International Journal Science and Technology
IJST Vol 2 No. 1 March 2023 | ISSN: 2829-0437 (print), ISSN: 2829-050X (online), Page 48-53

CONSTRUCTION DESIGN FOR 4.5 BAR WATER TUBE TYPE BOILER USING SOLIDWORKS 2018 SOFTWARE

Ariyanto
Department of Mechanical Engineering, Faculty of Industrial Technology, Gunadarma University, Indonesia

ABSTRACT

Distillation or simple distillation uses the principle of separating two or more liquids based on differences in the boiling points of each component. The distillation process itself has two main stages, namely the evaporation stage and the condensation or condensation stage. Therefore, distillation equipment uses a heating device in the form of a boiler and a cooler in the form of a heat exchanger. In the refining process, the heart of the distillation system lies in the boiler as a steam producing component. Therefore, the effectiveness of the boiler to produce saturated steam greatly determines the results of the refining process. To determine the power of the boiler, it is necessary to analyze the Boiler simulation calculations which include Von misses, displacement and safety factor simulations. The simulation is carried out at a pressure of 4.5 Bar which produces a Von misses max value. of 3.444 MPa, with the highest displacement value of 0.002 mm and the smallest value of 0 mm, and produces a safety factor value of 75. With this safety factor value, it can be said that the frame construction is safe.

Keywords: Boiler water tube, Von misses, Displacement, Safety factor.

INTRODUCTION

Indonesia itself is one of the largest producers of spices in the form of cloves in Asia which utilizes parts of the clove plant to be used as cooking spices, cosmetics and even medicines. In processing the parts of the clove plant, for example, clove leaves which are processed into oil, several methods can be used, one of which is distillation or evaporation. Distillation or simple distillation uses the principle of separating two or more liquids based on differences in the boiling points of each component. The distillation process itself has two main stages, namely the evaporation stage and the condensation or condensation stage. Therefore, distillation equipment uses a heating device in the form of a boiler and a cooler in the form of a heat exchanger. In the refining process, the heart of the distillation system lies in the boiler as a steam producing component. Therefore, the effectiveness of the boiler is great for producing very saturated steam

Determine the results of the distillation process. Fuel to Steam efficiency is the performance level of a boiler or steam boiler obtained from the ratio between the energy transferred to or absorbed by the working fluid in the boiler with the input of chemical energy from the fuel. The distillation process begins by heating the water until it evaporates in the boiler, then the steam enters the evaporation tank in which there are clove leaves of a predetermined weight, so that the oil in the leaves evaporates due to the temperature pressure from the steam produced from heating the water in the boiler, then steam flows into the condenser for condensation (condensation). The condensation process itself occurs due to flowing water to the wall (outside the condenser), so that the steam produced will return to 2 liquids. After the steam becomes liquid, the steam enters the oil separator to separate the existing oil and water. This process continues, and finally all the compounds in the liquid can be separated.

Harvest of cloves Clove plants (Syzigium aromaticum) are native Indonesian spices and are used in the cigarette, food and medicine industries. Clove plants can produce waste such as the stem and especially the leaves. The clove leaves are only allowed to fall scattered and scattered until they rot. Clove plants are found in eastern Indonesia, for example in North Sulawesi. This plant belongs to the Myrtaceae family which is found in the lowlands with an altitude of 1 - 900 m above sea level. The height of the clove plant can reach 5 - 10 m. The 5 cloves plant has unique properties because all parts of the tree contain essential oils, starting from the roots, stems, leaves to. According to Tjitrosoepomo (2005) Clove plants (Syzigium aromaticum) in plant systematics (taxonomy) are classified as follows:

Kingdom	: Plantae	Division	: Magnoliophyta
Class	: Maglionopsida	Order	: Myrtales
Family	: Myrtaceae	Genus	: Syzigium
Species	: Syzigium aromaticum		

