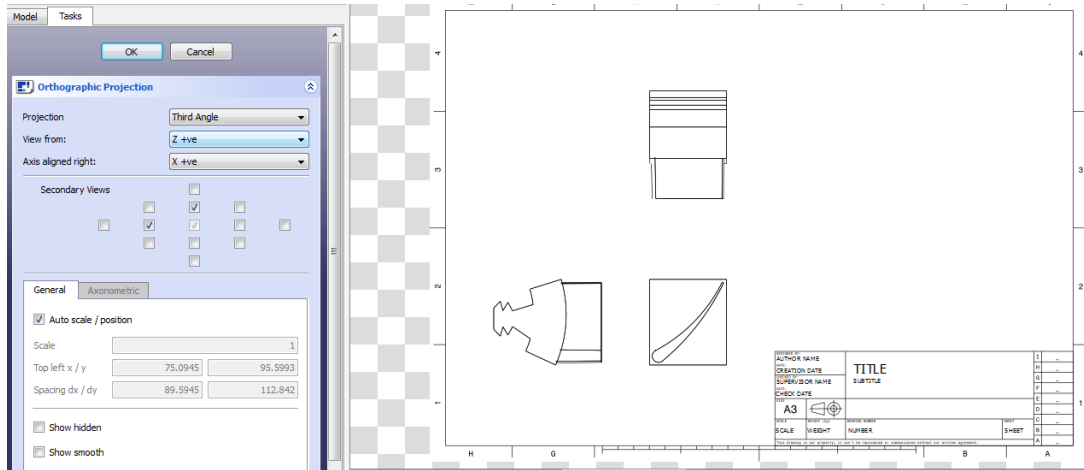
DRAWN BY:		TITLE		I	...
AUTHOR NAME		SUBTITLE		II	...
CREATION DATE				III	...
SUPERVISOR NAME				IV	...
CHECK DATE				V	...
SCALE				VI	...
WEIGHT				VII	...
NUMBER				VIII	...
SHEET				IX	...
TITLE				X	...
SUBTITLE				XI	...

7 Select the part and the page in the left together (by CTRL), insert an orthographic projection of a part in the active drawing.





8 Choose Z +ve, in view form, and then put the right symbol in two cases.

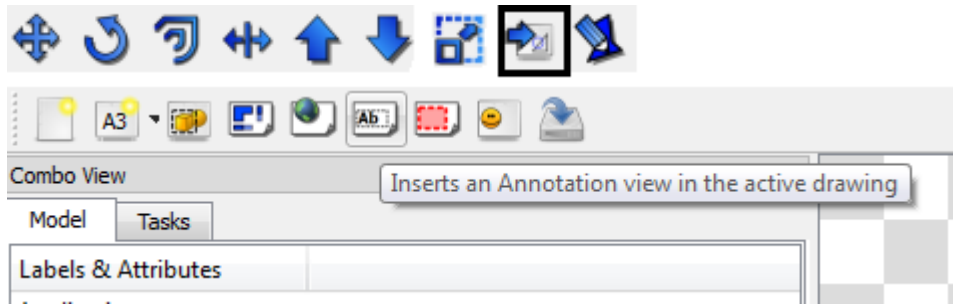


9 You can insert a new view, then change the placement of the view according to the placement of the others.

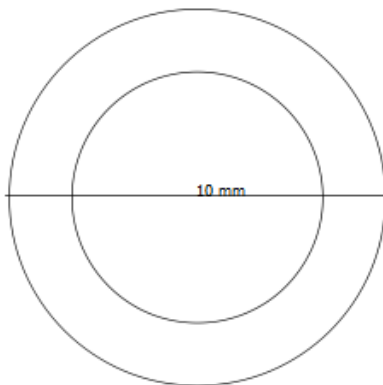


Property	Value
Base	
Label	View003
Drawing view	
Line Width	0.35
Hidden Width	0.15
Tolerance	0.05
X	10.00
Y	10.00
Scale	1.00
Rotation	0.00
Shape view	
Direction	[0.00 0.00 1.00]

10 In the start menu, use the “sketcher” for putting any lines or other, then you can put it on the drawing sheet by select an icon in the draft section. (After selection the “page” and the “sketcher” together). And also you can inserts an annotation (after selection of the objet and page together).



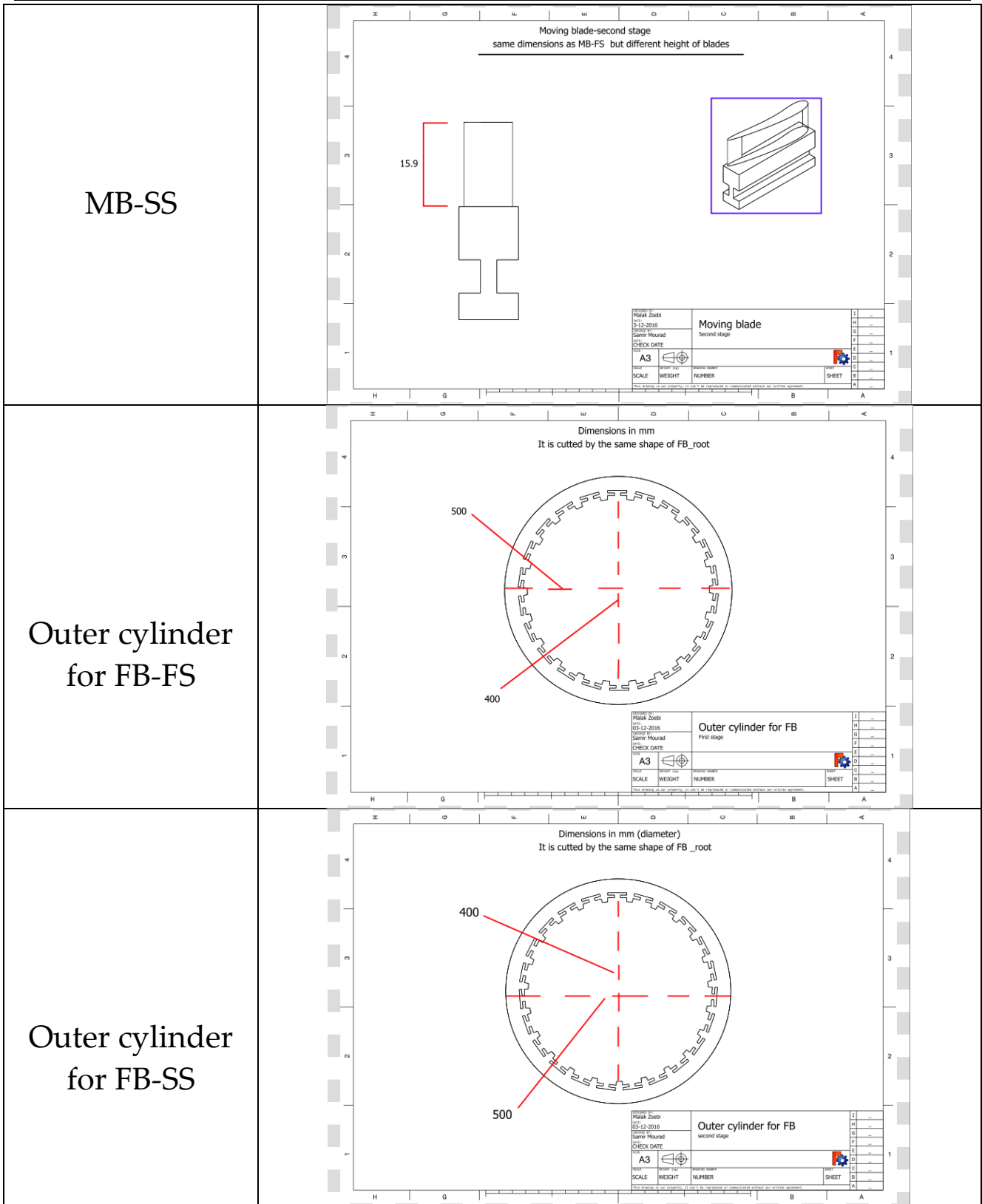
You obtain as this (for example):



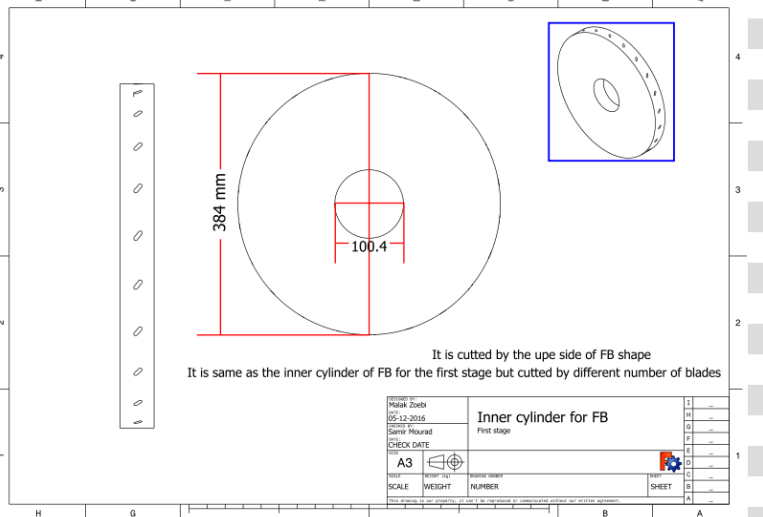
DRAWING BY: AUTHOR NAME CREATION DATE DRAWING BY: SUPERVISOR NAME CHECK DATE		TITLE SUBTITLE	I -- H -- G -- F -- E -- D -- C -- B -- A --
TITLE: A3		DRAWING NUMBER	SHEET
SCALE	WEIGHT	NUMBER	SHEET
<small>This drawing is our property. It can't be reproduced or communicated without our written agreement.</small>			A --

3.3.2 2D drawings of our 1.5 MW turbine

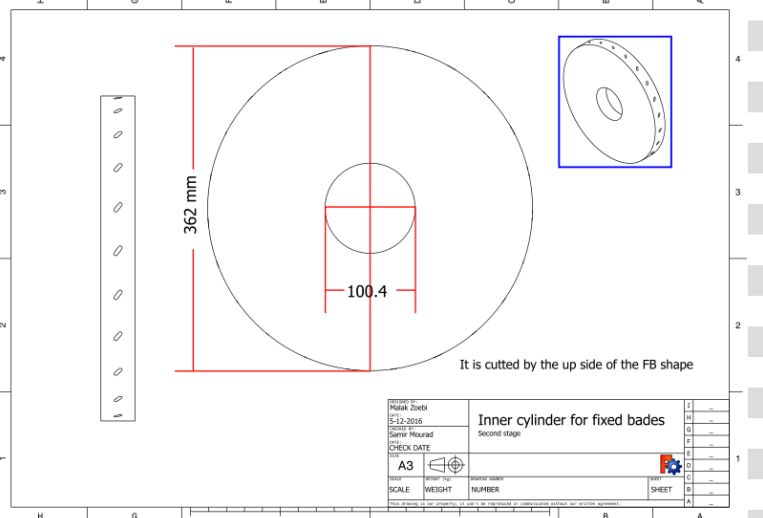
Name	2D Drawing
<p>FB-FS</p>	<p>Fixed blade for first stage (Dimensions in mm)</p>
<p>FB-SS</p>	<p>Fixed blade-second stage. Same as in the first stage but different height of blade</p>
<p>MB-FS</p>	<p>Moving blade-first stage Dimensions in mm</p>



