Prototype of Integrated Mini Exhausting System For Fish Canning Process

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Abstract. The pre-cooking process carried out in the fish canning industry still uses the method of steaming on the stove. The difference in the capacity of the pre-cooking and sterilization processes causes a long holding time, which has the potential for microorganism contamination and low productivity. Research on the prototype of an integrated semi-automatic mini exhausting unit with a capacity of up to 300 cans of 115 mL using a hot steam source from a sterilization retort has to increase production capacity and efficiency. The size mini exhausting has a size of 4 meters x 1 meter and is made of 304 stainless material. It has 3 parts, namely the preparation part, the heating part, and the draining section. The drain part was located on the outside of the mini exhausting box. The draining part has a pan that can be rotated 150 degrees to remove the fish liquid in the can before the next process. The results of the exhausting room temperature reached 90°C within 8 minutes at an autoclave pressure of 0.8 bar. Fish meat reaches a temperature of 80 degrees after heating in the 12th minute. In the mini exhausting system, production capacity can be increased up to 8 times, with 25% electrical energy efficiency.

1. Introduction
Precooking is an important stage in the fish canning process. Precooking aims to reduce the number of microbes, inactivate enzymes, reduce the water content of fish, make meat more compact, reduce fat content, air (oxygen), and reduce the pressure inside the can. The pre-cooking process usually uses hot steam with a minimum temperature of 60°C. The pre-cooking temperature used reached 90°C for 18-20 minutes (Bratt, 2010). The initial cooking temperature varies based on the size of the fish to be processed. In general, the initial cooking temperature is around 98°C. This temperature using so that the fishbone temperature reaches a minimum of 60-65°C [1]. The minimum temperature for cooked fish is measure at the deepest part of the fish. According to the official websites of the FDA and USDA, the minimum temperature for cooked fish is 145°F or 62.8 °C.

The precooking process in large-scale fish canning production uses an exhausting device with a steam boiler. Meanwhile, in the small-scale fish canning process, steaming is still used on the stove with a capacity of 40 small 115 mL cans. If the retort used for the sterilization process has the capacity of 200 cans, then the precooking process will cause a long holding time. This condition can lead to contamination and inefficient. This steaming method has many drawbacks, namely uncontrolled
temperature, unstable heat, and low production capacity. This condition can cause the fish to be undercooked or overcooked so that it will affect the quality of the fish canning product.

To increase productivity and improve the quality of products, it is necessary to make a prototype of a mini exhausting system integrated with the fish canning process. This concept considers the use of a joint heating system between the pre-cooking and sterilization processes. Water vapor for the pre-cooking process uses steam from the autoclave. After the pre-cooking process is complete, the sterilization process uses the same autoclave, so that there is an efficiency of heating time from the heat stored in the machine from the previous process [2]. The application of this integrated mini exhausting system can shorten the heating and processing time because it uses the heat stored in the retort from the pre-cooking process. The purpose of this research was made and calculated field capacity prototype a mini exhausting system integrated of fish canning process.

2. Related Work
An exhauster is a tool used to create a vacuum condition in the headspace of the can before the can is closed which is called exhausting [3]. This exhausting process aims to reduce the oxygen content in the can (especially when heating in the retort) to reduce corrosion, limit the oxidation process by food, and prevent the growth of aerobic microorganisms that will reduce quality and safety [4].

The exhaust consists of a belt conveyor, a pipe equipped with a spreader, a valve for regulating the flow of hot steam, and an exhaust box. The working principle of the exhauster is to drain hot steam from the boiler through a pipe equipped with a spreader into the exhaust box. This hot steam is used to expel the air in the can headspace running on the rails in the exhauster. The exhausting time is set by adjusting the speed of the belt conveyor. While the exhausting temperature is set by adjusting the steam faucet on the exhauster [5].

