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Application of Used Oil-Fired Chicken Coop Heating Technology for Reduced Operational Costs

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ABSTRACT

This research aims to develop used oil-fired chicken coop heating technology that can reduce operational costs on farms. In the poultry farming industry, poorly controlled cage temperatures can affect the productivity and health of broiler chickens. Therefore, an efficient and environmentally friendly heating system is needed. One of the solutions offered is the use of used oil as an alternative fuel that has the potential to replace conventional fuels. This research method uses a literature study approach and field survey to obtain data on appropriate heating techniques. The study also examines the application of efficient combustion systems and heating technologies that separate clean air and dirty air. Based on the results of the design, manufacture, and testing of the appliance, it can be concluded that the output produced from the heater is in accordance with the needs of the cage, which is in the temperature range of 32-34°C. In addition, the ventilation system works well, where clean air is expelled through the output, while dirty air is expelled through the exhaust. The layout designed for the combustion process also runs smoothly, supporting the overall efficiency and effectiveness of the system.

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INTRODUCTION

The chicken farming industry is one of the important sectors in the Indonesian economy, especially in meeting the animal protein needs of the community. As the demand for chicken meat increases, efficiency in the production process, especially in chicken rearing, is becoming a very crucial factor to consider. One of the aspects that affects the success of chicken rearing is the temperature regulation of the cage. Unstable cage temperatures, especially in the rainy season or in areas with low temperatures, can cause chicken stress, decrease egg productivity, and increase chicken mortality rates (Purwati et al., 2023).

Heating the cage is one of the solutions to overcome the problem of low temperatures in chicken coops. Effective heating can increase the temperature of the cage and create a more comfortable environment for chickens, which in turn will improve the animal's welfare and productivity. However, the use of heating for chicken coops requires considerable operational costs, especially if it uses fossil energy such as gas or electricity. This cost is an additional burden for chicken farmers, who are generally already burdened with the cost of feed and other care (Palupi, 2015).

One of the efforts that can be made to reduce the operational costs of chicken coop heaters is to utilize alternative energy sources that are cheaper and environmentally friendly. One alternative that can be considered is the use of used oil as heating fuel. Used oil produced from vehicle and engine maintenance activities has the potential to be recycled into a more economical alternative fuel compared to gas or electricity. The use of used oil as a fuel for heating chicken coops can reduce dependence on fossil energy, which is not only more expensive but also risks to environmental sustainability (Cui et al., 2019; Yellow, Red; Daryanto & ..., 2023).

The application of used oil-fired cage heating technology can also be expected as a form of sustainable implementation of environmentally friendly technology. In the long term, the use of used oil can be a more economical energy alternative and has the potential to reduce dependence on increasingly limited conventional energy sources. In addition, the application of this technology is expected to be a good example for other chicken farmers to adopt more cost-effective and environmentally friendly technological solutions.

THEORETICAL REVIEW

Geothermal Energy Sources

Geothermal energy is one of the renewable energy sources produced from the heat in the bowels of the earth. Geothermal comes from geothermal processes, which are energy produced by the Earth's core that continuously emits heat energy due to the decay of radioactive elements such as uranium, thorium, and potassium, as well as residual heat from the formation of planet Earth itself. This process generates heat that travels towards the earth's surface and can be utilized for a variety of purposes, be it for heating, power generation, or other industrial applications (Adistia et al., 2020). However, despite its great potential, the use of geothermal energy is limited to areas that have fairly active geothermal sources, so the development of infrastructure for

PLTP requires a considerable initial investment. Geothermal energy also has the advantage of being able to produce energy continuously, without depending on weather conditions, making it an attractive choice for sustainable energy sources (Meilani & Wuryandani, 2010).

Solar Thermal Energy Sources

Solar thermal energy is one of the most abundant forms of renewable energy and can be used for a variety of applications, such as water heating, electrical energy treatment, and other heating processes. This energy source comes from electromagnetic radiation emitted by the Sun in the form of light and heat, most of which is infrared radiation. This energy reaches the Earth through convection and radiation processes, and can be utilized directly with various technologies (Yuwono et al., 2021). The utilization of solar thermal energy can be done with two main technologies: solar thermal and solar photovoltaic. Solar thermal is used to capture heat from sunlight and use it for water or air heating, which can be applied to household water heaters, room heating, or even industrial heating. Meanwhile, solar photovoltaic (PV) converts solar energy into electrical energy by using semiconductor-based solar cells, which are widely applied to generate electricity on a small and large scale, both for household use and large-scale power generation (Ummah, 2019).

