

The Design of Mini Boiler Using Liquefied Petroleum Gas (LPG) for Tofu Home Industry

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Abstract---The tofu home industry in Subang Regency still uses traditional stove with firewood for boiling process. The obstacle which is experienced by the tofu entrepreneurs is the smoke produced from burning firewood can affect the sense of tofu and the smell becomes smell. The purpose of this study is to produce a mini boiler for the tofu home industry so that it can improve the quality of tofu. The research method consists of several stages, namely the process of design, making work preparation, preparation of the tools and materials needed, manufacturing process and assembly of mini boiler components and performance test. The result of the study was created a mini boiler with dimensions outside the body diameter of a mini boiler 32.6 cm, length 80 cm, thickness 4 mm, steam tube diameter 22 cm, length 30 cm and thickness 4 mm, capacity 31.8 liters, the amount of heat generated at burner 41305,567 KJ/hour and heat propagation 2.339928×10^{-2} Cal/s on the burner and $0.66857665 \times 10^{-2}$ Cal/s on the economizer, the amount of fuel needed is 12.7972 kg/hour. After using mini boiler, the quality of tofu is better and does not smell smoke, and is more hygienic because there is no black smoke from the boiling process.

Keywords--- Mini Boiler, Liquefied Petroleum Gas, Tofu, Home Industry

I. Introduction

Tofu is coagulated soymilk and consumed on a wet or dry basis [1]. Dry tofu has high protein content (50%) and fat content (27%), and also contains sufficient amount of carbohydrates and minerals [2]. Tofu can be served as a meat or cheese substitute in more economical, nutritious, and versatile way [3]. Consumption of tofu in Indonesia reached 7.4 kg/person/year [4]. Based on data from the Indonesian Ministry of Industry and Trade (Deperindag), Industry and Trade Subang, the number of tofu small industries in Subang is 160 small industries [5]. Tofu making process generally consists of selecting soybean raw materials, soaking, milling, cooking or boiling, filtering, clotting (clumping), printing, and yellowing. Most home industries in Subang still use traditional methods in the process of cooking or boiling soybeans. The traditional cooking or boiling process of soybeans is heating the soybean porridge in the pan placed on the furnace or stove which is use firewood causing the crust of the soybean porridge on the pan, so that the aroma of tofu produced smells of smoke or called *sangit*. Besides that, the process need a long time so it is not efficient.

To overcome the weaknesses of boiling traditionally can be done with the application of mini boiler where boiling is done indirectly. The advantage of boiling with a mini boiler is that it will not smell because of the smoke of the combustion process. This is due to the furnace/kitchen burning mini boiler can be placed separately away from the

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tofu mixture. Besides this tool is more hygienic, the heating process is also faster, and according to business owners, it feels better. Therefore, the objective of this was to design and make mini boiler for tofu home industry.

II. Theory Study

Mini Boiler

Steam boilers are closed vessels especially used for steam generation from water by combustion of fuels (i.e., coal, gas and nuclear etc.). Most of production processes utilize this high pressure and high temperature steam (like for generation of power and heating substances etc.) [6]. There are various selection criteria of steam boiler in the market. Selection of a most suitable industrial boiler for a particular plant and fulfill all the process demands is one of the important tasks to achieve the goal of cost reduction and better performance. While selecting alternative, a clear understanding of the performance of various types of boilers with precise functionalities is required and various important criteria's are needed to be considered. An improper selection can negatively affect the plant performance, productivity, profitability and reputation of an organization [7]. The advantages of mini boiler are easy to operate, accept wide load fluctuations and because they can handle large of water, produce less variation in steam pressure [8]. The standard of mini boiler construction according to Indonesian National Standard (SNI) 05-6702-2002. SNI parameters for designing and developing mini boiler that is: normative references, material, design, welding, washout opening, feed water supply, blowoff, water gauge, fixture and fitting, pressure relief valves, steam stop valves, automatic devices, hydrostatic test and inspection. The requirement for mini boiler applies to boilers that do not exceed the following limits: 16 in. (400 mm) Inside diameter of shell, 20 ft² (1.9 m²) heating surface (not applicable to electric boilers), 5 ft³ (0.14 m³) gross volume, exclusive of casing and insulation [9].