The exhausting process has a working principle, namely steam supplied by the boiler, flowing through a pipe into the exhaust box. This hot steam is used to remove the air in the can which runs on the rails in the exhaust box. The speed of the exhausting process is regulated by adjusting the rail speed. Furthermore, the hot steam from the boiler has flowed through the pipe [6]. The exhaustion temperature can be adjusted by adjusting the steam valve. The material to be exhausted in the can is placed on a chain on the outside of the exhaust box. The lid of the can container is placed behind the can and passes through the rails together, after exiting the exhaust box the can is immediately closed. After the process is complete the boiler steam flow is stopped and the hot steam flow valve is closed, the tool is turned off and cleaned [3].

3. System Design
3.1 Hardware Design
The Mini Canning Exhausting (MCE) prototype is designed for pre-cooking with a capacity of 154 cans in 115mL packaging. MCE consists of 3 parts: the preparation section, the heating section, and the filter section. The three parts are connected in a conveyor system using stainless ball bearings. The first part is the preparation section, which has a size of 46 cm x 73.5 cm and a capacity of 77 cans of 115 mL which will be used for the precooking preparation process, namely the arrangement of cans and the installation of temperature sensors. The second part is for the process of heating fish or pre-cooking. This section consists of a heating box, steam lines, chimneys, and water reservoirs. The heating box measuring 107 cm x 65.5 cm x 44.5 cm, has a capacity of 154 cans. This section also has a door that can be opened and closed which serves to enter and exit the can during the pre-cooking process. The third part is water and fish filtration. This section is a hollow box made of stainless steel, which can accommodate one pan with a capacity of 77 cans. The box can be rotated up to 150 degrees to remove residual water and oil from the pre-cooking process. The design of the MCE prototype is shown in Figure 1.
3.2 Software Design

This integrated mini exhausting system equipment is equipped with a microcontroller-based digital monitoring system that functions to measure the quality of the pre-cooking process. This monitoring system consists of 4 DS18B waterproof temperatures sensor and one thermocouple sensor. The DS18B sensor probe is used to measure the temperature in the can, while the thermocouple is used to measure the temperature of the heating box. Sensor values are displayed on the OLED graphic LCD. If the average temperature of the four sensors $\geq 80$ degrees Celsius, the buzzer will sound and the microcontroller will start calculating the heating time. This setting system will make it easier for the operator to set the pre-cooking time to match the desired processing results or set standards. The system can also be connected to a GUI on the computer to store data during the pre-cooking process and display it in graphical form. Figure 2a is a block diagram of the monitoring system on the MCE, and Figure 2b is a programming flow diagram for the ATMega328 microcontroller.

![Figure 1. Design prototype mini canning exhausting](image)

**Figure 2a.**
4. Result and Discussion

4.1. System Realization

The MCE prototype uses 304 stainless steel to be safe from contamination. Figure 3 is the realization of the MCE prototype. The hot steam generated from the retort will be channeled into the heating chamber. The hot steam trapped in the box will circulate throughout the room and heat the fish in the can. There is a chimney at the top of the heating chamber. The chimney is equipped with a valve that can be manually rotated to dissipate hot steam if the room temperature exceeds the pre-cooking threshold. At the bottom of the heating room, there is a container for storing residual water from the heating process. After the heating process is complete, the can is inserted into the canning rotator to remove the remaining water and oil in the can [7].
According to the system design in chapter 3, a microcontroller-based MCE temperature monitoring device was created. Figure 4 is the result of the realization of the temperature monitoring device. The monitoring device can be powered in 2 ways: using PLN electricity, and/or using power from the computer's USB port. The temperature data of each sensor, average temperature, and heating time will be displayed on the LCD screen. The sensor used is waterproof with a working capacity of more than 110 degrees Celsius so it is safe to use in the production process that uses hot steam.