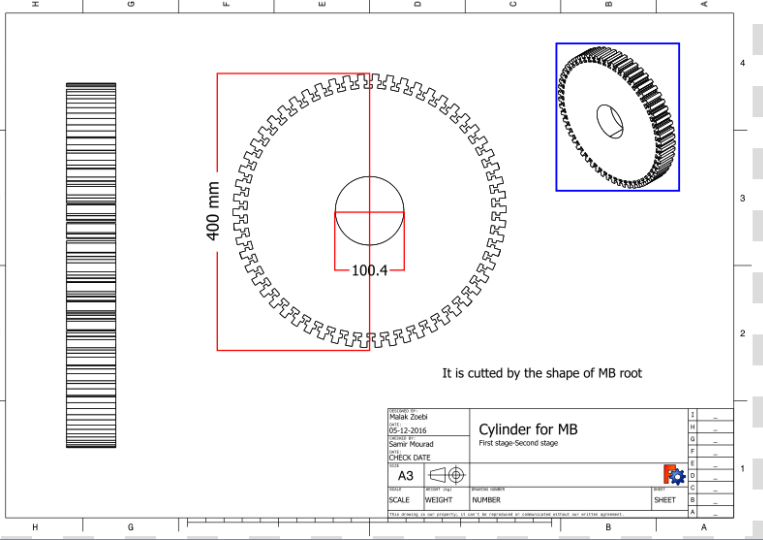
Inner cylinder for FB-FS



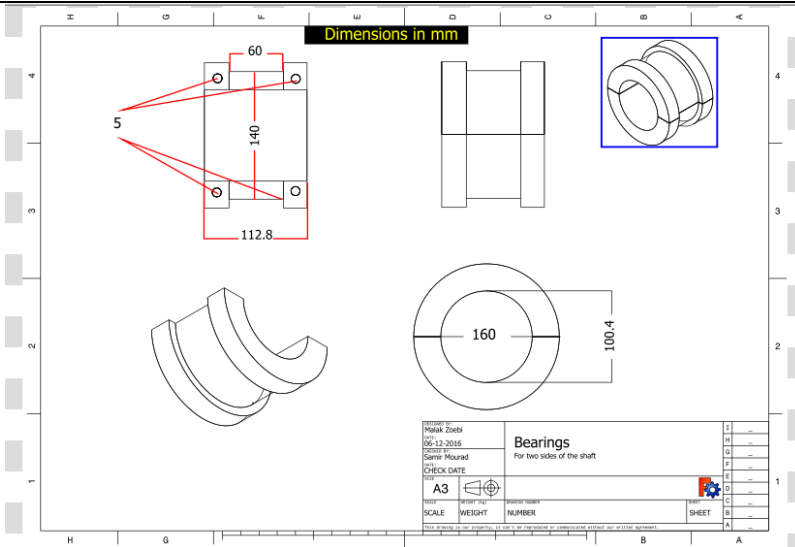
Inner cylinder for FB-SS



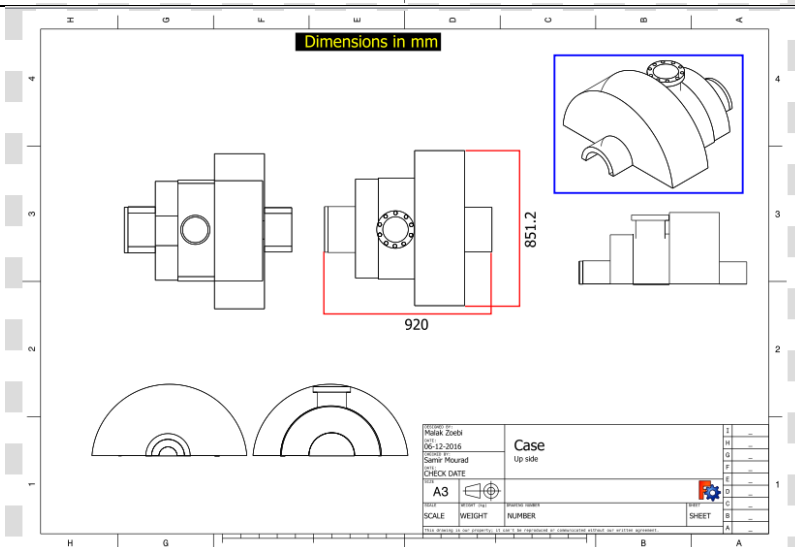
Cylinder for MB



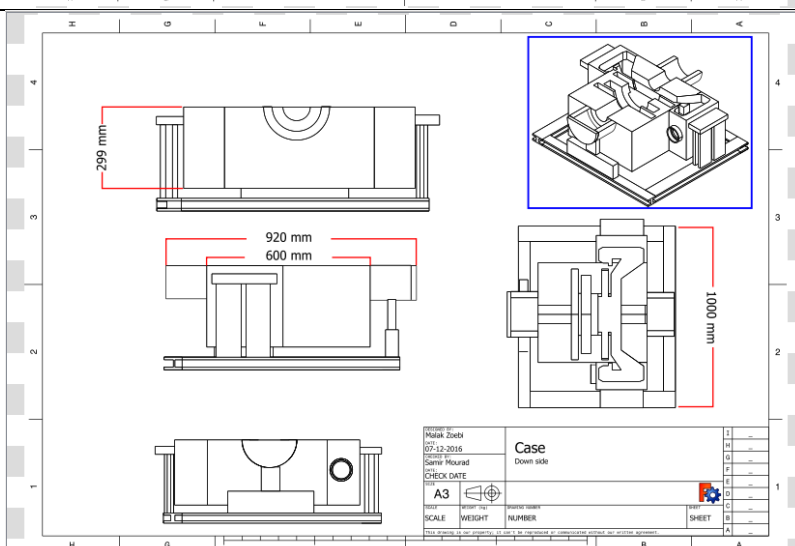
Bearings



Case (upside)



Case (down side)



3.4 Steam system parameters for a 2MW Turbine (14 bar, 195°C)

Main
About
Preferences
Glossary
Resources
Tutorials
Properties Calculators:
Saturated Properties
Steam Properties
Equipment Calculators:
Boiler
Heat Loss
Flash Tank
PRV w/ Desuperheating
Header
Deaerator
Steam Turbine
Steam System Modeler

Steam Turbine Calculator [watch tutorial](#) [view guide](#)

Calculates the energy generated or steam outlet conditions for a steam turbine.

Solve for:	
Outlet Properties ▾	
Inlet Steam	
Pressure*	200 psig
Temperature ▾ *	383 °F
Turbine Properties	
Selected Turbine Property	Power Out ▾
Isentropic Efficiency *	30 %
Generator Efficiency *	50 %
Power Out *	2000 kW
Outlet Steam	
Pressure*	30 psig
* Required <input type="button" value="Enter"/> <input type="button" value="reset"/>	

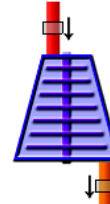
Examples:

Calculation Details and Assumptions below

WARNING:

- Inlet Steam Contains Condensate
- Steam Condensing in Turbine

Inlet Steam		Mass Flow	5,502.0 klb/hr
Pressure	200.0 psig	Sp. Enthalpy	356.8 btu/lbm
Temperature	383.0 °F	Sp. Entropy	0.545 btu/lbm/R
Phase	Liquid	Energy Flow	1,963.2 MMBtu/hr



Isentropic Efficiency	30.0 %
Energy Out	13.6 MMBtu/hr
Generator Efficiency	50.0 %
Power Out	2,000.0 kW

Outlet Steam		Mass Flow	5,502.0 klb/hr
Pressure	30.0 psig	Sp. Enthalpy	354.3 btu/lbm
Temperature	274.0 °F	Sp. Entropy	0.553 btu/lbm/R
Saturated	0.12	Energy Flow	1,949.5 MMBtu/hr

Required steam: about 2500 kg / hour.

3.4.1 Calculation details

Step 1: Determine Inlet Properties

Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow:

- Pressure = 200.0 psig
- Temperature = 383.0 °F
- [\[Steam Property Calculator\]](#) => Specific Enthalpy = 356.8 btu/lbm
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
[Inlet Energy Flow = 1,963.2 MMBtu/hr = 356.8 btu/lbm * 5,502.0 klb/hr]

Step 2: Calculate Ideal Outlet Properties (Inlet Entropy equals Outlet Entropy)

- Pressure = 30.0 psig
- Specific Entropy = 0.545 btu/lbm/R
- [\[Steam Property Calculator\]](#) => Specific Enthalpy = 348.5 btu/lbm

Step 3: If solve for 'Isentropic Efficiency', Determine Outlet Properties

Using the outlet specific enthalpy, calculate the isentropic efficiency:

- Isentropic Efficiency = (Inlet Specific Enthalpy - Outlet Specific Enthalpy) / (Inlet Specific Enthalpy - IDEAL Outlet Specific Enthalpy)

Step 3: If solve for 'Outlet Properties', Determine Outlet Specific Enthalpy

1. Isentropic Efficiency = (Inlet Specific Enthalpy - Outlet Specific Enthalpy) / (Inlet Specific Enthalpy - IDEAL Outlet Specific Enthalpy)
2. Isentropic Efficiency * (Inlet Specific Enthalpy - IDEAL Outlet Specific Enthalpy) = (Inlet Specific Enthalpy - Outlet Specific Enthalpy)
3. Outlet Specific Enthalpy = Inlet Specific Enthalpy - Isentropic Efficiency * (Inlet Specific Enthalpy - IDEAL Outlet Specific Enthalpy)
[Outlet Specific Enthalpy = 354.3 btu/lbm = 356.8 btu/lbm - 30.00 % * (356.8 btu/lbm - 348.5 btu/lbm)]

Using the outlet specific enthalpy, calculate the outlet properties:

- Pressure = 30.0 psig
- Specific Enthalpy = 354.3 btu/lbm
- [\[Steam Property Calculator\]](#) => Temperature = 274.0 °F

Step 4: Calculate Steam Turbine Energy Out and Generation (Power Out)

- Energy Out = (Inlet Specific Enthalpy - Outlet Specific Enthalpy) * Mass Flow
[Energy Out = 13.6 MMBtu/hr = (356.8 btu/lbm - 354.3 btu/lbm) * 5,502.0 klb/hr]
- Power Out = Energy Out * Generator Efficiency
[Power Out = 2,000.0 kW = 13.6 MMBtu/hr * 50.00 %]

3.5 Competitors: Backpressure Steam Turbines (500kW, 3 MW, 15 MW): Cost (\$/kW) and Performance Characteristics

	System		
Steam Turbine Parameters ⁵	1	2	3
Nominal Electricity Capacity (kW)	500	3000	15000
Typical Application	Industrial, PRV application	Industrial, universities, hospitals	Industrial, universities, hospitals
Equipment Cost (\$/kW) ⁶	668 \$	401 \$	392 \$
Total Installed Cost (\$/kW) ⁷	1136 \$	682 \$	666 \$
O&M Costs ⁸	0.010 \$	0.009 \$	0.006 \$
Turbine Isentropic Efficiency (%) ⁹	52.5 %	61.2 %	78.0 %
Generator/Gearbox Efficiency (%)	94 %	96 %	96 %
Steam Flow (lbs/hr)	20050	152600	494464
Inlet Pressure (psig)	500	600	700
Inlet Temperature (° Fahrenheit)	550	575	650
Outlet Pressure (psig)	50	150	150
Outlet Temperature (° Fahrenheit)	298	373	379.7
CHP System Parameters	1	2	3
Boiler Efficiency (%), HHV	80 %	80 %	80 %
Electric Efficiency (%), HHV ¹⁰	6.27 %	4.92 %	7.31 %
Fuel Input (MMBtu/hr)	27.2	208.3	700.1
Steam to Process (MMBtu/hr)	19.9	155.7	506.8
Steam to Process (kW)	5844	45624	148484
Total CHP Efficiency (%), HHV ¹¹	79.60 %	79.68 %	79.70 %
Power/Heat Ratio ¹²	0.086	0.066	0.101
Net Heat Rate (Btu/kWh) ¹³	4541	4540	4442

⁵Characteristics for “typical” commercially available steam turbine generator systems provided by Elliott Group.

⁶Equipment cost includes turbine, gearbox, generator, control system, couplings, oil system (if required), and packaging; boiler and steam system costs are not included.

⁷Installed costs vary greatly based on site-specific conditions; installed costs of a “typical” simple installation were estimated to be 50-70% of the equipment costs.

⁸Maintenance assumes normal service intervals over a 5 year period, excludes parts.

⁹The Isentropic efficiency of a turbine is a comparison of the actual power output compared to the ideal, or isentropic, output. It is a measure of the effectiveness of extracting work from the expansion process and is used to determine the outlet conditions of the steam from the turbine.

¹⁰ CHP electrical efficiency = Net electricity generated/Total fuel into boiler. A measure of the amount of boiler fuel converted into electricity.

¹¹Total CHP efficiency = (Net electricity generated + Net steam to process)/Total fuel into boiler.

¹²Power/Heat Ratio = CHP electrical power output (Btu)/useful heat output (Btu).

¹³Net Heat Rate = (total fuel input to the boiler - the fuel that would be required to generate the steam to process assuming the same boiler efficiency)/steam turbine electric output (kW).

Effective Electrical Efficiency (%), HHV	75.15	75.18	76.84
Heat/Fuel Ratio ¹⁴	0.733	0.748	0.724

Equipment costs shown include the steam turbine, gearbox, generator, control system, couplings, oil system (if required), and packaging. Installed costs vary greatly based on site-specific conditions. Installed costs of a “typical” simple installation were estimated to be 50-70 percent of the equipment costs. Boiler and steam system costs are not included in these estimates.

