Application of Vertical Stainless-Steel Type of Steam Boiler for Home Industry of Tofu

Radi¹, B P Bairawa², R F Putra³, P Triwitono⁴, Marheriyanto⁴

¹. Department of Agricultural and Biosystems Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada
². Bachelor Students at Department of Agricultural and Biosystems Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta
³. Department of Food and Agricultural Product Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta
⁴. Technician at Department of Agricultural and Biosystems Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta

Corresponding author’s email address: radi-tep@ugm.ac.id

Abstract. As a traditional food, tofu is a very popular food for Indonesian people. Tofu is a type of food that is produced from soybeans through a series of stages, one of which is the boiling stage. This stage plays a major role in determining the quality of the results. Although steam tofu technology has long been found with a number of advantages, tofu craftsmen generally still use the traditional method of boiling soybean porridge. This then makes the tofu produced has low quality. This study aims to introduce and observe the advantages of steam boiler technology in improving the boiling process of traditional soybean porridge. The research begins with the manufacture of a vertical fire pipe steam boiler made of stainless steel. The boiler is made with a diameter of 78 cm and a height of 120 cm. The steam boiler is designed with 7 fire pipes equipped with a chimney at the top. The steam boiler is designed and constructed in a laboratory, then applied to a small tofu processing industry with a capacity of 200 kg of dry soybeans per day. The activity of observing the performance of the steam boiler was carried out for several months. The results of the analysis show that: (1) the steam boiler has been functioning properly, (2) producing tofu with the boiler is more efficient, time saving, and cost-effective (less fuel), (3) quality of tofu produced with the boiler is better, especially when viewed from the aspect of taste.

Keywords: steam boiler, tofu processing, efficiency, quality, profits.

1. Introduction
Tofu is a traditional food that contains high quality protein source because there are many essential amino acids [1]. Tofu has a better vegetable protein content than animal protein sourced from meat, milk and eggs. Protein content in tofu is almost equivalent to meat. Tofu is very favored by all layer of society, other than that, it can be made without requiring special skills from someone [2].

To fulfill the need for such tofu consumption, has many emerging industries or small-medium enterprise (SME) of tofu processing. The tofu industry is generally a household scale industry in small towns with not too many workers and less large marketing areas [3]. In this production process, most of the entrepreneurs still using traditional methods, namely heating soybean slurry directly with wood fuel.
The downside to this is that many kitchens emit smoke that can affect the tofu and aroma of tofu (being burnt). In addition, the process takes a long time, where every process is always started from the beginning so that the energy used is not efficient.

To solve these issues, modernization of the tofu processing technology needs to be done. Nowadays, steam technology is seen as a new technology in the process of tofu making. In the process technology, cooking is not done in a furnace that is directly heated but uses a steam boiler to produce hot steam (super-heated steam) that is flowing on the soybean slurry. Hot steam will boil soy slurry quickly without causing yellow crust. In addition, a lot of vapor generated allows the process of heating the soybean slurry can be done in parallel so that it can save the processing time.

The use of steam boiler in the soybean slurry cooking process has been applied by some industries of tofu processing, one of which is in Small-Medium Enterprises (SME) of Tofu Processing "Al-Maaidah" which is a partner of Gadjah Mada University for devotion program to the community based utilization of research and application of appropriate technology in The Joint Venture Group "Campur Mandiri" City of Magelang, Central Java. Utilization of the use of steam boilers can save fuel usage compared with the application of many furnaces in a number of cooking tubs and suppress the need for production water that has the potential to suppress the amount of liquid waste produced.

Thus, the use of steam boilers is very beneficial. To know the benefits of using steam boiler obtained by SME of tofu processing "Al-Maaidah", then conducted research on environmental impacts, quality of tofu, and economics, so it can be known advantages and disadvantages of the use of steam boilers.

2. Material and Methods

2.1. Material

A steam boiler is made in the Laboratory of Energy and Agricultural Machinery especially in Sub-Laboratory of Agricultural Workshop; Department of Agricultural and Biosystem Engineering, Faculty of Agricultural Technology, Gadjah Mada University. Creation of a boiler started with the procurement of construction materials such as a eser plate, iron black pipe, iron water pipes, welding electrodes, and others. Once all materials are ready, then the construction equipment such as plate curvaterware, plate cutter, lathes, welding machines, grinding machines contained in the sub-laboratory is set up. Boiler making starts with cutting according to the size of the kettle plan followed by the scrapers and welding form open tubes. The top and bottom of the tube then covered with eser plate also with the thickness. Especially on the base. After forming the tube, pipe is installed in the middle of the boiler tube according to the types of kettles being contracted. After completion with welding and safety equipment, such as a pressure measuring device (manometer), pressure safety and safety device. The vacuum is also installed along with supporting pipes such as water inlet and steam outlets. After the final, the boiler is then tested installed on the partner program. Construction of a steam boiler is presented in Figure 1. Construction of Steam Boiler.

