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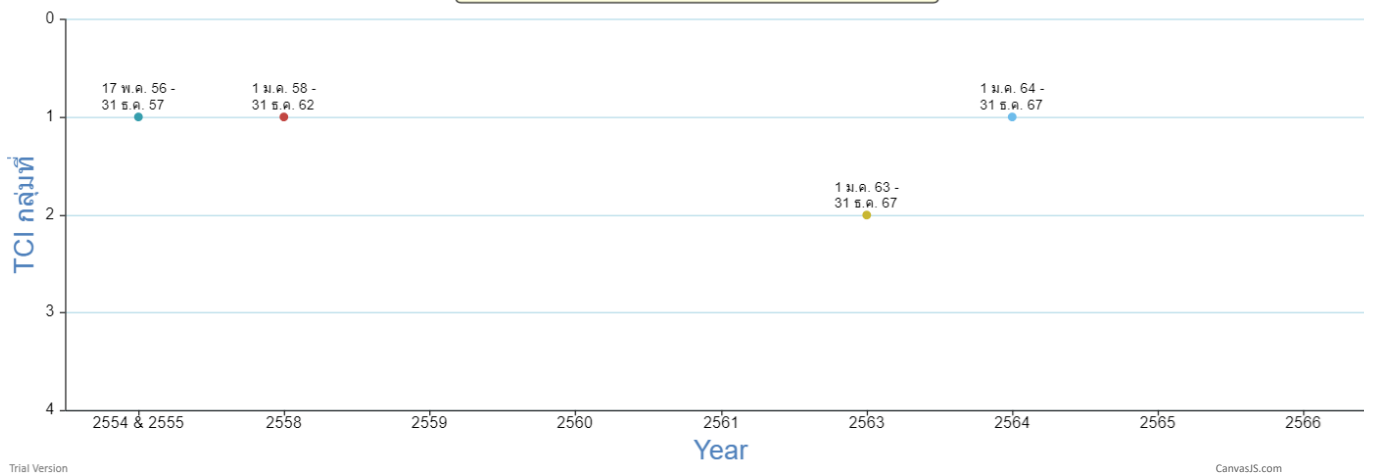
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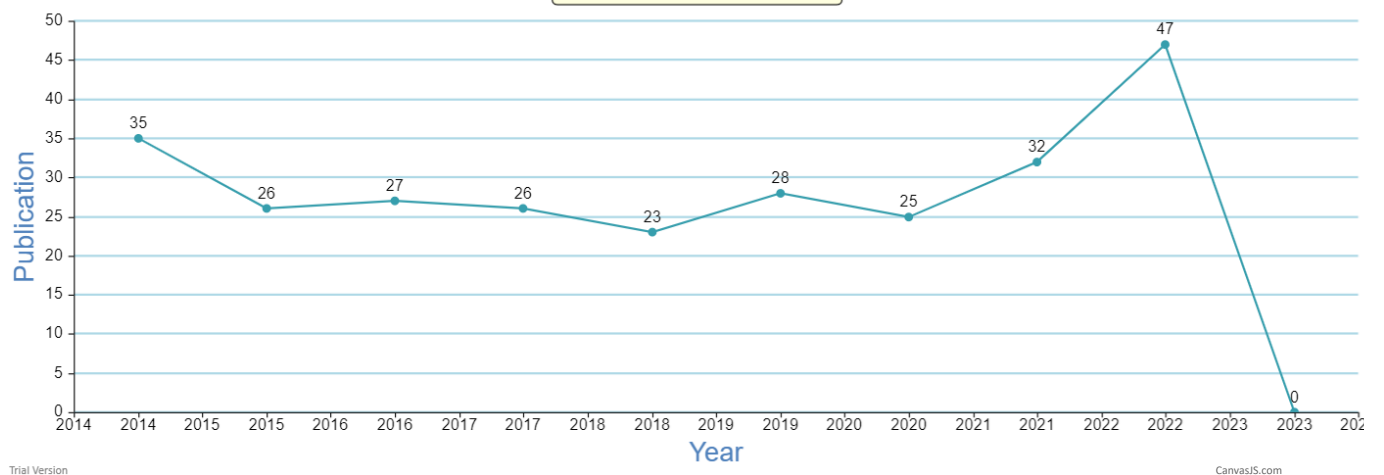
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Biogas for the use as Fuel in Sour Tamarind Cube Manufacture of OTOP in Duang Thong District, Phetchabun Province