Flame Heat Energy Source

The source of fire heat energy comes from the combustion of fuel that produces thermal energy that can be used for a variety of needs, such as heating, food processing, and power generation. Flame combustion involves a chemical reaction between fuel and oxygen that produces heat and light energy. Fuels commonly used to generate fire heat include coal, wood, natural gas, and oil. This energy is widely used in various industrial sectors, especially in the manufacturing, power generation, and foodstuffs processing industries (*Boiler - an Overview | ScienceDirect Topics*, n.d.).

Heat Transfer Concept

Heat transfer is the process of transferring thermal energy from one object to another that has a lower temperature. This process can occur through three main mechanisms: conduction, convection, and radiation. These three mechanisms work based on the temperature difference between two or more objects, which causes heat energy to move from a higher temperature to a lower temperature. An understanding of the concept of heat transfer is essential in a wide range of engineering applications, including in heating systems, appliance design, and industrial processes (Ketut Mahardika et al., 2023). Conduction heat flow is the process of transferring heat through a solid medium without mass transfer. In conduction, heat energy is transferred through the collision and vibration of molecules in materials that meet each other. Hotter molecules with higher kinetic energy will transfer some of their energy to cooler molecules through interactions between particles. This process continues until the temperature throughout the material becomes more even (Technique, n.d.). The conduction process is not only limited to other metallic or solid materials, but it can also occur in composite or mixed materials that have a certain conduction ability. One relevant example in the industry is the use of conductive materials in electronic equipment, where heat needs to be efficiently transferred from hot components to cooler parts to prevent damage (Kurniawati, 1999; Saputraa et al., 2022). Convection heat flow is a heat transfer mechanism that involves the movement of fluids (gases or liquids) to carry heat from one place to another. In convection, the hotter fluid will move up as its density decreases, while the cooler fluid will go down to replace the position of the hotter fluid. This process creates a flow cycle called convection circulation, which is essential for transferring heat in various systems such as heating, engine cooling, and heat dissipation systems in electronic devices (Heat Convection - Overview | ScienceDirect Topics, n.d.).

METHODOLOGY

In this study, several methods and techniques were used to obtain the data needed in developing used oil-fired chicken coop heaters. The methods used aim to obtain valid and accurate information, as well as support a more comprehensive analysis in designing an efficient heating system. The literature method is used to collect relevant information from various literatures, journals, books, and scientific articles that discuss heat energy, fuel sources, and heating technology. These literature sources will be used as a theoretical basis to understand the basic concepts underlying the design of used oil-fired chicken coop heaters, as well as to compare with previous research that has relevance. By utilizing existing references, researchers can gain a deeper understanding of existing theories and applications in this field, which will be applied in this study (Hendarti et al., 2009; Sari, 2020). The field survey method was carried out to collect data through direct observation at the location of the chicken farm.

The researcher will observe the condition of the cage, the heating system used, and the operational needs related to the temperature and comfort of the chicks. This field survey aims to obtain empirical data that is the basis for designing a more efficient and cheaper heating system, as well as providing solutions to problems faced by farmers (Budiawati et al., 2016). The data collection technique was carried out by testing the designed heating system, both those that use used fuel oil and conventional heating systems. The data collected includes parameters such as temperature, heating time, and temperature stability inside the cage. This test data is used to compare the performance of used oil-fired heaters with traditional heaters and evaluate the efficiency of using the fuel (Herlina, 2016). In addition, observation techniques are also applied to directly observe the heating system applied in the chicken coop, both directly in the field and through data obtained from sensors installed in the heating system. These observations include observations of air temperature conditions in the cage, heat distribution, chicken comfort, and the safety level of the used oil-fired heating system (Yuwono et al., 2021).

RESEARCH RESULTS

Tool Manufacturing

In the process of making a chicken coop heater, there are several important stages that must be done. The first step is to make a cover using a drum with a height of 930 mm, a diameter of 580 mm, and a thickness of 1.25 mm. This cover serves to cover the gaps so that hot air is not wasted during the heating process, as well as to support the running of the installation. Drums were chosen because of their suitable shape and affordable price, as well as their ability to conduct heat well. The process of making a cover begins by cutting the top of the drum according to the size and design that has been determined. Then, a hole is made at the bottom of the drum to insert the combustion furnace, which must be adjusted to the size of the furnace so that the installation is sturdy and there is no air leakage.