Liquefied Petroleum Gas (LPG) Fuel

Liquefied petroleum gas, known as LPG is used as an alternative fuel for vehicles with a combustion engine. LPG is a mixture of propane, butane and other substances of a small amount and it is obtained as a by-product of being manufacturing during the refining of petroleum [10]. The mixture of propane and butane is colorless and odorless [11]. LPG has higher octane number than petrol it is 106 up to 110. LPG has energy value is 45 MJ.kg⁻¹ and it has a density of 0.55kg. l⁻¹. LPG is gaseous form which is heavier than air and lighter than water as liquid. LPG is a mixture of propane, butane and other substances of a small amount. Propane and butane mixture is liquefied by cooling to a low temperature or by compressing. When being liquefied, the mixture's volume is reduced 260 times in comparison with gaseous phase. LPG is obtained during natural gas and oil extraction, or as a by-product of being manufactured during the refining of petroleum. The main substances of LPG are propane and butane. Propane - C₃H₈ is a saturated hydrocarbon with an energy value of 46 MJ.kg⁻¹ and calorific value of 11,070 kJ.kg⁻¹. Butane - C₄H₁₀ is highly inflammable and easily liquefiable gas with an energy value of 45 MJ.kg⁻¹ and calorific value of 10,920 kJ.kg⁻¹. LPG is not toxic, however, it is unbreathable with slightly toxic effects[12].

III. Research Method

The purpose of this study was to design mini boiler using LPG for home industry so that can improve the quality of tofu and its smell good. This research was did at the laboratory of the Center of Appropriate Technology Development, Indonesian Institute of Sciences (LIPI) on April until August 2018. The design process requires a series of

disciplines and a long time [13]. In order to the design specifications match the needs, an analysis of market demand is needed [14]. The steps of this research consist of:

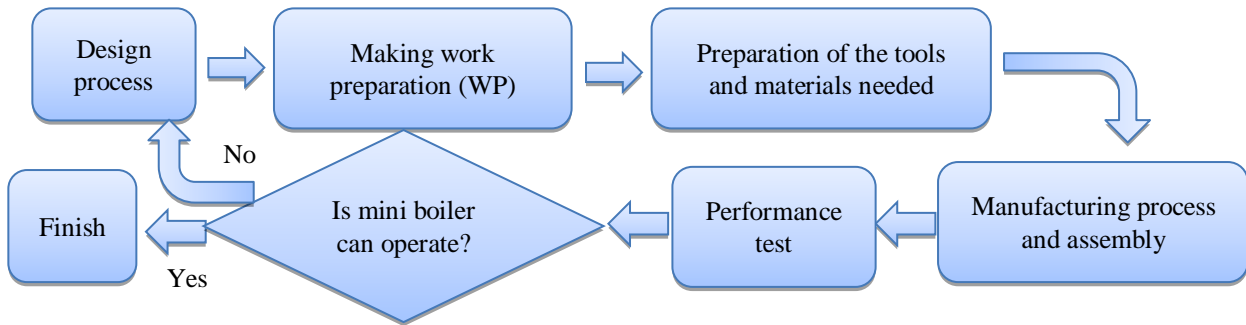


Figure 1. Research Steps

In this study, the design of mini boiler is made based on market needs, which are analysed into market demand design. The design using Autodesk inventor 2015. After the design process, the next step is making work preparation (WP). Work preparation is needed in order to know the steps in the manufacturing process of mini boiler. In work preparation there are work drawings, tools and machines to be used, calculation of cutting parameters, work steps, and occupational safety and health (K3). Then proceed with the preparation of the tools and materials needed. The next step is the manufacturing process and assembly of mini boiler. The manufacturing process is a procedure designed to produce changes to the material work process in order to increase the sale value of the material [15]. After the manufacturing process, the next step is to test engine performance to find out whether it can run well or not. If the mini boiler can work well, then the manufacturing process has been completed, but if it has not been able to work optimally, the weaknesses are analyzed and improvements are made in the manufacturing process to produce an appropriate performance test.

IV. Research Result and Discussion

Mini boiler design

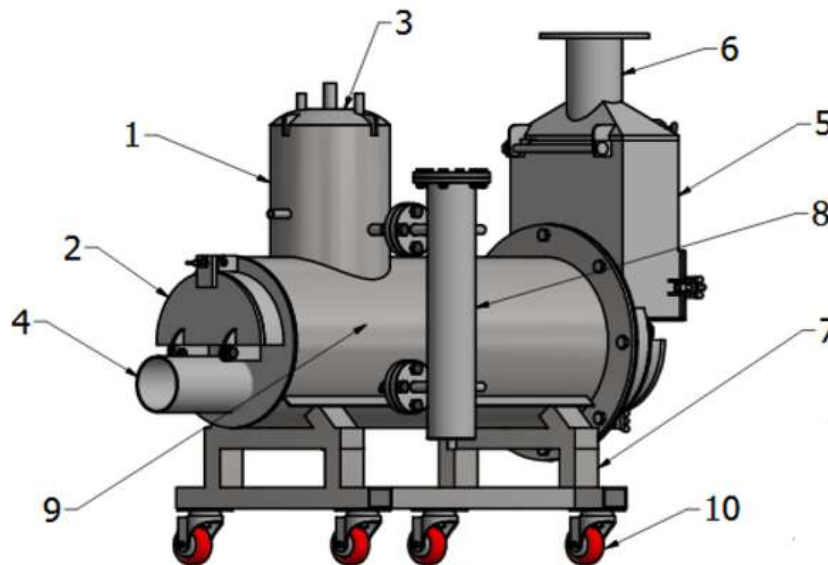


Figure 2. Mini boiler: (1) steam tube, (2) window, (3) steam cover, (4) furnace, (5) economizer, (6) flue, (7) arm, (8) water level, (9) tank, (10) wheel