Clove leaves have characteristics that are easy to distinguish from other plant leaves. The leaves are stiff, green or reddish green, young leaves are yellow-green mixed with reddish and shiny colors, elliptical in shape with sharp edges while the underside is opaque green. Single leaf and sit opposite. The axillary node of the first branch leaves shoots which become the second branch, and so on so that branches grow.[1]

Figure 1. Clove

RESEARCH METHOD

Clove leaf oil

Clove leaf oil is obtained by steam and water distillation of the fallen leaves of the clove plant Eugenia carophyllata Tumberg. Clove leaf oil contains two main components, namely eugenol with a content of around 80-85% and karyofilen around 10-15%. In addition to these two main components, there are components whose quantity is relatively small, namely alpha kubeben, alpha kopaen, humulen,

Since clove oil contains some aceteugenol (eugenol acetate), in addition to free eugenol, it is customary to saponify the former and report the total phenol content as eugenol.

Table 1. Clove Oil Quality With Different Refining

	Water Distillation Method	**Steam Distillation Method**
Density 15°	1,048 to 1,055	1.059 to1,065
Eugenol content (per volume)	85 to 89%	91 to 95%

Classification of Boilers

Boilers basically consist of a closed drum at the base and in its development are equipped with fire pipes and water pipes.

A. Based on the Relative Position Between Steam and Water

1) Fire-tube boiler In a fire-tube boiler, the fluid flowing in the pipe is flame gas (combustion product), which carries thermal energy, which immediately transfers to the boiler water through the heating surface. The purpose of these fire pipes is to facilitate the distribution of heat (heat) to the boiler water.

Figure 2. Boiler FireTube

2) Water-tube boiler In a water-tube boiler, the fluid flowing in the pipe is water, while outside the pipe is flame gas (combustion product), which carries heat energy (thermal energy), which immediately transfers it to the water. boiler through the heating surface.

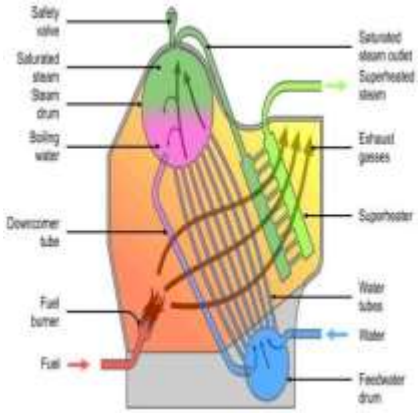


Figure 3. Boiler Watertube

B. Based on Water Circulation Method

1) Boiler with natural circulation (natural circulation steam boiler). In a natural circulation boiler, the circulation of water in the boiler occurs naturally, namely light water rises while heavy water falls, so that natural convection flows occur. Generally the boiler operates in natural flow.
2) Boiler with forced circulation (forced circulation steam boiler). In a forced circulation steam boiler, the forced flow is obtained from a centrifugal pump driven by an electric motor, for example. Forced flow systems are used in high pressure boilers.

C. Based on Work Pressure

1) Low-pressure boiler: has a pressure of 15 - 20 Bar
2) Medium-pressure boiler: has a pressure of 20-80 Bar.
3) High-pressure boiler: has a pressure of more than 80 Bar.
4) Sub-critical boiler: The critical point of a boiler is a condition where boiler water vapor reaches a temperature of 560°C at a pressure of 221 Bar. If a boiler works under these conditions, the boiler is called a subcritical boiler. Usually subcritical boilers are designed to work at a pressure of 160 Bar and a steam temperature of 540°C.

Tools and Materials for Watertube Boiler Design

In the process of designing the Boiler Watertube tool, tools and materials are needed to support the process. The following are the tools and materials used for this design process.

