

# Steam Boiler Technology for Making Soybean Porridge without Smell of Wood Burning Smoke o Tofu Production

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## Abstract

Small industries that make tofu indirectly experience problems in the soybean porridge cooking process. This porridge is the forerunner of tofu. Tofu Serasi Asli product senses an annoying situation to the environment and the development. Furthermore, it is divided into problems of production and management aspects. The boiler design shows that separating the steam production from the pan by flowing saturated steam in each soybean plot. The advantages of using a steam boiler are that the cooking pan does not produce scale and saves time, increases capacity, higher pressure reaches 300 kPa and creates smoke-free kitchen space and a healthier and more hygienic production kitchen. Fuel savings of 48%, an increase in the income of small and medium enterprises and the quality of the tofu produced is better and does not smell of burning smoke.

*Keywords: Steam boiler, Tofu Matching; wood fuel, crust, saturated steam*

## INTRODUCTION

Tofu Serasi is white tofu made from soybeans which are dense and smooth. Tofu harmoniously is different from regular tofu, so that visitors in the Bandungan tourist area much favour it. In addition to the savoury taste of tofu, harmonious tofu has a high protein content (according to SNI, at most minuscule nine g/100 g). Tofu Serasi has been around since 1980. Currently, there are about eight Tofu Serasi

craftsmen in Bandungan. as a snack or snack by frying. This top-rated product is miserable if there are problems in its production, so process modifications are needed.

The tofu production process is generally divided into two main stages, namely the protein extraction stage (grind soybeans, cook soybean porridge, and filter) and the protein coagulation stage into tofu products. Adding 30 times the amount of water to extract soybean mass can

increase the protein obtained (Yuwono & Susanto, 2016). Making tofu products has milling-boiling-filtering (hot extraction). However, the uniqueness of the Tofu Serasi MSME industry is that the process sequence is: milling-filtering-boiling (cold extraction). The advantage of the cold extraction process is that soybean juice has two functions. The filtering soy juice is made into tofu or soy milk. On the other hand, this harmonious tofu uses a printing process where some of the sugar cane juice is taken and wrapped one by one with a large amount of cloth and then pressed (pressed) to reduce the water content. The resulting product has been proven to be very popular with consumers. It is found that the harmonious tofu product is more supply, denser, and has a higher selling value. The next difference is mismatched tofu is made without added preservatives, but it can last longer (7 days).

The decline in the quality of tofu, especially in its aroma, uses a stove, there is a production process where to produce steam, some tofu industries use used jerrycan oil (Andrianto et al., 2016) the release of combustion smoke that enters the tofu product which can affect the tofu and the aroma of the tofu. In addition, every process starts from scratch or a batch system, so energy is rather wasteful and takes a long time (Bairawa et al., 2021). The boiler design provides ease of operation, safety, repair and cleaning (Bahadori et al., 2014). The obstacle that is still encountered and becomes a problem for research partners is that boiling soybean porridge in Partners is still

carried out in a conventional way using a large pot with a diameter of 50 cm and a height of 50 cm. The raw material is heated in a wood-fired stove has many drawbacks regarding processing time, quality and fuel requirements to boil four large pots.

Boiling with this wood-fired stove takes a long time. Managing 100 kg of soybeans into tofu requires a boiling process for 6 hours. The long boiling time is due to the long preparation time and the relatively small capacity of the pot and wood-burning stove. At the bottom of the pan, a crust will form. If the cooking process is too long or too hot, the crust will be thicker. The charred crust will affect the aroma and colour of the tofu pulp. If these are going to reuse the pan, it must be cleaned first. Descaling requires more effort that takes time and effort. On the other hand, soybean porridge is prone to quality degradation during processing, so it is crucial to ensure a smooth crust and odour around cooking.