![Construction of Steam Boiler](image-url)
2.2. Methods

The success indicators of the activity to be measured include:

a. Increased production capability

This parameter will be measured through the observation of the process, especially the cooking process between the use of new technology and traditional cooking for the same capacity. The results observation of the average length of soy slurry cooking time per batches for a traditional cooking process and with a steam boiler. This data is then compared.

b. Efficiency of fuel use

This parameter will be measured through the observation of the amount of fuel used for the soybean slurry cooking process. Amount of fuel for each batch of cooking either traditional or with the boiler will be compared.

c. Quality improvement of Tofu

This parameter will be measured through both physics and chemists observation to the tofu product resulting between traditional tofu processing with tofu produced with a steam boiler. Data analysis results then compared to assessing how much quality improvement the technological introduction.

d. Production water use

In addition to the parameters already mentioned, this activity will also evaluate the use of water for tofu production activities. Parameters is measured to determine if the boiler technology is able to suppress production water usage compared to the cooking process manually. Data on the amount of production water between the traditional with steam technology is then compared.

3. Results and Discussion

The team has managed to create a steam boiler set that has been installed in the tofu industry as an activity partner. Steam boiler installation as in the Figure 2. Steam Boiler Installation. A set of steam boiler consists of:

1) Boiler tubes where the water is heated to the size of diameter 78 cm and height 120 cm.
2) Inside the boiler tube there are 7 fire pipes with diameter 10 cm
3) On the outside of the body is attached: 1) manometer, 2) safety valve, 3) pipe water suspect in the boiler
4) Chimney with height 300 cm
5) Steam conduit pipe with diameter 38 cm
3.1. Specifications of the Steam Boiler

The steam boiler made has specifications as shown in Table 1. Steam boiler type TPD80 has a diameter of 78 cm, with a height of 120 cm, has 7 fire pipes to accelerate the production of super-saturated steam. The steam boiler is designed with a working pressure of 1.5 atm and is capable of producing steam with temperatures between 200 - 240 °C. The boiler is equipped with an automatic water input system that allows the boiler to be operated continuously. In addition, the steam boiler is also equipped with reliable safety in the form of a pressure safety valve to keep the working pressure at a safe limit, as well as a vacuum valve which functions to keep the boiler from being damaged in case of sudden temperature change.

Filling water for the starter as high as 30 cm or about 140 liters. The fuel used to heat the boiler is sawdust. Materials that are processed in one time are 12 kg of dry soybeans. Cooking time, time to open and close the steamer with steam, is 30 minutes per cook. Decrease in the height of the kettle water indicator for one-time cooking is 3.5 cm. One-time filling of kettle water as high as 30 cm can be used for 6 times of cooking. For 10 times of cooking, the kettle must be added 2 times.

### Table 1. Steam Boiler Specifications

| No | Parameters         | Description          |
|----|--------------------|----------------------|
| 1  | Type               | TPD80                |
| 2  | Diameter           | 78 cm                |
| 3  | Height             | 120 cm               |
| 4  | Weight             | 140 kg               |
| 5  | Steam thermal      | 200-240 °C           |
| 6  | Pressure           | 1.5 atm              |
| 7  | Production Capacity| 100-200 kg per day   |

3.2. Performance observation of steam boilers

Performance observation is done to know the benefits of steam boiler compared to traditional cooking. Some of the observed parameters are the use fuel, cooking time, water demand, and visual quality. Results the observation is presented in Table 2. The comparison of soy slurry cooking between steam
boiler and traditional method. Based on the observation, the use of a steam boiler can save fuel, time, and better quality of tofu.

The adoption of a boiler in the tofu industry greatly helps increase productivity and the quality of tofu produced. Nevertheless, there are stages of tofu production process that require the development of machinery or equipment for productivity and tofu quality more increased. For example, the partner is still doing the soy slurry extortion process and tofu presses with simple/manual equipment. Through the development and application of appropriate technology in the other opportunities are expected to be made better tofu press machine.

**Table 2. The comparison of soy slurry cooking between steam boiler and traditional method**

| Parameters          | Traditional | with Steam Boiler | Description       |
|---------------------|-------------|-------------------|-------------------|
| Fuel (kg)           | 20          | 13.3              | 33.5% more efficient |
| Cooking time (minutes) | 75          | 30                | 60% more efficient | 67% more efficient |
| Water needs (l)     | 45          | 10                | Better taste      | More hygienic     |
| Smell               | Maybe Burnt | Not burnt         |                   |
| Color               | White brownish | White              |                   |

4. **Conclusion**

The resulting steam boiler proved to be more efficient and has many advantages, such as more time saving (shorter), cost-effective (less fuel) and energy saving and more production capacity; Tofu produced using a steam boiler has better quality, which is tastier and more hygienic; Tofu production costs with the use of a lower boiler, then for the same amount of production a greater profit will be obtained.

**References**

[1] E. Harmayani, E. S. Rahayu, T. F. Djiaafar, C. A. Sari, dan T. Marwati, “Pemanfaatan kultur Pediococcus acidilactici F-11 penghasil bakteriosin sebagai penggumpal pada pembuatan tahu,” *J. Penelit. Pascapanen Pertan.*, vol. 6, no. 1, hal. 10–20, 2018.

[2] D. Supriatna, *Membuat Tahu Sumedang*. Penebar Swadaya, 2005.

[3] R. Fatoni, T. Septiani, dan R. P. Mikasasari, “Kajian Tekno-Ekonomis Pabrik Tahu di Kabupaten Pemalang Jawa Tengah,” 2016.

[4] S. Sudarman, S. Suwahyo, dan S. Sunyoto, “PENERAPAN KETEL UAP (STEAM BOILER) PADA INDUSTRI PENGOLAHAN TAHU UNTUK MENINGKATKAN EFISIENSI DAN KUALITAS PRODUK,” *Sainteknol J. Sains dan Teknol.*, vol. 13, no. 1, 2015.