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Abstract: The goal of this project is to design and construct a gas purification system and a gas compressing unit for biogas, an eco-friendly fuel used to produce sour tamarind at the OTOP manufacturing facility in Duang Thong District, Phetchabun Province. The first aim is to study and build purifying scrubbing equipment. A scrubbing device is a type of gas purification system used to separate raw biogas and remove pollutants as it exits the digester. Its filter parts are made of carbon dioxide (CO₂), water vapour (H₂O), and hydrogen sulfide (H₂S). The second step is to build and test a machine for compressing pure biogas into a gas tank. This machine includes a compressor and a metering system controlled by an electric device. The last step is to conduct a scrubbing test and an examination of the proper biogas output. The results of the test and analysis found that up to 98.0% of the biogas produced by the scrubber is Methane (CH₄) gas. The remaining 2 percent is other impurities or compounds from raw biogas, which could potentially be removed. The average test result of filling the gas tank with the gas each time revealed that it could hold 0.2 kilograms of gas, consumed 0.037 kWh of electricity, took 12 minutes and 23 seconds to fill, and could bake 125 kilograms of tamarinds in 1 hour and 20 minutes. The result of low-cost solar radiation protection drying technology transfer at Duang Thong Community Enterprise Group in Phetchabun Province is based on the demonstration of baking at the enterprise group and the delivery of knowledge about the bakers to 20 group members. All three aspects of the assessment had an average of 4.7 out of 5. which shows satisfaction at the highest level.

Keywords: Raw Biogas; Biogas Scrubbing; Sour Tamarind Cube manufacturing

1. Introduction

The sour tamarind cube product has been the best of OTOP (One Tambon One Product) in Duang Thong district, Phetchabun Province, from 2019 to 2021. One of the important processes for sour tamarind cube manufacturing is the tamarind boiling process. Normally, the tamarind boiling process in OTOP Duang Thong would require a 15-kilogram LPG gas tank for every 1000 kilograms of sour tamarind per day. The use of LPG gas is the cause of the rising cost of OTOP Duang Thong manufacturing. Currently, biogas technology is one of the alternative energy sources and is becoming the best choice of fuel for cooking, such as boiling, burning, and drying, in rural or developing communities. Biogas can be produced through a process called biogas digester by collecting organic wastes in rural areas [1].



Fig. 1 Elastic balloon containing raw biogas

The pig farmers in villages nearby the tamarind processing group have been collecting pig biogas by covering pig manure pits with PE plastics, which create elastic balloons containing raw biogas, as shown in Fig. 1. These farmers could only use the pig biogas for household cooking; any unused biogas would be discarded. Therefore, the research team proposed the idea of reserving the unused biogas in gas tanks, which is later used for steam heating the tamarind in Doung Thong Group manufacturing.

The process of biogas production is a simple and low-cost technology that encourages a circular economy and healthy cooking. It can also be used in household cooking applications since biogas is a clean-burning fuel [2]. However, the disadvantage of biogas fuel is the need for a pre-purification process to remove impurities such as carbon dioxide, nitrogen, water vapour, and hydrogen sulfide that came along with the digester gas, as shown in Table-1, including sulfide (H_2S), nitrogen (N_2), carbon dioxide (CO_2), and water vapour (H_2O). These impurities are caused by reducing heat and increasing the capacity of the biogas tank [3].

As a result, the goal of this research is to create purer CH_4 gas filtration before filling it into gas tanks and using the gas as fuel in the tamarind baking process to reduce the cost of tamarind production for the Duang Thong Community Enterprise Group.