After that, the legs are installed on the bottom of the drum as a foundation to maintain the stability of the tool and ensure that the drum does not come into direct contact with the ground or the floor of the cage. These legs are firmly welded to support the weight of the drum and ensure that the tool remains sturdy. In the next stage, a box-shaped hole is cut on the side of the drum as a door to light the fire and check the combustion process. This door is equipped with hinges and locks to make it easy to open and close the door and ensure safety during the combustion process.

The installation of the locks on the door is carried out carefully so that the door remains tightly closed during use. In addition, additional plates are installed on the top of the drum to strengthen the locks and prevent air leakage. Furthermore, the top of the drum that was previously cut was perforated to install an exhaust duct to discharge the combustion gases. This exhaust duct ensures that the hot air generated by the combustion furnace can flow properly, preventing gas buildup inside the drum, and supporting the performance of the heating system.

The final stage is the creation of the hot air outlet needed for the chicken coop. This duct is made large enough for the hot air flow to escape smoothly. To strengthen and stabilize the air ducts, additional plates are installed around the ducts and welded with precision. The welding process is carried out carefully so that there is no air leakage that reduces the efficiency of the tool. Once all parts are neatly and firmly installed, the chicken coop heater cover is ready for testing and ensures the appliance is functioning properly, resulting in optimal temperatures for chickens, and helping to reduce operational costs on the farm.

Figure 1. Heater Cover

For the manufacture of pipes in the chicken coop heating device, the first stage is to make a cut on the drum cap. After that, the drum is carefully split to make it wider so that it can be further processed and adjusted to the desired design. This cleavage is important to ensure the drum can be modified to the required size. After the drum is divided in two, the next step is to roll the drum using a roller machine to straighten the drum that was previously curved, making it easier to shape and cut.

After the rolling is complete, the drum that has been straightened is cut into several pieces with a predetermined size, namely 60 cm long and 40 cm wide. For this cutting, a hand grinder is used to make the cut more precise. It is important to use safety equipment such as goggles and gloves to avoid potential injuries from sparks. After the drum plate is cut, 15 holes with a diameter of 88.25 mm are made on the drum plate, which will be used for the installation of the installation pipes. These holes are carefully made so that the pipes can be installed perfectly.

The pipes are then inserted into the holes that have been made, and the position of the pipes must be ensured to be firmly attached. Once the pipe is installed, welding is carried out to ensure that the pipe stays in position and does not move. After the welding process is complete, the welded parts are then polished using a hand grinder to smooth the surface and ensure a neat and even welding result. Furthermore, the curvature on the assembled side is carried out with a curve size of 85 mm to ensure airflow in accordance with the planned design.

The final part of the pipe installation manufacturing is the cutting of the drum plates that are left to be used as pipe installation covers. These plates are installed and welded to the installation parts that have been created to keep the tool sturdy and safe. At the bottom of the tool, a hole is made to insert a 300 mm long iron pipe that serves as an airflow conduit into the pipe installation. These pipes conduct the hot air generated by the combustion system into the installation pipes. To ensure the stability of the tool, 23 cm long elbow legs are installed at the bottom of the tool to provide additional support, ensuring that the tool remains sturdy and does not slide easily. After all stages are completed, the chicken coop heater is ready to be used, functioning efficiently to circulate hot air according to the needs of the chicken coop.

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Figure 2. Heating Equipment Pipe

For the manufacture of stoves, the materials used are used tools that are widely sold in the industrial market at affordable prices. However, the selection of a used fire extinguisher as a stove stove needs to pay attention to the shape and size of the fire extinguisher to match the desired design. The manufacturing process begins by cutting off the top of the apparatus to make it easier to insert fuel later. This cut is essential so that the top of the aper has enough access to place fuel easily.

After the top of the aper is cut, the next step is to make a hole in the bottom side of the aper tube. This hole is made with a diameter of 39.1 mm to insert an iron pipe that serves as an air supply line from the blower. The process of making holes is carried out using a grinder with small eyes so that the cutting is more precise and does not damage the material. Once the hole is formed, an iron pipe is inserted into the hole and welded carefully to ensure that the position of the pipe remains firmly.