3.5.1 Performance Losses

Steam turbines, especially smaller units, may leak steam around blade rows and out the end seals. When the turbine operates or exhausts at a low pressure, as is the case with condensing steam turbines, air can also leak into the system. The leakages cause less power to be produced than expected, and the makeup water has to be treated to avoid boiler and turbine material problems. Air that has leaked needs to be removed, which is usually done by a steam air ejector or a fan removing non-condensable gases from the condenser.

Steam turbine applications usually operate continuously for extended periods of time, even though the steam fed to the unit and the power delivered may vary (slowly) during such periods of continuous operation. As most steam turbines are selected for applications with high duty factors, the nature of their application often takes care of the need to have only slow temperature changes during operation, and long startup times can be tolerated. Steam boilers similarly may have long startup times, although rapid start-up boilers are available.

3.5.2 Maintenance

Steam turbines are very rugged units, with operational life often exceeding 50 years. Maintenance is simple, comprised mainly of making sure that all fluids (steam flowing through the turbine and the oil for the bearing) are always clean and at the proper temperature with low levels of moisture or high steam quality or superheat. The oil lubrication system must be clean and at the correct operating temperature and level to maintain proper performance. Other items include inspecting auxiliaries such as lubricating-oil pumps, coolers and oil strainers and checking safety devices such as the operation of over speed trips.

In order to obtain reliable service, steam turbines require long warm-up periods so that there are minimal thermal expansion stress and wear concerns. Steam turbine maintenance costs are typically below \$0.01/kWh. Boilers and any associated solid fuel processing and handling equipment that is part of the boiler/steam turbine plant require their own types of maintenance which can add \$0.02/kWh for maintenance and \$0.015/kWh for operating labor.

¹⁴Effective Electrical Efficiency = (Steam turbine electric power output) / (Total fuel into boiler – (steam to process/boiler efficiency)). Equivalent to 3,412 Btu/kWh/Net Heat Rate.

* For typical systems available in 2014.

One maintenance issue with steam turbines is that solids can carry over from the boiler and deposit on turbine nozzles and other internal parts, degrading turbine efficiency and power output. Some of these are water soluble but others are not. Three methods are employed to remove such deposits: 1) manual removal; 2) cracking off deposits by shutting the turbine off and allowing it to cool; and 3) for water soluble deposits, water washing while the turbine is running.

An often-overlooked component in the steam power system is the steam (safety) stop valve, which is immediately ahead of the steam turbine and is designed to be able to experience the full temperature and pressure of the steam supply. This safety valve is necessary because if the generator electric load were lost (an occasional occurrence), the turbine would rapidly over speed and destroy itself. Other accidents are also possible, supporting the need for the turbine stop valve, which may add significant cost to the system. (4)

3.5.3 Steam Turbine Lubricating oil Characteristics

Mostly turbine of steam power plant may have its rotational 3000 rpm to produce required power. Due to friction the temperature of bearing, rotor may increase which, combined with other factors, may leads to the failure of bearing hence produce a serious damage to turbine and plant. Plant stability, production depends on the turbine and turbine stability depends on bearing life as bearing will always be damage first. This causes the shutdown of power plant and hence gives a loss of money. Lubricant has vast effect on the life of bearing that's why much care should be given while selecting it. We are going to be familiar with some of the properties, a lubricant should have. (5)

3.5.3.1 Background

For the turbine shaft to move freely, it rides upon several lubricant-filled bearings. These bearings are usually simple bearings into which the lubricating oil is pumped under high pressures. The oil lubricates the bearing through hydrodynamic lubrication. The bearings and the shaft are separated by a pressurized film of oil to prevent any metal-to-metal contact.

Figure 3 is a simple illustration of the general components and travel route of turbine oil in a steam turbine lubrication system.

Along with providing lubrication to the shaft bearings, the lubricant also lubricates the oil pump, and in some systems is used as a turbine control fluid in the hydraulic governing system. Many steam turbines have an isolated governing system that contains its own fluid. In order to ensure that the high-pressure lubricant is properly supplied to the bearings, it is pumped from an oil tank (reservoir), through an elaborate system of flow control valves, an oil cooler, through the bearing, and finally back to the oil tank.

The oil is constantly agitated as it circulates through the system. This agitation is important to note, as it provides both benefits and challenges for the oil during its lifetime in the turbine.

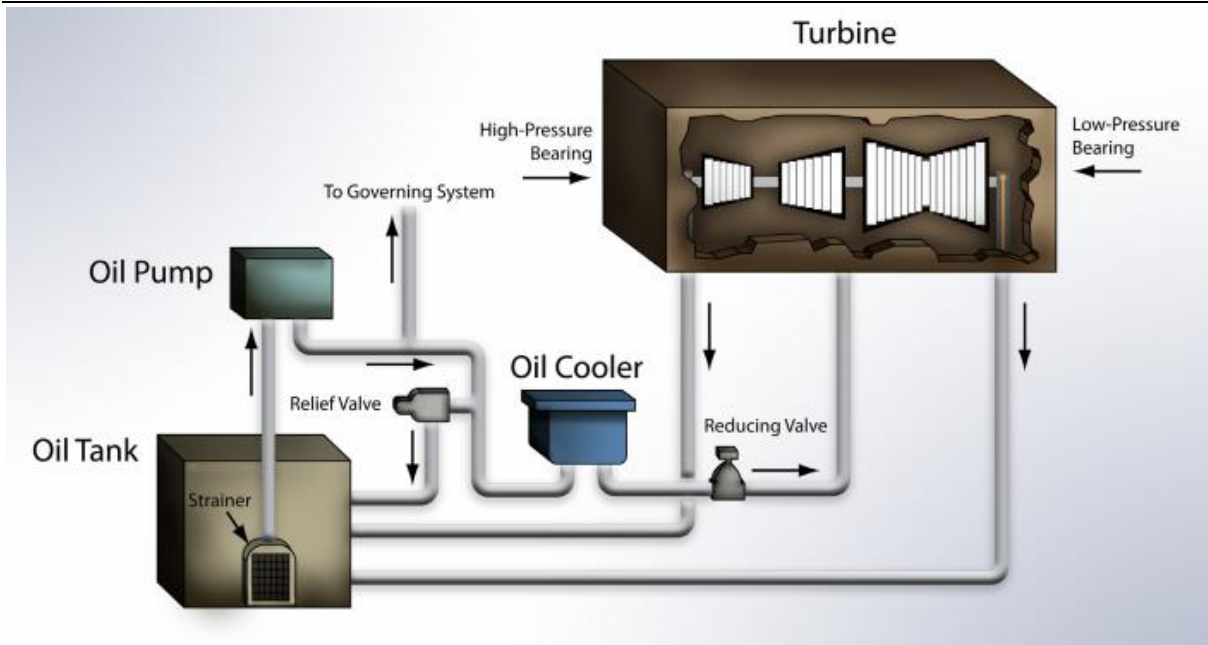


Figure 15: Steam turbine lubrication system (6)

3.5.4 Viscosity

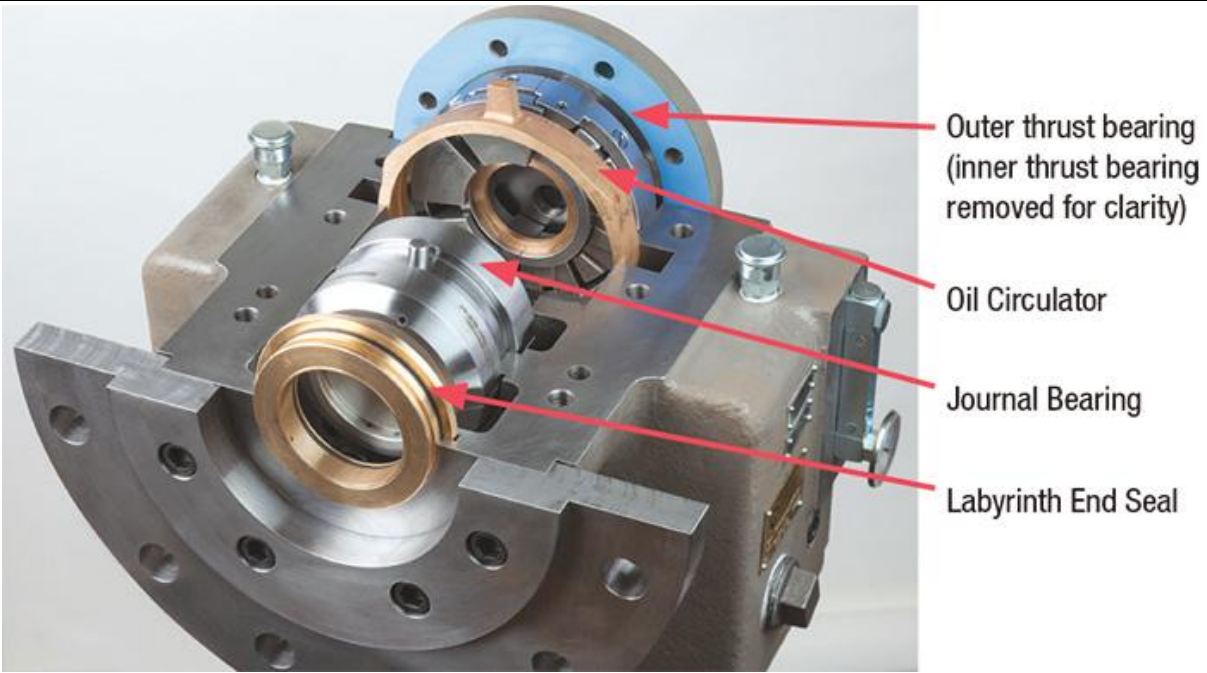
The journal and thrust bearings of steam turbines require lubrication. Oils having higher viscosity provide a greater margin of safety in the bearings. However, its friction losses are high. In high-speed turbines, the heat generation becomes significant. Most oils used in this service have International Organization for Standardization (ISO) viscosity grade 32. Higher viscosity is used in some applications, ISO viscosity grade 46 (41.4 to 50.6 CST at 40°C). (5)

3.6 Turbine bearing

3.6.1 Introduction

Bearings are used to prevent friction between parts during relative movement. In machinery they fall into two primary categories: anti-friction or rolling element bearings and hydrodynamic journal bearings. The primary function of a bearing is to carry load between a rotor and the case with as little wear as possible. This bearing function exists in almost every occurrence of daily life from the watch on your wrist to the automobile you drive to the disk drive in your computer. In industry, the use of journal bearings is specialized for rotating machinery both low and high speed.

The purpose of using the bearing	غايات إستعمال البيرنج
Seals: we use it for not moving right or left	نستعملها كي لا تتحرك لا شمالاً ولا يميناً
Journal bearings: Maintain orthogonally	تحافظ على التعامدية
Thrust bearings: Keeps the pivotal	تحافظ على المحورية



To know how bearing is manufactured, watch this video in the link:

<https://www.youtube.com/watch?v=x-cN2TRmVMk>



Figure 16: Min bearings for steam turbine

Table 1: Material for bearings

Bearing Material	Hardness kg/mm ²	Minimum Shaft Hardness kg/mm ²	Hardness Ratio
Lead-base babbitt	15-20	150	8
Tin-base babbitt	20-30	150	6
Alkali-hardened lead	22-26	200-250	9
Copper-lead	20-23	300	14
Silver (overplated)	25-50	300	8
Cadmium base	30-40	200-250	6
Aluminum alloy	45-50	300	6
Lead bronze	40-80	300	5
Tin bronze	60-80	300-400	5

Source: Wilcock and Booser, *Bearing Design and Application*, McGraw-Hill, 1957.

3.7 Materials needs and calculations

The range of alloys used in steam turbines is relatively small, partly because of the need to ensure a good match of thermal properties, such as expansion and conductivity, and partly because of the need for high temperature strength at acceptable cost. The commercial alloys used depend on the maximum temperatures and pressures to which specific components will be exposed, and these are heavily dependent upon the detailed design of the turbine, which can vary significantly among the various manufacturers. Since this is the case, the starting point for any overall discussion of materials issues is to list the main components of interest, and to identify the conditions under which they will be required to operate. The main components considered here are: the turbine casing/shell (including the steam chest), cylinders and valve bodies; bolting; turbine rotors or discs; and vanes and blades.

The inner cylinder and steam chest should be fabricated from the same material as the rotor, to avoid thermal mismatch.

The alloys most commonly used for steam turbine rotors and/or discs are the CrMoVWNbN steels, which can vary in chromium content from 1-13% depending on the preference of individual manufacturers.