Conventional boiling with a wood-fired stove also affects the aroma of tofu porridge (Figure 1). If the fire is not appropriately maintained, the tofu porridge will taste an unpleasant smell. Cooking in a pot also requires more effort, as the porridge has to be cooked in separate pans. One cooking process takes four large pots to boil soybean porridge to process 100 kg of soybeans into tofu. The boiling process takes up to 5 hours. The long boiling time is due to the long preparation time, and the boiling is done alternately.



**Figure 1.** The process of cooking soybean porridge to extract using wood fired.

## METHOD

Based on the problems faced by the partners, a solution is agreed upon with the partners, namely, making and implementing a steam boiler. The design of the steam boiler is as shown in Figure 2. The function of the steam boiler is to produce steam that was set for temperature and steam pressure—the advantage of boiling with a steam boiler set to make tofu. In addition, making tofu will be free from strong odours due to the fumes of the combustion process (furnace with separate tofu slurry processing pan). Another advantage is that making tofu is faster and cleaner/hygienic.

Soybeans soaked for four hours with a ratio of soybean: water as much as 1:3, drained, milled with soybean: water ratio as much as 1:2. The boiling process should be conducted approximately 3-10 minutes at 100–120°C at 105-300 kPa. This process was for cooking the porridge, protein denaturation and removing beany flavour.

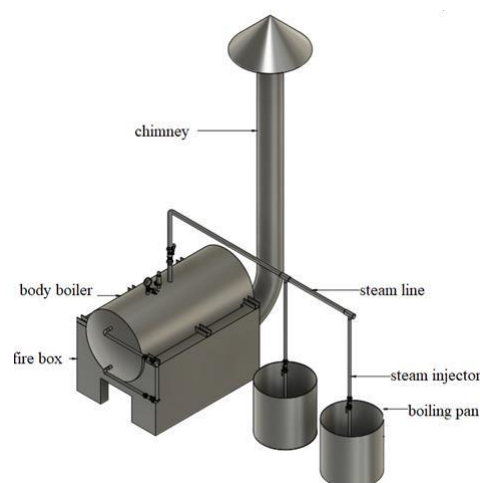
The design of the steam in 3 dimensions by considering the conditions in the field and future considerations. Water that meets the requirements of boiler water is prepared to be formed into saturated steam. Steam generation is assisted by heating from the firebox from below

then heating the boiler's body so that saturated steam flows through the steam line and steam injector to the pot, which causes the soybean porridge to boil.

Based on the problems faced, the agreed solution was using a steam boiler for boiling soybean porridge. They were applied to a simple steam boiler which is safe and easy to operate. The kettle is made of 304 stainless steel to the standards for processed food products. This type of iron has good rust resistance and higher maximum allowable stress than mild steel (Kutz et al., 2018). The steam boiler is equipped with measuring instruments for temperature, pressure, safety valve and water level.

In general, water tube boilers have a variety of shell types with circulating water in the pipe and the heating arrangement that surrounds it. Judging from the working pressure to produce steam up to about 100 kg/h, the increase in steam pressure is about 500 kPa and results in a higher saturated temperature of around 140°C.

The boiler unit provides space for the furnace unit to generate heat through the fuel combustion process. Installing more burners/heaters in the boiler vertically and horizontally makes it easier to control the temperature in each section/water pipe.



**Figure 2.** Steam Boiler Design for the Tofu Industry in 3-dimensional form

The feed control valve offers the correct amount of water feed into the tube at the right rate, and the steam control valve is used to control the steam outlet pressure. A pressure gauge is attached to the boiler unit to measure the steam generation pressure in the boiler unit (Behrendt & Stoyanov (2018).

The boiler drum is cylindrical in shape with a rigid structure. A curved shape forms at the bottom drum, referred to as accumulated sludge, depositing impurities in the water before being put into the tube. The safety control valve controls the excess pressure in the drum and avoids unnecessary, dangerous situations.