A. Tools

1) Computer to design and simulate Boiler Watertube tools
2) Thermocouples to measure the temperature of the fluid
3) Thermometer display as a tool to display temperature information detected by the thermocouple.
4) The thermometer gun is used to measure the temperature of the combustion chamber

B. Materials

1) Material ½ inch copper as raw material for making tubes
2) Stainless Steel material as a raw material for making boiler walls
3) LPG gas as boiler fuel
4) Water as a fluid that is evaporated

Watertube Boiler Design

The designed boiler is of the watertube type with seven tubes per row arranged in parallel, which in construction consists of:

1. Tube which has a diameter of 12.7 mm and a length of 320 mm made of copper material which is connected with a U-bend tube to facilitate connection and welding.
2. The boiler wall is designed using iron plate material with specifications of length 300 mm, width 300 mm, height 200 mm, and plate thickness of 1 mm. For perforated plates the size of the diameter outer tube with a tube pitch of 50 mm and an inclination angle between tubes of 36.87°. In the design of the watertube boiler module, there are seven tubes for one row, where to fulfill the plane of the boiler wall, seven rows of tubes are needed in series, so that there are a total of 49 tubes.

Design of Water Tube Boiler Equipment the Boiler Water Tube design consists of:

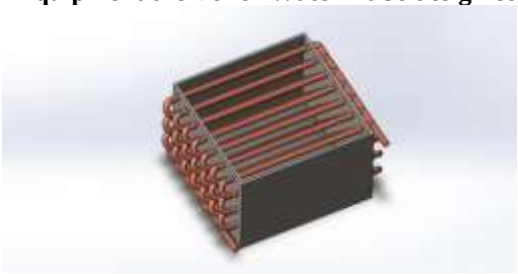
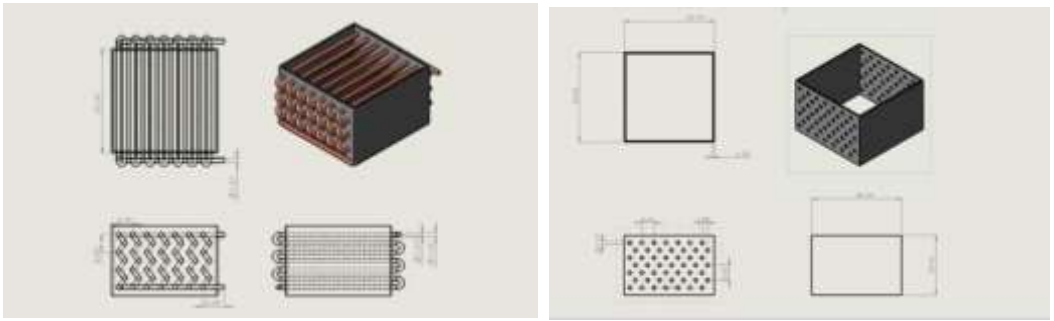