These alloys are widely used up to a temperature limit of about 566°C, and the higher-W, lower-Nb and -C versions are capable of 593°C. (7)

Choose for the shaft AISI 4340 Alloy Steel

And for the casing cast iron.

Its proprieties are shown in the table below:

Table 2: properties of AISI 4340 Alloy Steel. (8)

Properties	Metric Imperial	
	Tensile strength	745 MPa
Yield strength	470 MPa	68200 psi
Bulk modulus (typical for steel)	140 GPa	20300 ksi
Shear modulus (typical for steel)	80 GPa	11600 ksi
Elastic modulus	190-210 GPa	27557-30458 ksi
Poisson's ratio	0.27-0.30	0.27-0.30
Elongation at break	22%	22%
Reduction of area	50%	50%
Hardness, Brinell	217	217
Hardness, Knoop (converted from Brinell hardness)	240	240
Hardness, Rockwell B (converted from Brinell hardness)	95	95
Hardness, Rockwell C (converted from Brinell hardness. Value below normal HRC range, for comparison purposes only)	17	17
Hardness, Vickers (converted from Brinell hardness)	228	228
Machinability (annealed and cold drawn. Based on 100 machinability for AISI 1212 steel.)	50	50

So rigidity equal to 79979185 N/m^2 (it is called also shear modulus).

Notice that 1 ksi (Pound force per square inch) = 6894.76 N/m^2 .

Twisting moment:

$$P = M_t \times w$$

$$M_t = \frac{P}{w} = \frac{1.5 \times 10^6}{\frac{2\pi \times 3000}{60}} = 4774.65 \text{ N.m.}$$

Shear stress:

$$I_p = \frac{\pi D^4}{32} = \frac{\pi \times 100^4}{32} = 9817477.042 \text{ mm}^4.$$

$$\tau = \frac{M_t \times r}{I_p} = \frac{4774.65 \times 10^3 \times 50}{9817477.042} = 24.317 \text{ N/mm}^2.$$

Torsional deflection:

$$\frac{\theta G}{L} = \frac{M_t \tau}{I_p r}$$

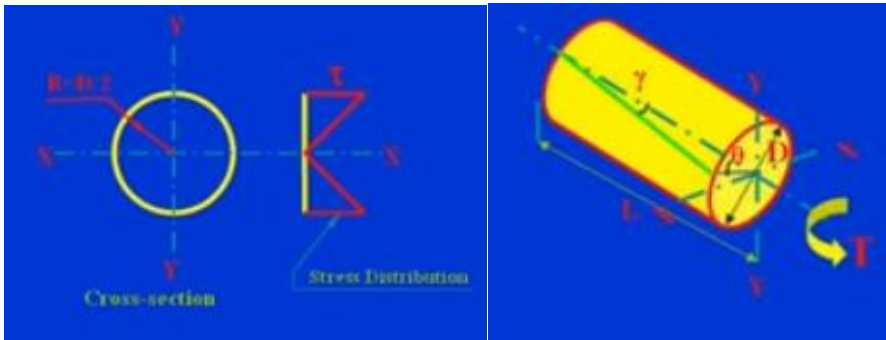


Figure 17 stress distribution

$$\theta = \frac{M_t L}{I_p}$$

$$\theta = \frac{4774.65 \times 10^3 \times 700}{79979185 \times 9817477.042} = 4.26 \times 10^{-6} \text{ rad.}$$

$$\theta = 4.26 \times 10^{-6} \text{ rad} = 4.26 \times 10^{-6} \times \frac{360}{2\pi} = 2.44 \times 10^{-4}$$

Stainless steel type 403 is a special high quality steel made for blades and buckets for steam turbine and jet engine compressors. This grade is eminently suited for very highly stressed parts. This material is magnetic in all conditions.

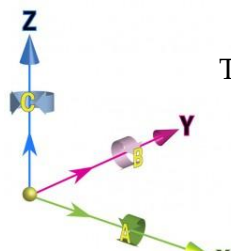
3.8 5D CNC machining

3.8.1 What is 5-Axis?

When someone uses the term “5-axis” they are typically referring to the ability of a CNC machine to move a part or a tool on five different axes at the same time. 3-axis machining centers move a part in two directions (X and Y), and the tool moves up and down (Z). 5-Axis machining centers can rotate on two additional rotary axes (A and B) which help the cutting tool approach the part from all directions.

3.8.2 Basics of axis configuration

To understand machine configurations, it's important to understand the basic terminology of 5-axis machining centers. If you think in terms of a 3-axis machining center, it has an X-axis, Y-axis, and Z-axis. With a 5-axis machining center, the additional rotary axes will rotate about two of those three primary axes.



The axis that rotates about or under the Z-axis is called the C-axis.

The axis that rotates about the Y-axis is called the B-axis.

The axis that rotates about the X-axis is called the A-axis. (1)

Figure 18 (Image courtesy of Hurco North America.)

Although there are 6-axis CNC machines, such as Zimmermann's FZ 100 Portal milling machine, 5-axis configurations are more common, since adding a sixth axis typically offers few additional benefits.

One last note about axis-labeling conventions: in a vertical machining center, the X- and Y-axes reside in the horizontal plane while the Z-axis resides in the vertical plane. In a horizontal machining center, the Z-axis and Y-axis are reversed. See the diagram below: (2)

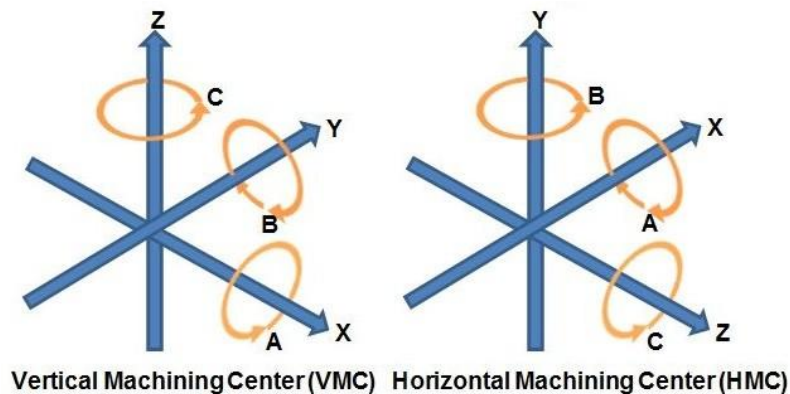


Figure 19 (Image courtesy of Cameron Anderson/Aerotech.)

3.8.3 How a router works

The power behind any router is its CAD/CAM software. The CAD software allows the user to create a design they want the router to cut. Once this design has been made, the CAM software converts the design into a tool path code that the router can understand.

The computer then translates this code into signals that control the movement of the router's drive system. The drive system contains the spindle, which is the part that holds the actual router bits. The spindle rotates these bits 8,000 to 50,000 times per minute in order to cut the material. Simply put, the user creates a design and uses software to make instructions for the router to follow.

3.9 3-axis routers vs. 5-axis routers

Now that you have a working knowledge of how a router works you can better understand the differences between various models. Although 4-axis routers exist, the most common CNC routers available and the ones MultiCam Canada offers are 3 and 5-axis routers.

3-axis CNC routers cut along three axes at the same time; the x-axis, the y-axis, and the z-axis. Cutting along the x-axis moves the router bit from front to back, cutting along the y-axis moves it from left to right, and cutting across the z-axis moves it up and down. These machines are used primarily for cutting flat, 2-dimensional parts.

5-axis CNC routers can cut along two additional axes than 3-axis routers. These routers have the ability to cut on five sides of a piece of material simultaneously, which expands the operator's capabilities and flexibility. Unlike their 3-axis counterparts, these machines are usually used to cut large 3-dimensional parts. In addition, 5-axis routers have a taller gantry and longer x-axis, which allows them to cut larger part; however, this comes at a serious cost; the taller the gantry and the longer the x-axis, the less the accurate and stable these machines are. For proper quality control, the height of the gantry and the length of the x-axis should be limited as much as possible.

Although routers seem like simple machines, they are highly sophisticated pieces of technology that require a certain level of expertise to operate. 5-axis routers tend to be more expensive than traditional 3-axis models, but ultimately offer greater flexibility and enable users to be more creative with their designs. (3)

3.10 Thermal efficiency if the steam is superheated

We worked on a steam turbine which has a power of 1.5 MW.

This turbine is composed of two parts, and each part has two stages.

The electric efficiency is equal to 0.96; mechanic efficiency is equal to 0.95; interne efficiency of turbine is equal to 0.9.

Entry pressure for the turbine is 14 bars, and the entry temperature is 250°C. The pressure in the condenser is 12 kPa.

Figure 20 shows the installation of an incineration power plant with the steam turbine in that case.

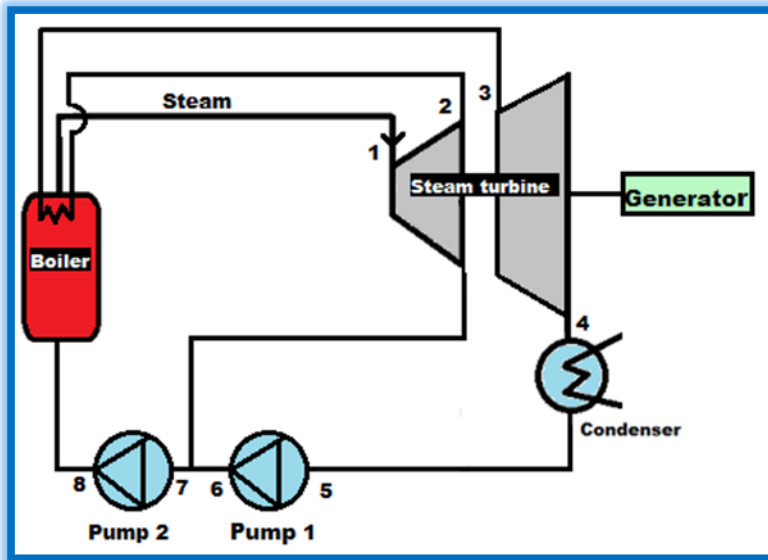


Figure 20 installation

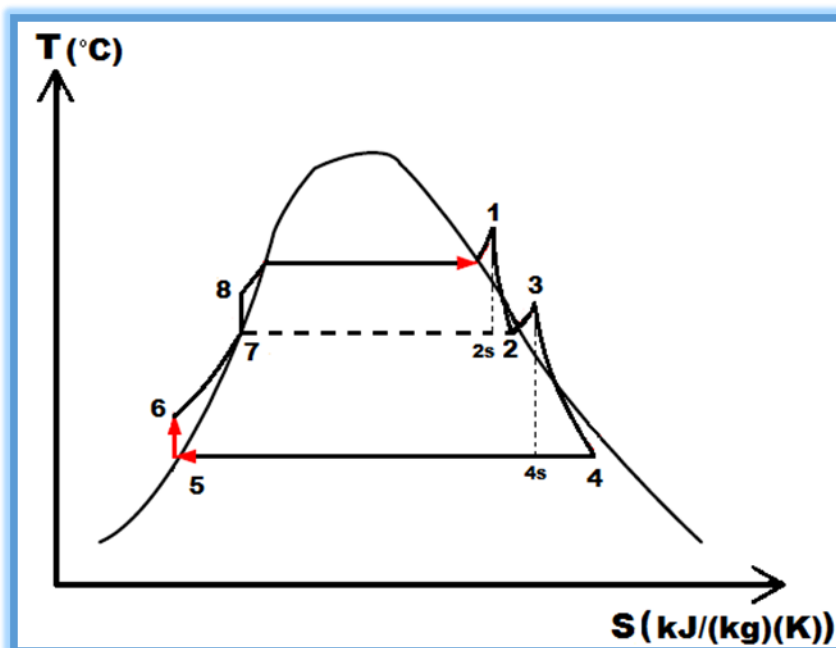


Figure 21 Rankine cycle

Calculate enthalpy, entropy, etc... for each point.

So the thermal efficiency is :

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$$\eta = \frac{\text{Net work}}{\text{Quantity of steam additional } Q} = \frac{\Delta W_{net}}{Q}$$
$$\eta = \frac{(h_1 - h_2) + (1 - \dot{m}_1)(h_3 - h_4) - [(1 - \dot{m}_1)(h_6 - h_5) + (h_8 - h_7)]}{(h_1 - h_8) + (1 - \dot{m}_1)(h_3 - h_2)}$$
$$\eta = \frac{(2926.56 - 2665.22547) + (1.0.14395)(2865.6 - 2392.85925) - [(1 - 0.14395)(207.388 - 207.1) + 562.3 - 561.2]}{(2926.56 - 562.2) + (1 - 0.14395)(2865.6 - 2665.22547)}$$

→ $\eta = 26.26\%$.