Hot flue gas was through the tube from bottom to top. The circulating water is converted to steam, which is collected from the top end for further use. The critical parts of the water tube boiler can be the boiler drum, fire control burner, mud drum, furnace unit, safety valve, feed water filter, provide check valve, steam control stop valve.

Process parameters contain four sets of values. These parameters are the temperature at which the feed water was 100 to 120°C and supplied with cold water. (100 to 130 L). The operating condition of the feed water pressure was 150 to 300 kPa. Furthermore, the saturated steam, the amount of vapour produced, and the pressure is examined. It is hoped that the maximum steam yield capacity will be the optimal choice.

**RESULT AND DISCUSSION**

The water was heated by several sources of heat generated by fuel combustion in the firebox and finally produced steam. Saturated steam can be supplied at a specified pressure for industrial process work in a tofu factory and to produce hot water used for heating installations (Kispotta et al., 2014). Logically, the steam boiler must have a minimum capacity of 10 L of water and a minimum working pressure of around 300 kPa (Parves, 2017). The advantage of the process that produces saturated steam is indicated in the boiler. Some fins function to increase the heat transfer rate.

The complex process of heat transfer inside the boiler takes place in the furnace chamber, the configuration of the burners (Askarova et al., 2014), the non-uniform supply of air and fuel to the burner system, and the two-phase flow of the medium in the pipes. This condition also depends on the thermal and physical properties of water, steam and flue gases at pressure and temperature or a temperature only. The natural circulation of water in the boiler is possible due to the difference between the densities of the water-steam mixture (Grądziel et al., 2019).

Boilers in power plants are also exposed to high pressure and temperature variations caused by intermittent load cycles. Consumption of compressed components in the high-medium pressure rotor section depends on periodic and cumulative thermal stresses with time.

**Table 1.** Technical Specifications of Steam boiler for cooking Soybean porridge

Parameter	Value/Description
• Steam boiler type	horizontal tube boiler
• Steam capacity	± 100 kg/h
• Steam Boiler Volume	600 L
• Inner diameter	750 mm
• Type of steam output	saturated steam
• Operating temperature	100°C – 140°C
• Operating pressure	50-490 kPa
• Fuel: wood (or other waste biomass)	wood (or other waste biomass)

The technical specifications for the steam boiler are as shown in Table 1 at a minimum temperature of the boiling point of water and using saturated steam. The application of this boiler has advantages compared to the previous boiling process. Some of the benefits of using a steam boiler that tofu artisans feel are shown in Figure 3, with several improvements. The cooking time of soybean porridge shows a significant difference. The processing time is shorter, from the original 2-3 h/process is only 15 min. The pressure used is very high of 3 bar, which is imposed directly on the air above the slurry. The volume is increased from the usual one to cook one pot of tofu porridge with a capacity of 100 L. The boiling pot has a diameter of 56 cm, a height of 60 cm, or a volume of 147 L and can be more panicked with the production of saturated steam can also be increased. The fuel used is wood, which can be saved as 48% per month with a value of 1,200,000 rupiahs.

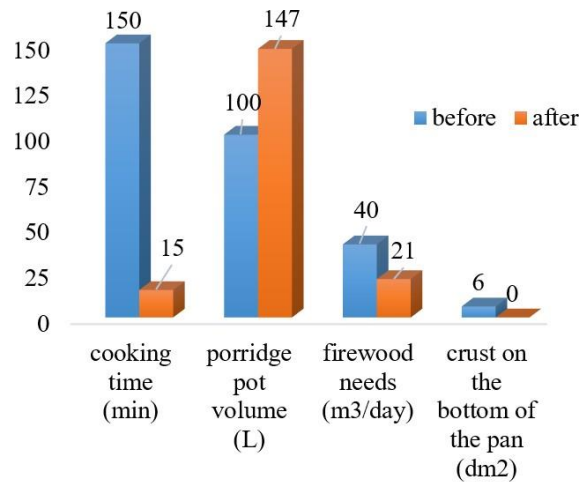
On the other hand, the quality of tofu is getting better, namely free from strong odours and

cleaner. Heat pretreatment markedly increased the hardness of tofu transglutaminase crosslinking by strengthening the gel network, which was associated with partial denaturation that facilitated enzymatic crosslinking (Jian et al., 2014). The production room is healthier and cleaner because it is smoke-free and very comfortable for workers to pay attention to the steam boiler combustion chamber separated from the production room.