Figure 4. Water Boiler Tube



a) **b)**

Figure 5. a) *Tube*, **b)** Boiler Wall

Clove Leaf Distillation System Scheme

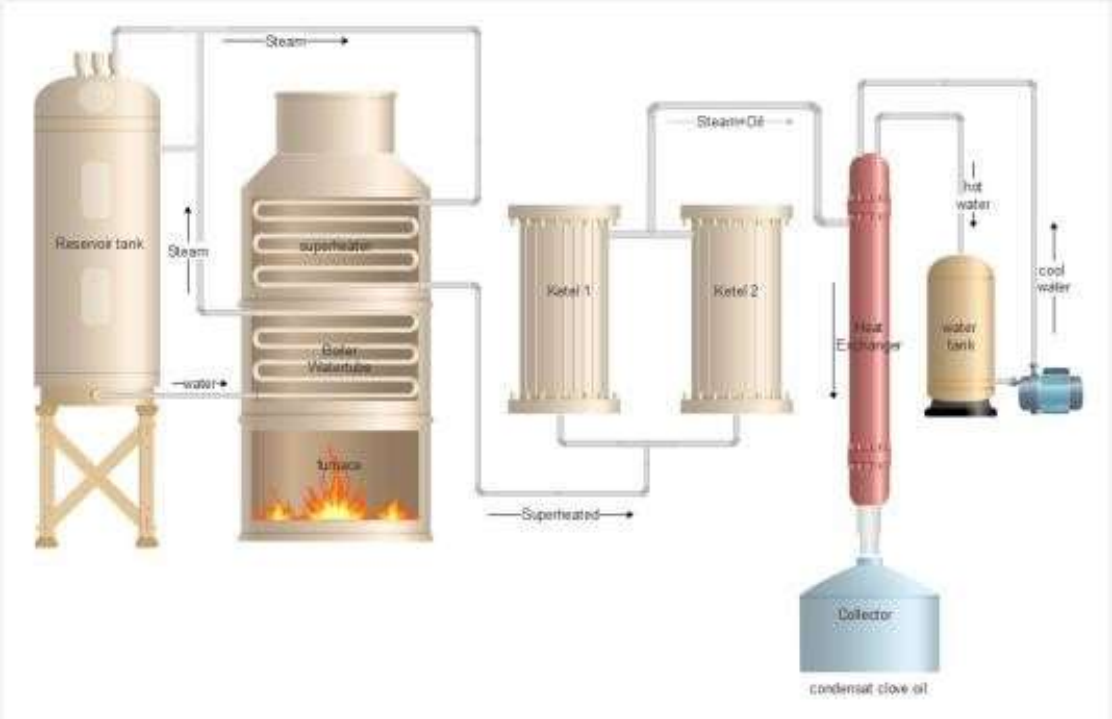


Figure 7. Clove Leaf Distillation System Scheme

Clove Leaf Distillation System Analysis Based on the watertube boiler design that has been done, then the implementation process for the clove leaf distillation system that has been made is carried out. It is hoped that the design of a watertube boiler can maximize the distillation process from clove leaves.

Boiler Water Tube Component

Analysis Boiler Water Tube analysis was carried out using solidworks 2018 software and also using the calculations that have been included in the literature review to obtain data that will later be entered into the solidworks analysis software.

Figure 8. Analysist Boiler water tube

For the material itself, the boiler uses two kinds of materials, namely for the boiler wall using AISI 304 Stainless Steel Sheet (ss) 22 because it is rust-resistant, strong, durable and resistant to high temperatures, and is very suitable for small industries because the price is quite affordable.

Property	Value	Units
Mass Density	8000	kg/m^3
Tensile Strength	394380000	N/m^2
Compressive Strength		N/m^2
Yield Strength	258646000	N/m^2
Thermal Expansion Coefficient	2.4e-05	/K
Thermal Conductivity	390	W/(m-K)
Specific Heat	390	J/(kg-K)
Material Damping Ratio		N/A

Figure 9. Material AISI 304 Stainless Steel Sheet (ss)

And for the second material, namely cooper or copper because it has very good heat conduction properties.

Property	Value	Units
Elastic Modulus	190000	N/mm^2
Poisson's Ratio	0.29	N/A
Shear Modulus	75000	N/mm^2
Mass Density	8000	kg/m^3
Tensile Strength	517.017	N/mm^2
Compressive Strength		N/mm^2
Yield Strength	206.807	N/mm^2
Thermal Expansion Coefficient	1.8e-05	/K
Thermal Conductivity	16	W/(m-K)
Specific Heat	500	J/(kg-K)

Figure 10. Material Cooper or Copper

Watertube Boiler Specifications

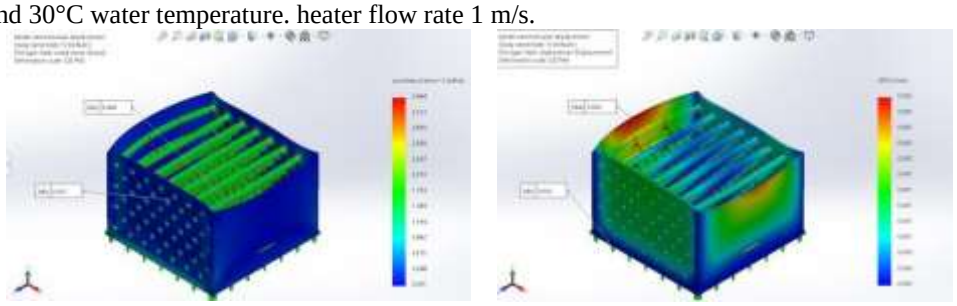
In this design, it calculates the Boiler Watertube directly, using a type of copper material for the tube sides. The initial data for calculating the design of this watertube boiler include:

1. Fluid inlet temperature (air) (Tl) : 30°C
2. Fluid outlet temperature (steam) (Tv) : 133.5°C
3. Incoming fluid pressure = outgoing fluid (P) : 4.5 sticks
4. Planned Mass Flow (ṁ) : 34 kg/hour
5. Dimensions of the boiler body, L x W x H (mm) : 300 x 300 x 200
6. Tube Diameter (d) : 12.7 mm (1/2 in)
7. Planned efficiency (η) : 65%

RESULT AND DISCUSSION

Before carrying out a simulation using Solidwork Design, it must be assembled first and there must be no problems with the design parts.

The simulation is divided into 2 parts, the first part is Displacement and the second is the Safety Factor simulation of water flow in the tube by entering parameter data in the form of 4.5 bar water pressure, 0.5 m/s flow rate, and 30°C water temperature. heater flow rate 1 m/s.



a) **b)**

Figure 11. a) Von Misses Stress, b) Displacement

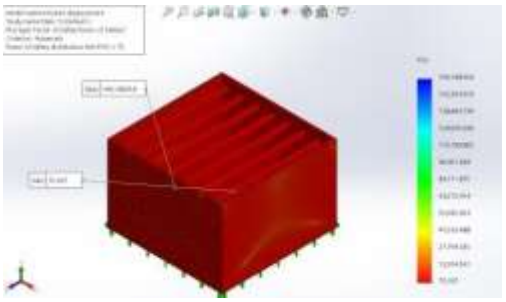


Figure 12. Safety Factor

After the simulation based on the picture above, it can be seen that the Boiler Water Tube pipe material is given a pressure of 4.5 bar or 65.267 psi and Von Mises is simulated with a maximum value of 3.444 MPa and then displacement is still below the maximum value of 0.002 mm. And for the safety factor simulation value of 75.

CONCLUSION AND SUGGESTIONS

Conclusion

From the results of this writing several conclusions can be drawn, including the following: The Boiler Water Tube material for clove leaf distillation uses 2 types of materials, namely for the Tube itself using copper or Cooper material and for the Boiler wall using AISI 304 Stainless Steel Sheet (ss). After the simulation based on the image above, it can be seen that the Boiler Water Tube pipe material and given a pressure of 4.5 bar or 65.267 psi and simulated by Von Mises with a maximum value of 3.444 MPa then displacement is still below the maximum value of 0.002 mm, and for the safety factor simulation value of 75.

Suggestion

The following are suggestions for processing the watertube boiler design data, including:

1. To get maximum results and precision, it is necessary to add parameters to determine the performance of this steam boiler.
2. In the process of initiating a design, it must go through a calculation process first to reduce design errors.

REFERENCES

[1] Ike Ridha Rusnani, 2012, Pengaruh Pemotongan Akar Tunggang Bengkok Terhadap Pertumbuhan Bibit Cengkeh (Syzygium aromaticum), Universitas Muhammadiyah Surakarta. ArangSampah Organik, CV IRDH

[2] Yohana E dan Askhabulyamin, 2009, Perhitungan Efisiensi Dan Konversi Dari Bahan Bakar Solar KeGas Pada Boiler Ebara HKL 1800 KA, Volume 11, Rotasi [3] Rachmat Subagyo, 2018, Bahan Ajar : Sistem Pembangkit Uap dan Turbin,Universitas Lambung Mangkurat, Banjarbaru

[4] Lalu Mustiadi, 2020, Buku Ajar Distilasi Uap Dan Bahan Bakar Pelet

[5] Sjahrul Bustaman, 2011, Potensi Pengembangan Minyak Daun CengkihSebagai Komoditas Ekspor Maluku, Litbang Pertanian, Bogor