3.11 Dynamo generator

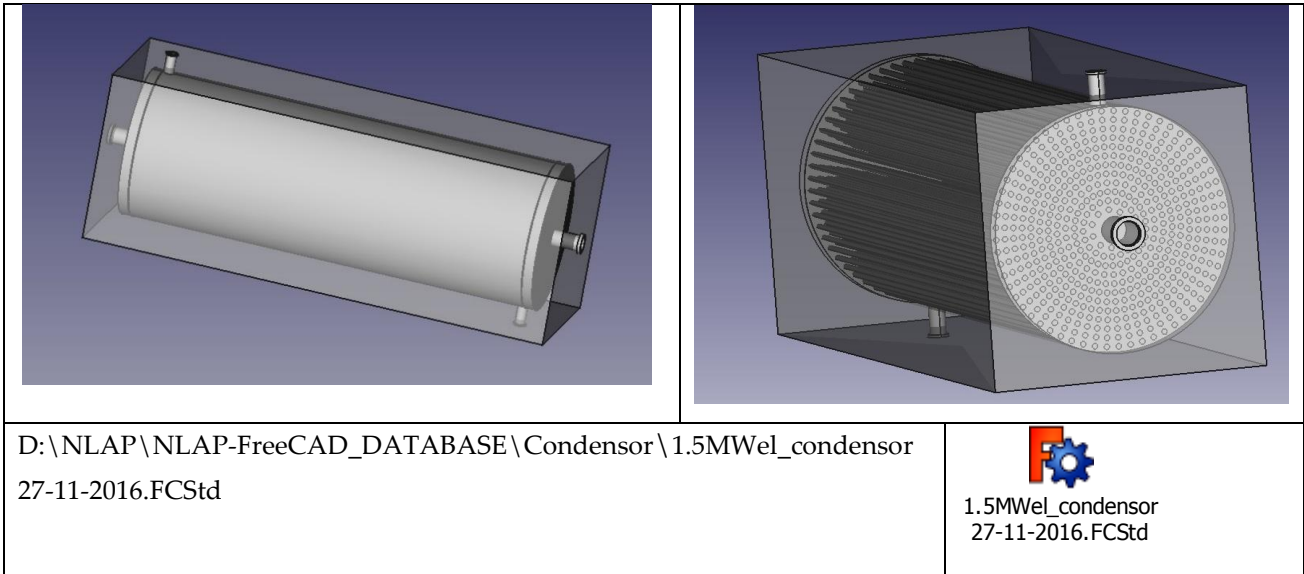
A generator 1 MW cost 7000 \$ from alibaba



4.1 Condenser Specification

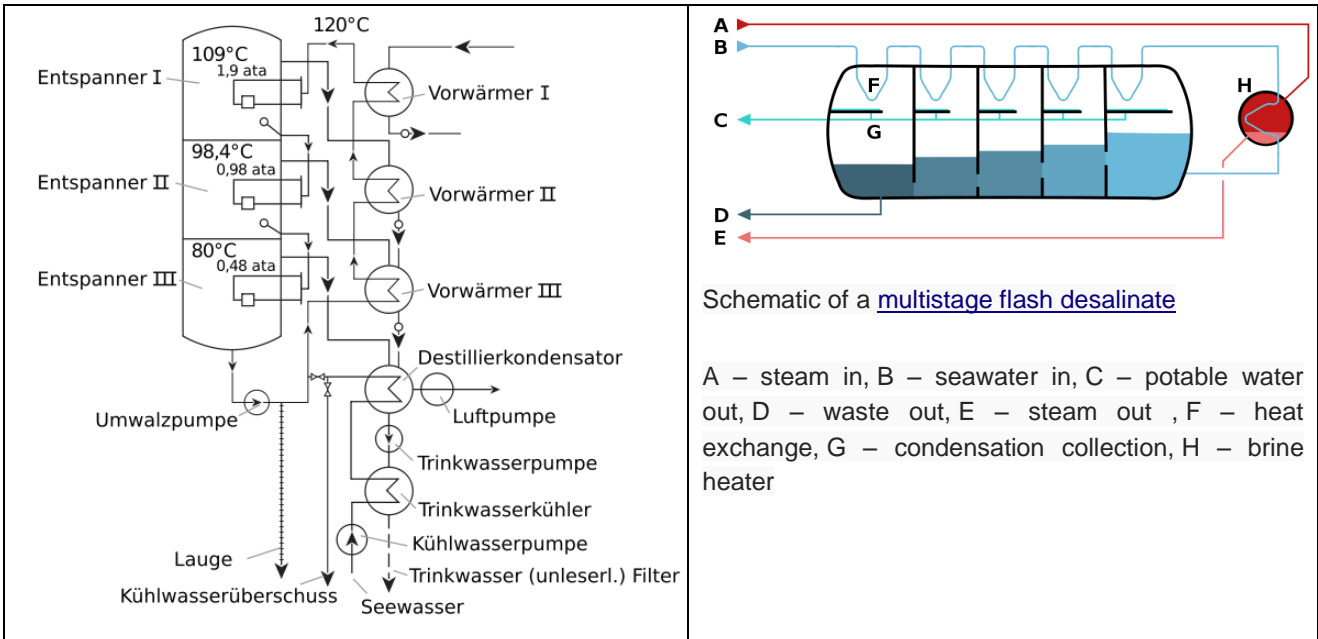
- Length: 6 m, Number of tubes 530
- 1 inch tubes (50cm as rad 20";6 m)
- Heat transfer between steam and water

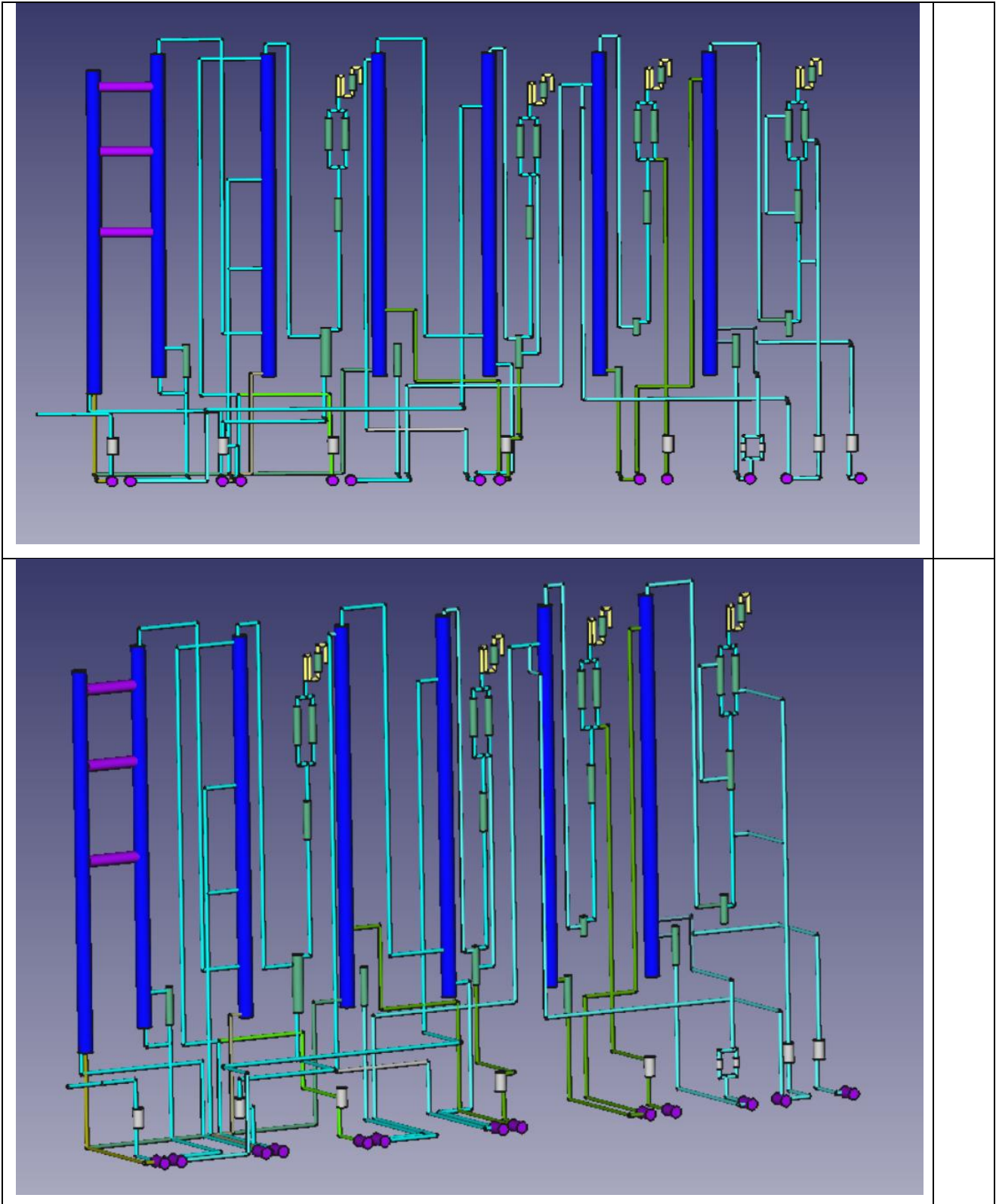
4.2 نموذج ببرنامج FreeCAD



4.3 Cooling of condenser

4.3.1 Sea water desalting unit for condenser cooling cycle (schema)





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4.4 Cost for cooling with fresh sea water cycle (only with piping to sea)

500 متر بعيد من البحر: 1000 متر انابيب

Cooling						
	Length [m]	قصتر 6 متر #	Price per pipe element	Total price		
Pipes	1000	167	\$30	\$5,000		
		#Pumps	Price per pump			
Pumps		2	\$200	\$400		
					Total cooling	
					\$5,400	

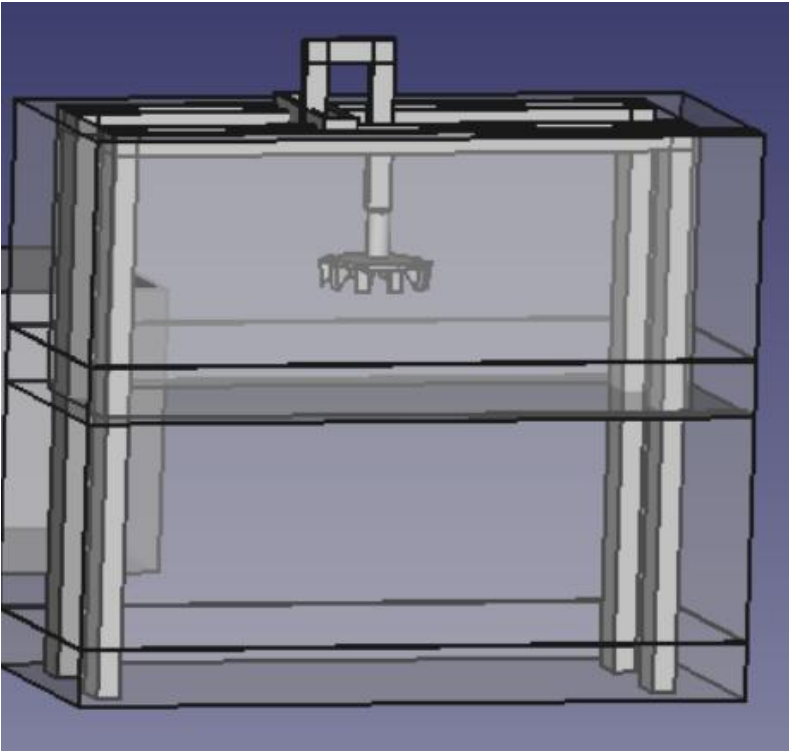
Length:6 m

Width:2 m

Hight:2 m

12 sheet of steel / (1:2m)/thickness :4 mm





Climbing Tubes:

- vertical: 216 tubes (2 inch, 2.5 m)
- horizontal : 216 tubes (2 inch, 1 m)
- 4 tubes (4 inch, 12 m)
- 216 flosses (sheets) (2 inch)

Sheets:

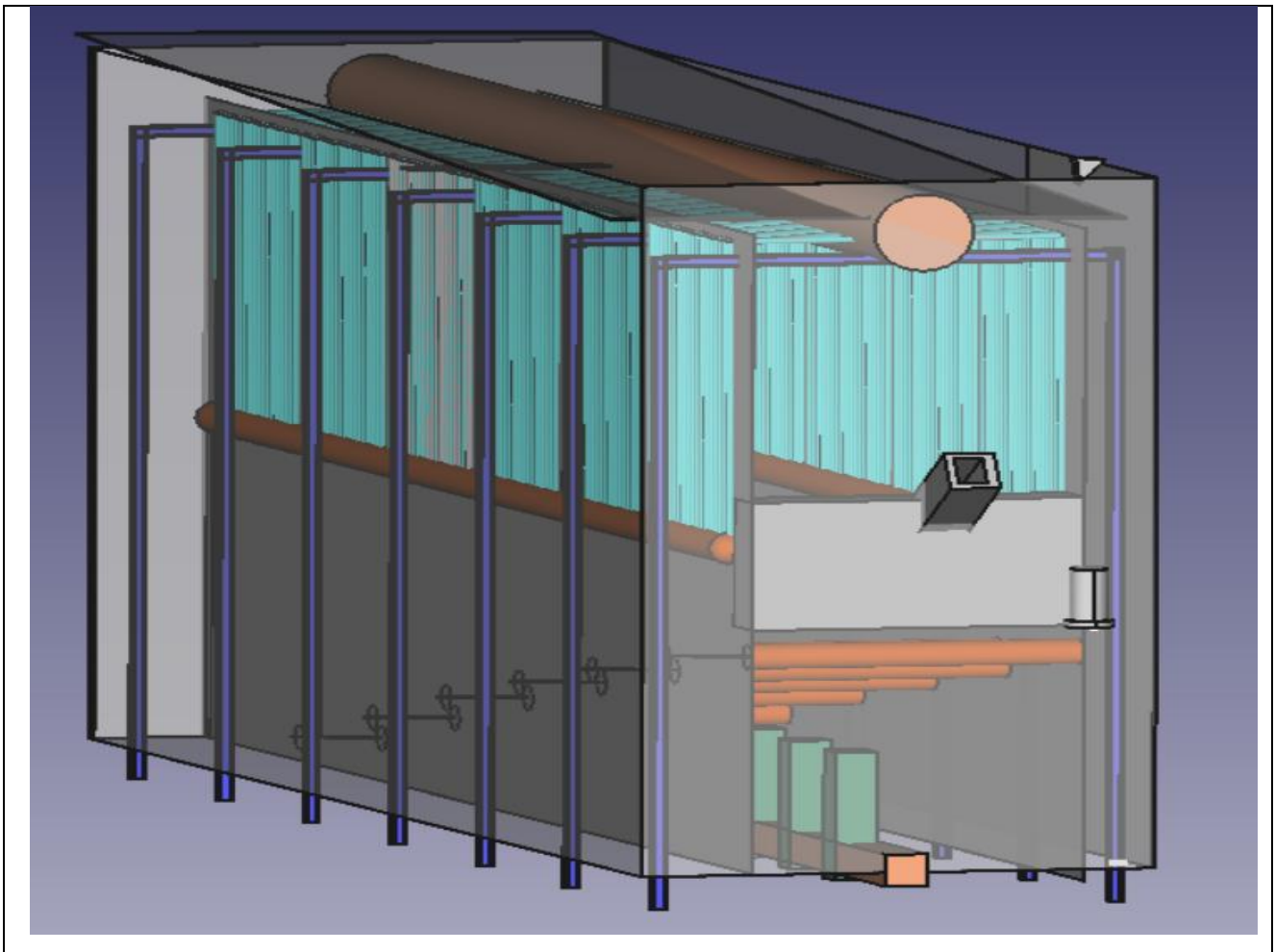
- 30 sheets (1:2 m) with thickness 4 mm
- 12 sheet (1:2 m) with thickness 4 mm
- 12 sheet (1:2 m) with thickness 4 mm to the incinerator
- sheet should be steel or stainless 306
- vaporiser : tube (rad=4", length 12 m)

Tube: between condenser and turbine :

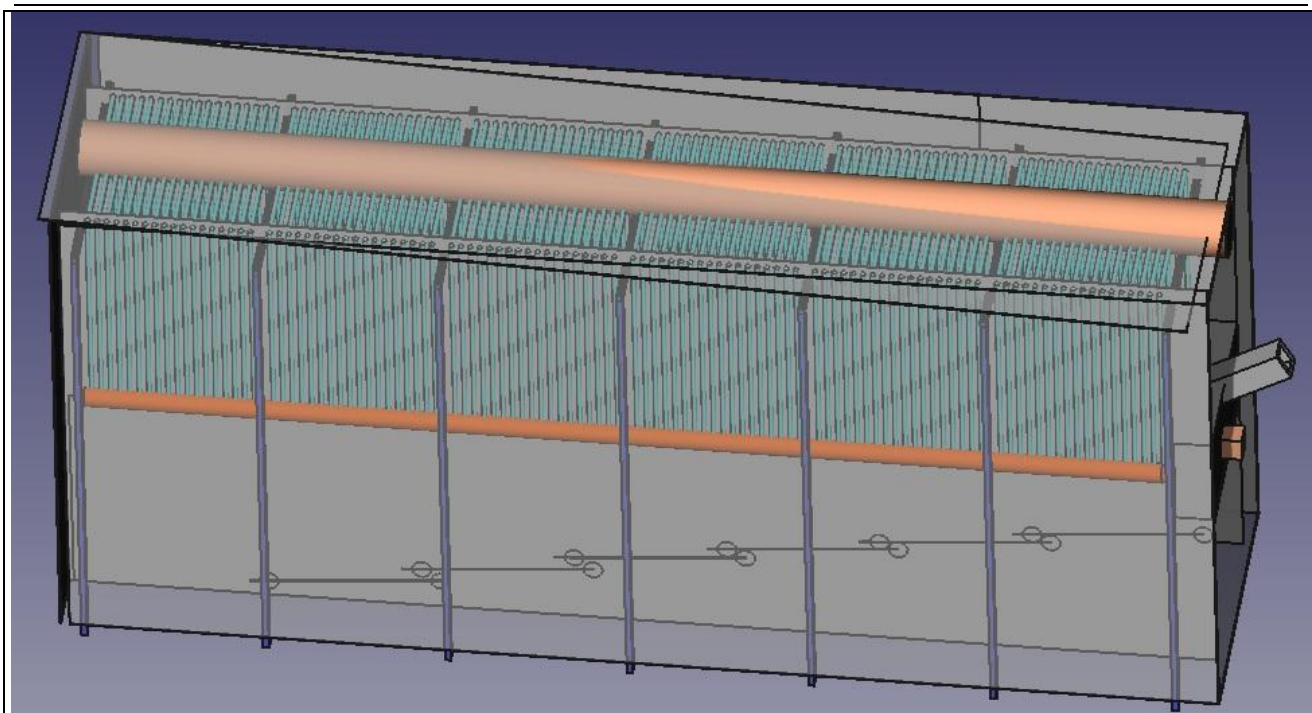
2 tubes: length (6m), diameter: 4 inch

tube between pressure and turbine: length (6m), diameter (2 inch)

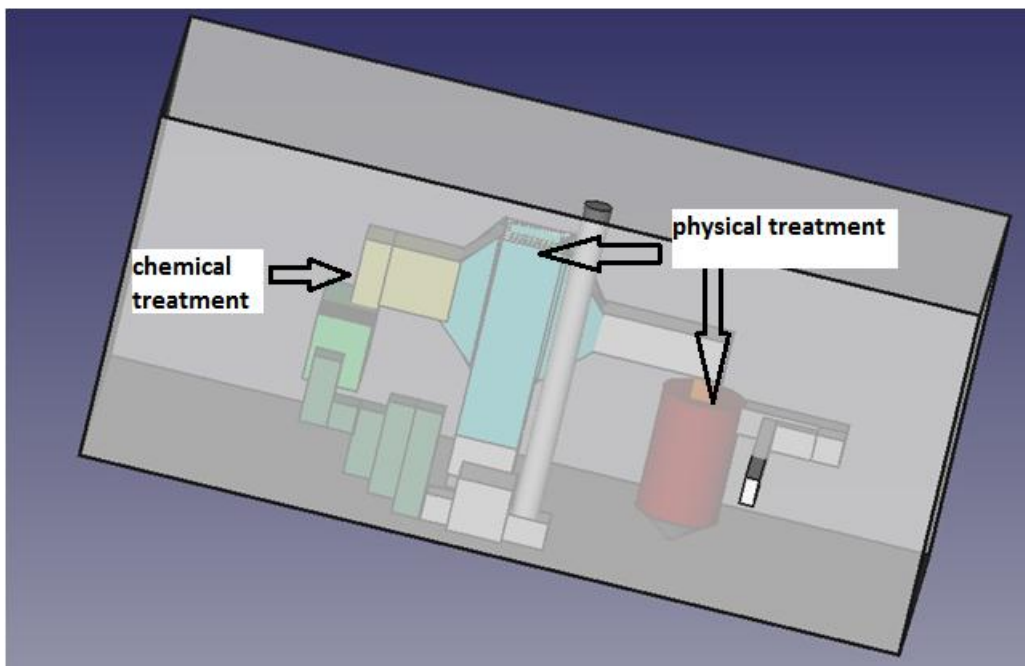
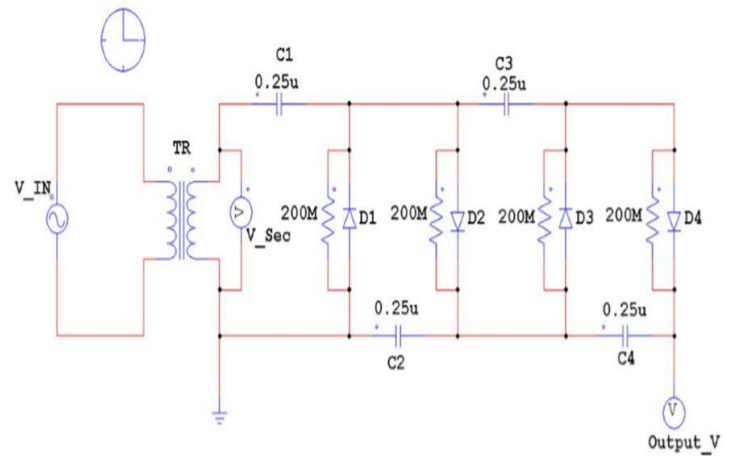
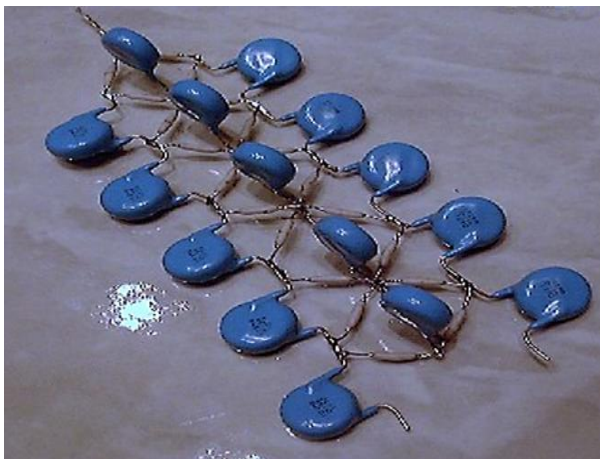
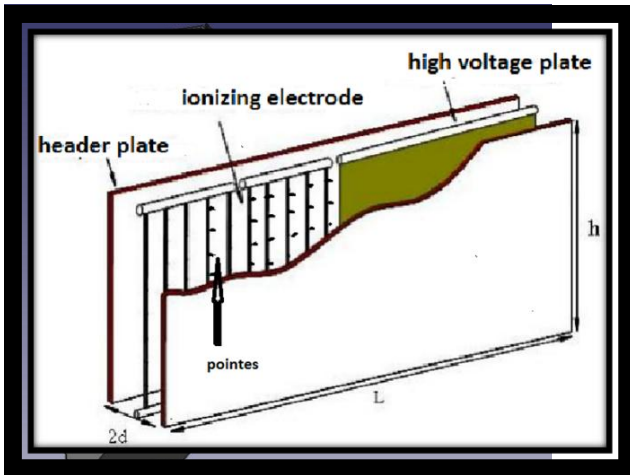
Pressure vessel: length: 12 m, diameter: 0,6 m, thickness: 16 mm (or more)



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27-11-16_1.5MWel_i
ncinerator.FCStd



انظر "Master Thesis Maysaa Kamareddine, 2016"