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Table 1 Furnace Temperature Data Capture for 10 Minutes

No	Time (second)	Furnace Temperature (T_1) °c
1	0	30
2	60	113
3	120	225
4	180	420
5	240	478
6	300	650
7	360	655
8	420	680
9	480	690
10	540	694
11	**600**	**702**

Table 1 shows the change in furnace temperature over 10 minutes with measurements every 60 seconds. At the beginning of the measurement, the furnace temperature starts at 30°C and increases significantly over time. After 1 minute, the temperature rises to 113°C, and the biggest increase occurs between 240 seconds (4 minutes) and 300 seconds (5 minutes), with the temperature increasing from 478°C to 650°C. Although the temperature continues to rise, the rate of increase slows down, reaching 702°C in 10 minutes. This table illustrates the effectiveness of heating systems in generating high temperatures for the heating process.

Table 2 Taking temperature data of the outside wall and inside the pipe installation of the middle pipe section for 10 minutes.

No	Time (second)	Outside Temperature Bottom Pipe Wall Center (°c)	Temperature Inside the Bottom Pipe Wall of the Center (°c)
1	0	30	30
2	60	101	90
3	120	209	150
4	180	418	330
5	240	460	377
6	300	600	503
7	360	630	537
8	420	678	581
9	480	685	590
10	540	690	605
11	**600**	**698**	**607**

Table 2 presents temperature data on the outside and inside walls of the installation pipe located in the center of the pipe for 10 minutes. Measurements are taken every 60 seconds, starting from 0th second until reaching 600 seconds (10 minutes). The temperature outside the pipe wall is recorded starting at 30°C and increasing faster than the temperature inside the pipe wall. At 600 seconds, the temperature outside the pipe wall reached 698°C, while the temperature inside the pipe wall was recorded at 607°C. This difference indicates that the temperature on the outside of the pipe is higher, likely due to heat transfer from the heating source.

Table 3 Total Temperature of Outside and Inside Pipe Walls

Time (s)	**Pipe Wall 1(°c)**		**Pipe Wall 2(°c)**		**Pipe Wall 3(°c)**	
	Inside	**Outside**	**Inside**	**Outside**	**Inside**	**Outside**
600	B= 600	B= 509	B= 698	B= 607	B= 600	B= 509
	A= 409	A= 426	A= 425	A= 460	A= 391	A= 439
Average	**504,5**	**467,5**	**561,5**	**533,5**	**495,5**	**474**

Table 3 shows the temperature on the outside and inside walls of the three sections of the installation pipe (Pipe 1, Pipe 2, and Pipe 3) at 600 seconds (10 minutes). Here, the temperature of the outside and inside walls of each pipe is recorded to give an idea of the temperature distribution of different parts of the pipe.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the design, manufacture, and testing of the tool, it can be concluded that this heating device has succeeded in fulfilling the goal that has been set, which is to maintain the temperature in the chicken coop in the optimal range, which is between 32-34°C. This is especially important to create a comfortable environment for chickens, especially in a rearing process that requires a stable temperature. In addition, the ventilation system applied to this appliance is proven to work well, where clean air is expelled through the output to ensure good air quality inside the enclosure, while dirty air containing pollutants and harmful gases is expelled through the exhaust. This process helps maintain healthy air circulation, reduces the risk of harmful gas buildup, and ensures that chickens are healthy. On the other hand, layouts designed for the combustion process also show positive results. Combustion runs smoothly, allowing the heating process to run more efficiently and effectively, so that fuel use is more optimal. Thus, this tool not only succeeds in achieving its function of maintaining the temperature of the cage, but also creates an efficient system in the management of resources and energy.

FURTHER STUDY

The design of this used oil-fired chicken coop heater still has many shortcomings, both in terms of material selection, aesthetics, and the working mechanism and function of the tool. Therefore, it is hoped that this tool can be perfected in the future. Some of the things that the authors think can be improved in this heating device include: first, the application of automation in the working mechanism of the tool, which can simplify operation and ensure temperature stability more efficiently; Second, improvements to the design of the heating device installation mechanism, so that it is easier to install and operate in various cage conditions, and safer to use. These improvements are expected to improve the performance and durability of the tool in the long term, as well as provide better comfort for chickens placed in the cage.

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