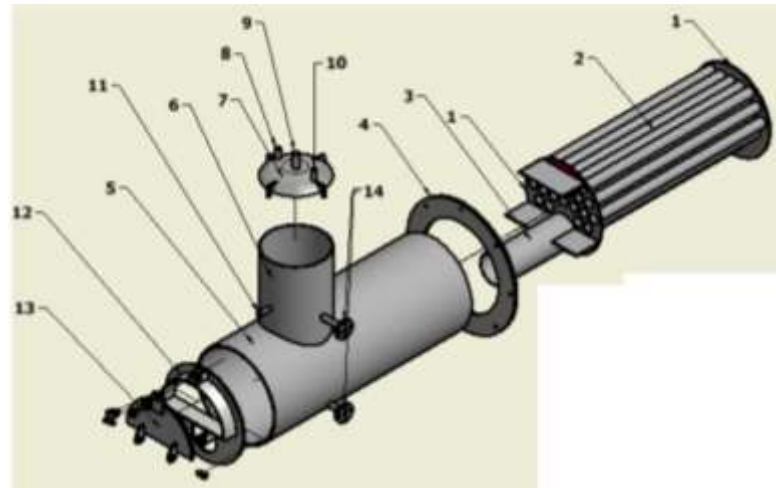


Figure 3. Mini boiler body: (1) tube sheet, (2) Fire pipe, (3) furnace, (4) flank, (5) water tank, (6) steam tank, (7) steam tank cover, (8) socket safety valve, (9) socket output, (10) socket pressure gauge, (11) socket thermometer, (12) tube window, (13) window, (14) flank water level

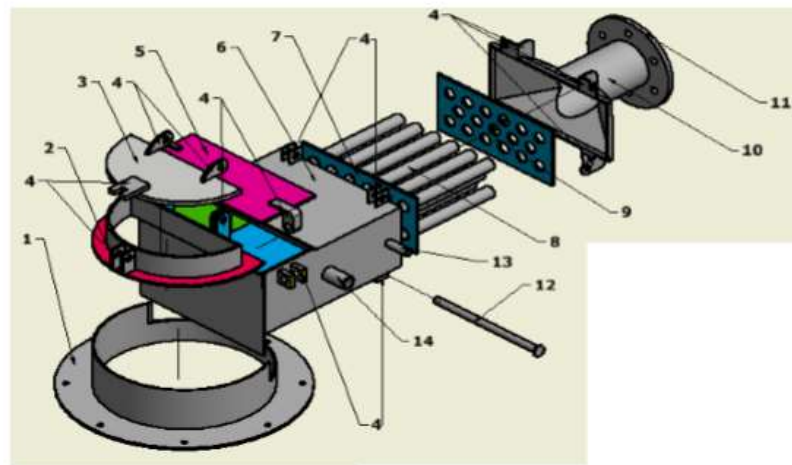


Figure 4. Economizer: (1) flank economizer, (2) tube window, (3) window, (4) switch, (5) window economizer, (6) casing economizer, (7) tube sheet economizer, (8) fire pipe, (9) tube sheet, (10) flue, (11) flue flank, (12) buffer screw, (13) socket input water, (14) socket output water

Manufacturing process

The manufacturing process based to instruction in work preparation (WP). There are several process in manufacturing consists of: cutting, machining, welding and assembly. The result of the study was created a mini boiler with dimensions outside the body diameter of a mini boiler 32.6 cm, length 80 cm, thickness 4 mm, steam tube diameter 22 cm, length 30 cm and thickness 4 mm, capacity 31.8 liters, the amount of heat generated at burner 41305,567 KJ/hour and heat propagation 2.339928×10^{-2} Cal/s on the burner and $0.66857665 \times 10^{-2}$ Cal/s on the economizer, the amount of fuel needed is 12.7972 kg/hour. After using mini boiler, the quality of tofu is better and does not smell smoke, and is more hygienic because there is no black smoke from the boiling process.



Figure 5. Mini boiler

V. Conclusions

The design of mini boiler due to need of tofu home industry. The specification of mini boiler is amount of heat generated at burner 41305,567 KJ/hour and heat propagation 2.339928×10^{-2} Cal/s on the burner and $0.66857665 \times 10^{-2}$ Cal/s on the economizer, the amount of fuel needed is 12.7972 kg/hour. Mini boiler can operated in home industry and make the quality of tofu better than before and the smell is good.

Acknowledgement

The researchers would like to thank to the Center of Appropriate Technology Development, Indonesian Institute of Sciences (LIPI) that has lent the laboratory so we can do the project of this research.

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