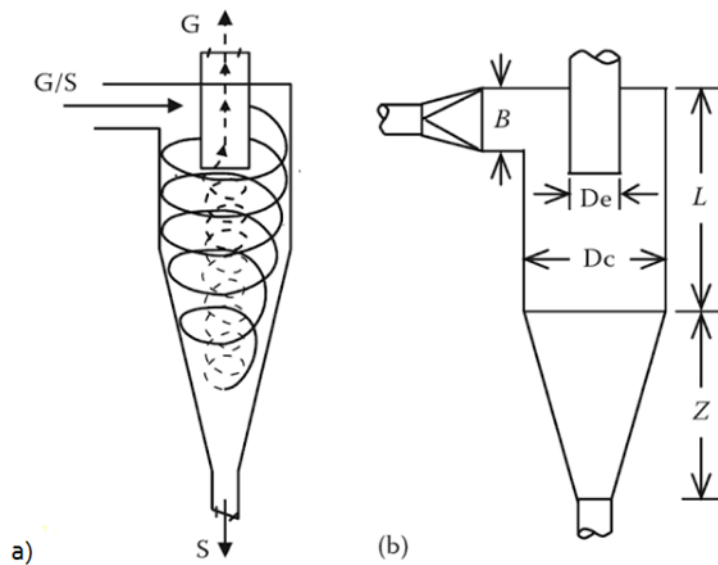
8.1 ESP¹⁵

Quality	عرض (متر) Width	طول (متر) Length	العدد Quantity	السماكة (مم) thickness
حديد مزيبق Iron quicksilver	1	2	6	0.5
فولاذ steel	1	2	1	5
قضيب نحاس Copper rod	قطر 6 مم	0.8	43	-

Inlet, outlet of ESP: 2 sheet (1:2m)

Chimney: 2 sheet (1:2m)

Cyclone: 2 sheet (1:2m) iron quicksilver



a) Flow pattern in cyclone separator. (b) Standard cyclone dimensions. S, solids; G, air; D_c , cyclone diameter; $2D_c$; $B = D_e = D_c/2$.

8.2 Incineration Tests¹⁶

➤ Incineration without plastic

- ¹⁵ Electrostatic preceptor
- ¹⁶ Master Thesis Maysaa Kamareddine, 2016, see www.aecenar.com/publications



Figure 23: beginning of combustion

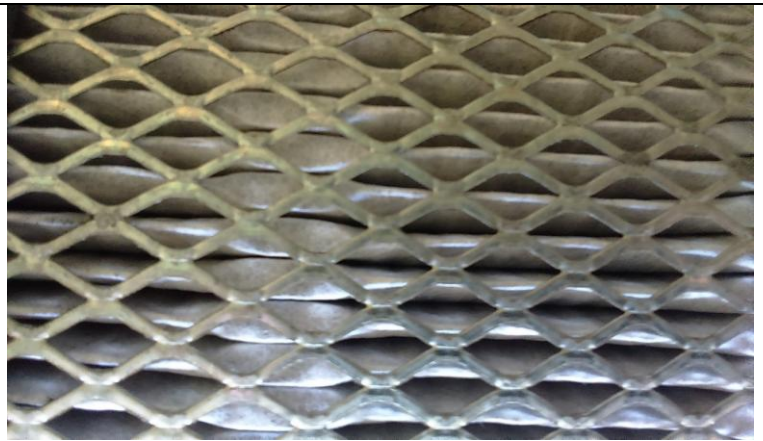


Figure 24: filter media after treatment



Figure 25: chimney during incineration

Calculation of emissions

$$V_2 = V_1 * (P_1/P_2) * (T_2/T_1) * (Z_2/Z_1)$$

Converting to uniform units

$$V_1 = 314.000 \text{ Nm}^3/\text{h}$$

$$P_1 = 1.000 \text{ atm}$$

$$T_1 = 273.150 \text{ }^\circ\text{K}$$

$$T_2 = 323.150 \text{ }^\circ\text{K}$$

$$P_2 = 1.000 \text{ atm}$$

P1, T1 normal conditions

P2, T2 specification for exhaust

Z1=1 (ideal), Z2=1.01(at 1 atm): Compressibility Factor

Calculation for V2

$$V_2 = 314.000 * (1.000/1.000) * (323.150/273.150) * (1.100/1.100)$$

$$V_2 = 375 \text{ m}^3/\text{h}$$

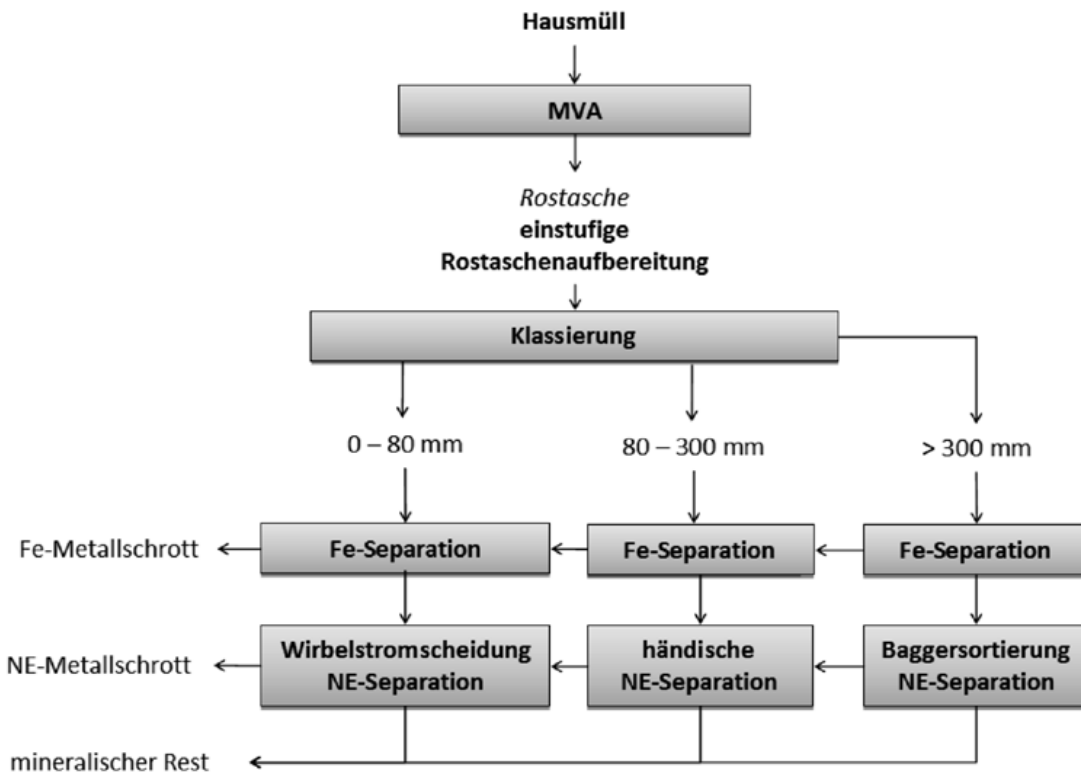
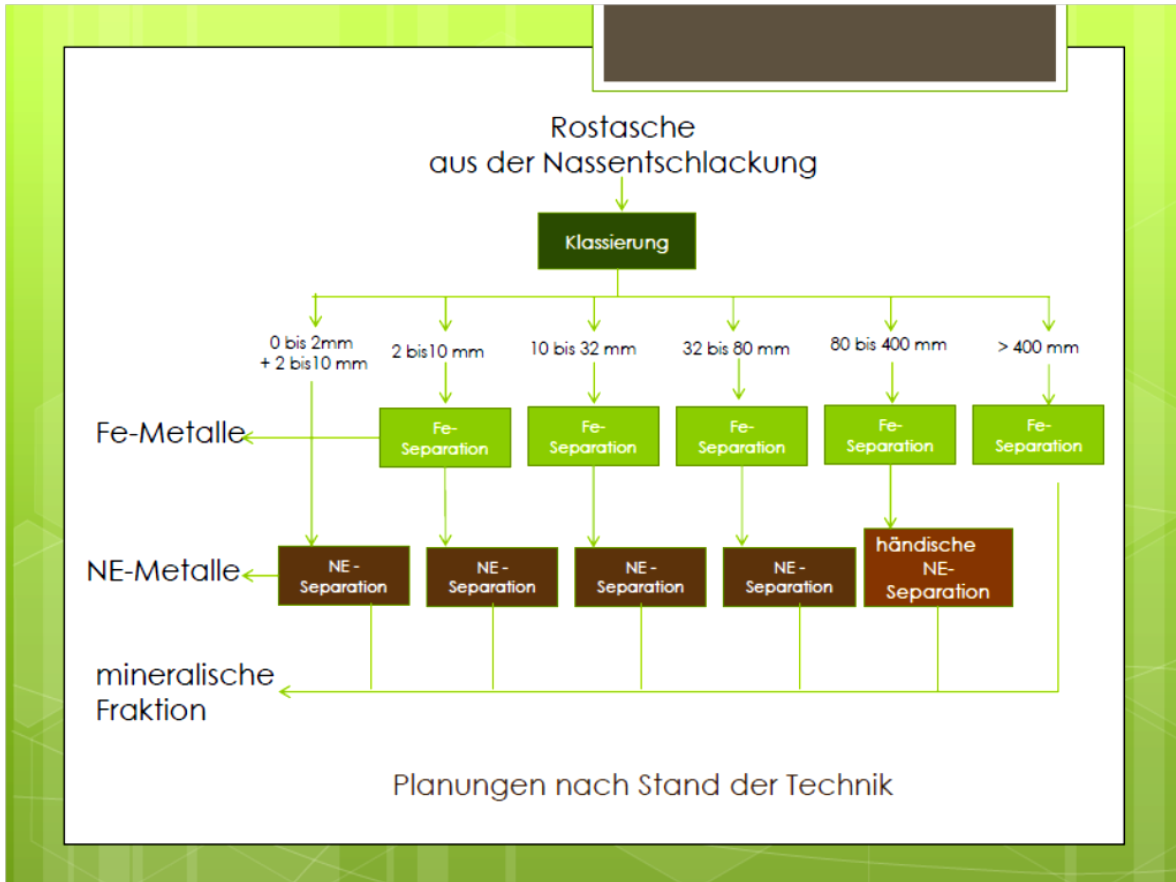
Or mass of filter before treatment =1300 g

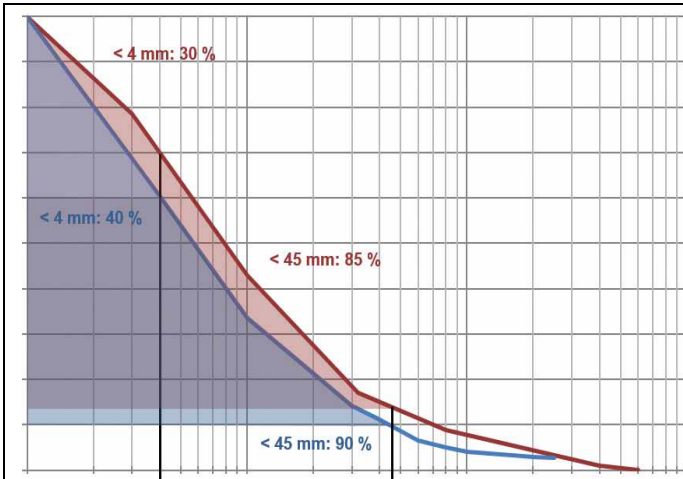
Mass after treatment =1364

The total mass of particulate =1364-1300=64 g

375 m³/h correspond to 64 g

معالجة Thus 170 mg / m³ < 200 mg/ m³ confirm to Lebanese standard (annex D) positive results





Schadstoffe (Alwast)	
Parameter	Wertebereich
Arsen	3 bis 15 mg/kg
Blei	1.000 bis 3.500 mg/kg
Cadium	2 bis 20 mg/kg
Chrom ges.	200 bis 1.000 mg/kg
Kupfer	1.000 bis 10.000 mg/kg
Nickel	100 bis 500 mg/kg
Wertstoffe	
Parameter	Verwertbare Anteile
Fe-Metall	8 %
NE-Metall	2 %
VA-Metall	1 %

توزيع حجم الجسيمات من الرماد: ما بين 0 و 45 مللمتر تشكل 90% من الرماد

Die Metalle sind ferner in die Fraktionen Eisenmetalle (Fe) und Nichteisenmetalle (NE) zu unterteilen.

drei Hauptbestandteile der Rostasche

المكونات الرئيسية الثلاثة للرماد



84% معادن (minerals)

(وما لم تغيره عملية الحرق مثل بطون ، حجر،

ارميد، ...)