![Figure 4. MCE](image)

4.2. Testing result
The test was carried out by carrying out 1 production process (154 cans of 115mL size). Fish that have been cut and put in cans are placed on a baking sheet and sensors are mounted on the inside of the meat. Figure 5 is how to place the temperature sensor on the can. The sensor probe is placed inside the fish meat so that the temperature measured during the pre-cooking process is truly accurate. The thermocouple sensor is placed freely on the outside of the can to measure the temperature conditions of the heating room. In the initial process, 20 liters of water are heated in the Autoclave. The heating process to form steam at a pressure of 1.4 Bar takes about 35 minutes. After that, the steam inlet valve is opened to allow hot steam to flow into the heating chamber. From the normal temperature (27 degrees Celsius), the fish reaches an average temperature of 80 degrees after 30 minutes. The heating process data is stored in the application and displayed in the graphic figure 6. The microcontroller will send serial temperature data updates to the computer every 1 second.

![Figure 5. Placement of sensors on canned fish](image)
Figure 6. Precooking Graph

Figure 6. The graph of the pre-cooking process shows that the room temperature is around 70 degrees Celsius. This is influenced by the distribution of heat to canned fish. After the average temperature of the fish reaches 70 degrees Celsius, the temperature of the heating room begins to rise again to 85 degrees Celsius. The pre-cooking time starts to count when the average temperature of the four DS18B20 sensors reaches 80 degrees Celsius. According to the pre-cooking procedure of canned fish, the minimum heating time is 12 minutes. The autoclave steam pressure during heating is stable at 1 bar. Figure 7. shows the conditions during the pre-cooking process after the pre-cooking process for 12 minutes.

Figure 7. Precooking Process

Overall, the time for the pre-cooking process is shown in table 1. At the time of the initial heating of the autoclave, the temperature of the heating room was around 31 degrees Celsius. The average temperature of the fish is 27 degrees Celsius because the fish is frozen before slaughter. After 40 minutes, the steam in the autoclave can be used (pressure 1.2bar). The MCE steam inlet valve is then opened about 30% to allow water vapor to flow into the heating chamber. The autoclave pressure will decrease slowly at a pressure of 1 bar. With autoclave steam trapped in the heating chamber, causing heat to be distributed to the fish in the can. 4 sensors are used which are placed evenly to ensure that the heating in the 154 cans is evenly distributed. After the pre-cooking process is complete, the
process of seasoning, closing cans, and sterilization is carried out. Cans sterilization is done by placing cans in an autoclave at a pressure of 1 ATM for 20 minutes. Because the autoclave still stores the residual heat from the pre-cooking process, heating for the sterilization process takes 25% faster. So that the sterilization process can save electricity usage of 750Wh [8].

| Time | Heating Room Temperature | Test Data Fish Average Temperature | Status |
|------|--------------------------|-----------------------------------|--------|
| 0    | 31 °C                    | 27 °C                             | Autoclave Heating |
| 40   | 30 °C                    | 27 °C                             | Autoclave 1.2 Bar 90 °C |
| 50   | 70 °C                    | 35 °C                             | Steam is streamed to MCE |
| 60   | 72 °C                    | 45 °C                             | Steam is streamed to MCE |
| 70   | 85 °C                    | 78 °C                             | Steam is streamed to MCE |
| 80   | 86 °C                    | 82 °C                             | The heating counter starts counting |
| 92   | 80 °C                    | 78 °C                             | The heating chamber is opened, the steam stops flowing |
| 100  | 60 °C                    | 65 °C                             | The can is removed from the heating chamber |

5. Conclusion
This mini exhausting measures 2 meters x 0,75 meter with capacity about 154 cans and is made with 304 stainless materials, and on the outside of the mini exhausting box, there is a rotating pan mechanism to remove the liquid in the can before the next process. The results of the exhausting room temperature reaches 85°C within 12 minutes at autoclave pressure of 1.4 bar. Fish meat reaches a temperature of 80 degrees after heating in the 30th minute. With the use of a mini exhausting system, production capacity can be increased up to 8 times, with an electrical energy efficiency of 25%.

Acknowledgment
The authors would like to acknowledge the financial support of this work by grants from PNBP, State Polytechnic of Jember. The author also thanks to the P3M and Information Technology Department, State Polytechnic of Jember, which has provided support and assistance in completing this research.

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