Table 2 illustrates the results of steam generation in steam generation effectively, and all parameter relationships and Signal to Noise ratio values are presented simply. The parameters involved in the steam generation process are feed water temperature, feed water pressure, cold water supply, and boiler drum pressure. Hot water is fed to the boiler unit as the feedwater temperature. Similarly, the feedwater supply flows under several forces known as feed water pressure (Akpan & Fuls, 2018). The cold water supply is further heated as feed water into the boiler, and a pressure drum is developed.

**Tabel 2.** Summary of Trial Steam generatio

No	Feed Water			Steam generation (L)	S/N ratios
	Temperature (°C)	Pressure (kPa)	Volume supply (L)		
1	100	150	100	64.4	36.4
2	100	200	110	71.2	36.1
3	100	250	120	79.7	37
4	100	300	130	71.3	37.2
5	105	150	110	65.2	36.5
6	105	200	100	68.3	36.9
7	105	250	130	72.0	37.4
8	105	300	120	70.1	37.1
9	115	150	120	66.3	36.7
10	115	200	130	69.9	37.1
11	115	250	100	72.3	37.3
12	115	300	110	64.6	36.5
13	120	150	130	67.1	36.8
14	120	200	120	65.1	36.5
15	120	250	110	73.3	37.4
16	120	300	100	68.8	36.9



**Figure 3.** Significant changes in technology transfer without Crust on the bottom pan and Smell of Wood Burning Smoke

Furthermore, the temperature and pressure of saturated steam in the boiler are analyzed to obtain optimum steam production. Maximum steam generation was achieved as 73.3 L with a value of 37.4 for the S/N ratio. Other studies support the claim that triple-finned tubes can improve the performance of cross-flow tubes on heat transfer by increasing efficiency and decreasing the CO<sub>2</sub> pollution of a steam boiler (Wajkowski, 2016).

Although technically, the performance of a modified steam boiler can increase production capacity, it is also necessary to pay attention to regular steam boiler maintenance every six months so that the performance of the steam boiler is adequately maintained. Boiler feedwater should be selected from a water source free from heavy metals and lime to prevent scale in the boiler.

The steam flow rate on heat transfer in the boiler characterizing the heat exchanger resistance is analyzed (Tang et al., 2019). The results showed that bent fins could increase the rate of heat transfer and pressure drop by increasing turbulence intensity on the exhaust side compared to traditional serrated spirals of the same area. Considering the sizeable thermal surface in the heat transfer in the boiler, the large

number of small serrated fins successfully restores boiler efficiency on optimized temperature profile with better surface regulation (Mohtaram et al., 2021). Compared to conventional boilers, boilers with sandwiched membrane tubes have a higher heat transfer coefficient. The results can be used to design boilers with a smaller size but larger capacity (Somjun & Chinsuwan, 2017).

Minimal work has also been done on boilers equipped with serrated finned tubes for improved heat transfer and pressure drop performance (Babu et al., 2020). The test finned tubes are mounted in one smooth tube and form a shell-and-tube heat exchanger. Effect of external fin height and finned tube pitch on shell side flow and heat transfer (Liu et al., 2013).

## CONCLUSION

Based on the activities carried out, the steam boiler application can accelerate the tofu production process in terms of capacity and cooking time. A healthier and more hygienic production kitchen becomes healthier without the presence of smoke. The crust on the bottom of the pan is no longer found. Wood fuel savings of 48% so that the overall production matches tofu sold without the smell of burning smoke.

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