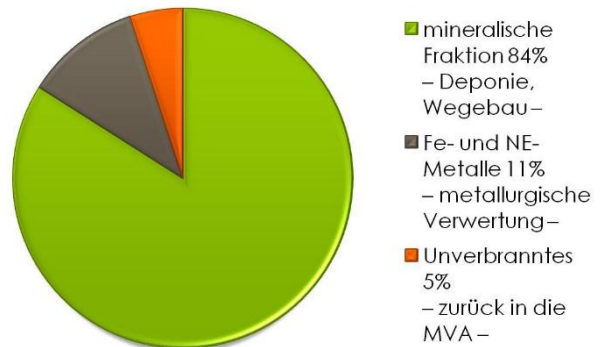
10% حديد (و الومينيوم، نحاس)

(Unter den Metallen sind eisenhaltiger Schrott, Aluminium, Kupfer und Messing vorhanden)

Im Hinblick auf eine spätere verfahrenstechnische Aufbereitung ist Rostasche in drei Hauptbestandteile aufzuteilen. Hierbei können aufgrund der Inhomogenität der Inputmaterialien nur Schwankungsbreiten angegeben werden. Das Bild 2 zeigt die beispielhafte Zusammensetzung aus uns vorliegenden Materialansprachen.

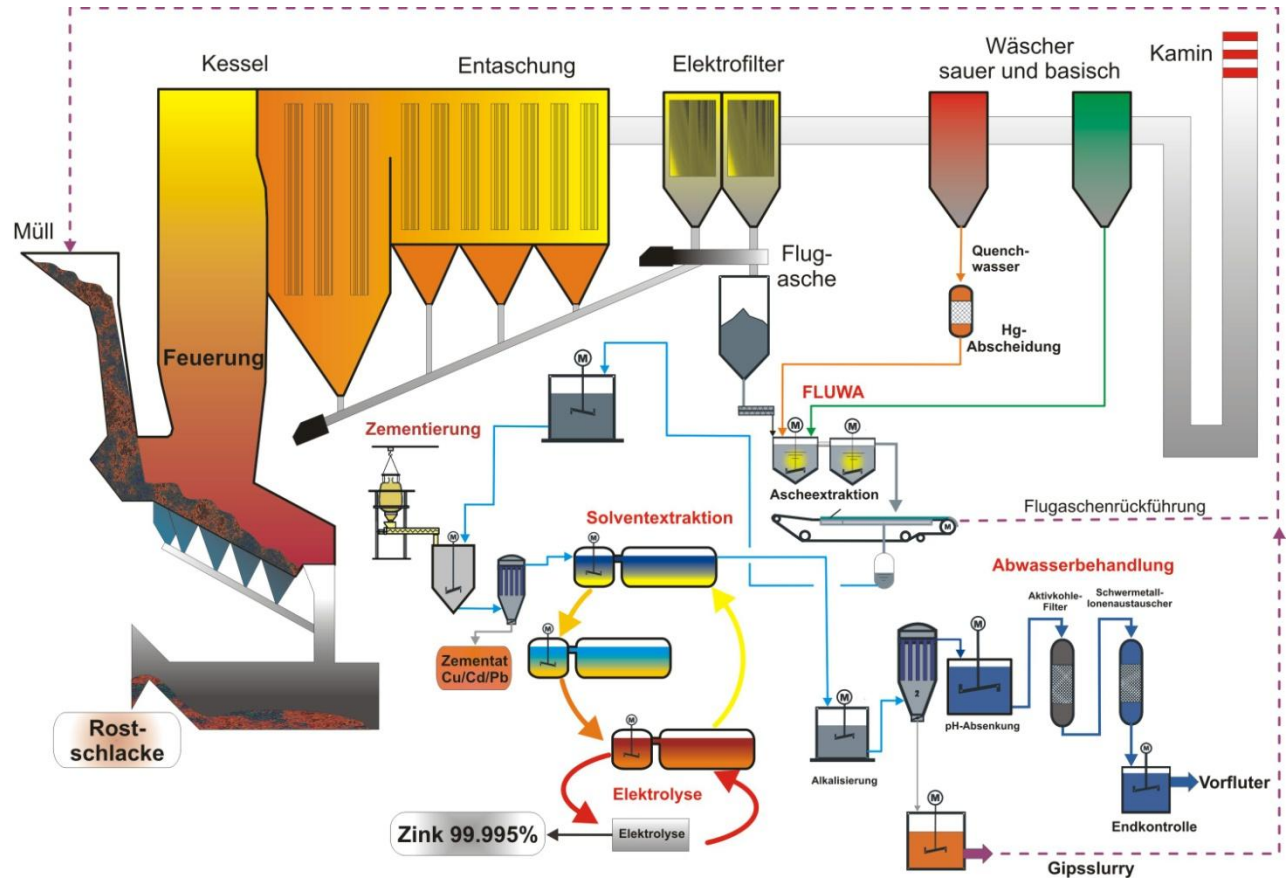
VA-Metall = Rostfreier Stahl (stainless steel)

Inhaltsstoffe von Rostaschen

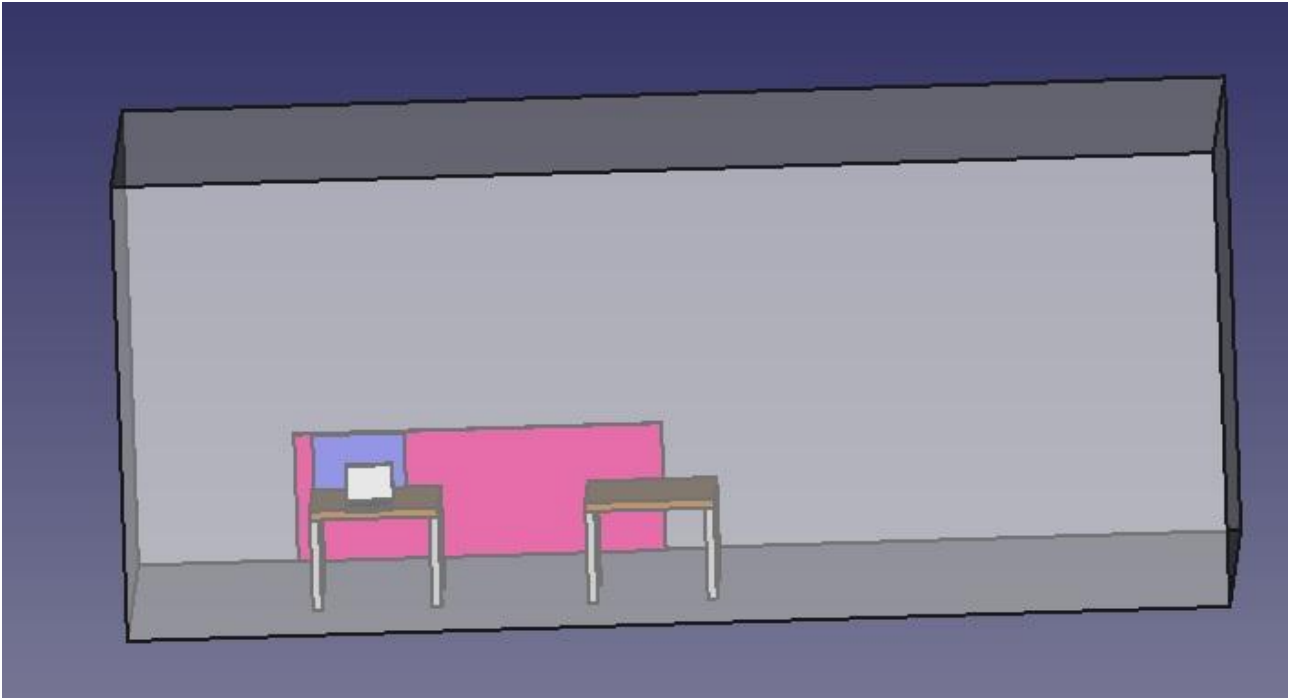


(5% لم يحرق ولكن قابل للحرق و يعاد الى المحرقة
 (مثل خشب، ورق، ثياب، ...)

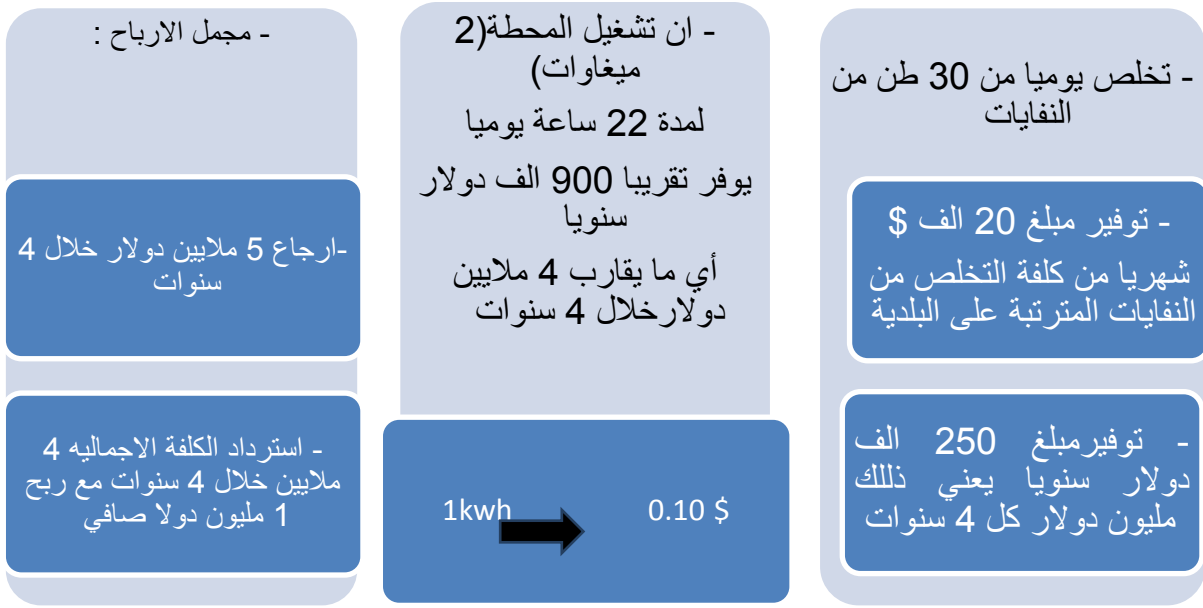
9.2 FLUREC/FLUWA



Chemical ash recycling



11 ارقام مالية وايجابيات لمشروع بناء وتشغيل محطة طاقة 1.5MW عن طريق حرق النفايات



12 المواد الاولية التي نحتاجها لبناء محطة 1.5MW

				prix(\$/6m) stainless 306	steel(\$/6m)	total (\$)
incinerator	number	rad(inch)	length			
vertical tubes	216	2	2.5		50	\$4,500
horizontal tubes	216	2	1			
sheet for v.tubes	30	4 mm thic	(1:2 m)		70	\$2,100
sheet for h.tubes	12	4 mm thic	(1:2m)		70	\$840
sheet for inciner	12	6 mm thic	(1:2m)		70	\$840
tube for vaporiser	1	4	12		100	\$100
condenser						
tubes	530	1	6 m	120		\$63,600
tube	1	12	6 m			
water tank						

13 Suppliers

تصنيع قطع (...CNC and others instruments)

Company	Phone number	Description	Address	E-mail web site
CNC LAB	06 412 895 03 476 916	Manufacture 3D design in plastic & open source hardware	Tripoli, Lebanon Bahsas, Behind Haykalieh Hospital, Harba Bld.	www.cnclab.com info@cnclab.com
Hasan Al Baba	03 828 256	Manufacture and casting	Tripoli, Lebanon Mina, Industry and Commerce street	
HI-Tech fabrication Fawaz Abdel Hadi	06 442 787 70 751 522	Precision mechanical parts manufacturing brass & steel marking heads maker	Tripoli, Lebanon Mahjar suhi P.O. Box 1274	www.hitechfabrication.com info@hitechfabrication.com sirfawaz@yahoo.com
Hannuf mechanical 'Corporation for casting and art construction	06 387 723 03 717 107	Manufacture and casting	Tripoli, Lebanon Al Badawi	
GPS Steel	03 196 225	Uses electric discharge machining process to shape any metal material rapidly by using desired modeled electrodes	Beirut, Lebanon Burj Hammoud	Gps.steel.co@gmail.com
Riyako factory	79 118 779 03 302 869	3D CNC machine, manufacture cupboard for cars	Tripoli, Lebanon Badawi, behind Al Ridani bakery	Zaher23357@gmail.com