Table 1 Substances of raw biogas from anaerobic digestion processes [4]

| Substance of Biogas | Percentage of Biogas (%) |
|-------------------------------------|--------------------------|
| Methane (CH ₄) | 50-60 |
| Carbon Dioxide (CO ₂) | 34-38 |
| Nitrogen (N ₂) | 0-5 |
| Water Vapour (H ₂ O) | 6 |
| Hydrogen Sulfide (H ₂ S) | trace |

2. Methods and Materials

2.1 Methods of Purifying and Compressing Biogas

The conceptual design of the purifying and compressing biogas system for use as fuel in the OTOP Duang Thong district is shown in Fig. 2. First, starting at the elastic balloon on the right, this corrects raw biogas and connects to the scrubbing system via PVC pipe outlets. The scrubbing system consists of three filter parts to separate and remove impurities, which are the input part or carbon dioxide filter, followed by a water vapour filter for water vapour removal, and the final part the hydrogen sulfide filter is the output part of the scrubbing system. Second, set up the gas compressing unit, which consists of a compressor, pressure switch, and pressure gate, then connect it to the output pipe of the hydrogen sulfide filter part. Finally, compress pure biogas into an LPG gas tank for use as fuel [5].

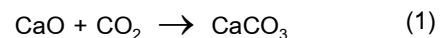
2.2 Materials of Impurities and Biogas Compressing System

2.2.1 Scrubbing System

The scrubbing system was designed for raw biogas purification to separate the substance of raw biogas and remove impurities produced by the digester. The scrubbing system is made up of three major components, which are as follows [3]: (1) Part of the carbon dioxide (CO₂) filter (2) Water vapor (H₂O) filter component and (3) Filter for hydrogen sulfide (H₂S). The materials of scrubbing in each part are as follows:

2.2.1.1 Carbon Dioxide (CO₂) Filter Part

This part is an input to a scrubbing system made from an enclosed PVC pipe, with a diameter of 10.24 cm and a length of 70 cm, which contains calcium carbonate and water at the site shown in Fig. 3. It is used to transform the carbon dioxide in raw biogas into calcium carbonate (CaCO₃) form. Calcium carbonate reacts with carbon dioxide into calcium carbonate form. The chemical reactions are as follows: (1) [6].



2.2.1.2 Water Vapour Filter Part

The water vapour or moisture filter is the second scrubbing part made of metal enclosed in a cylinder with a tube shown in Fig. 4. The inside of the Drier filter contains substances with hygroscopic properties such as silica gel, calcium sulfate, and alumina gel [7].

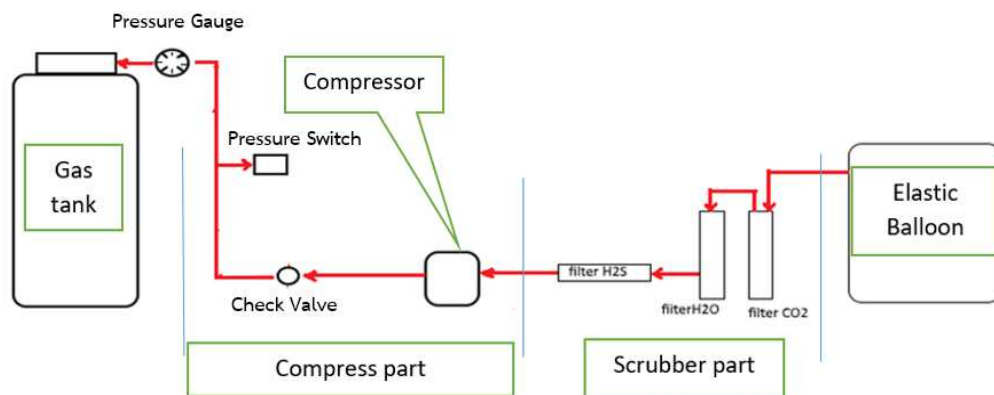


Fig. 2 Conceptual of scrubbing and compressing biogas system

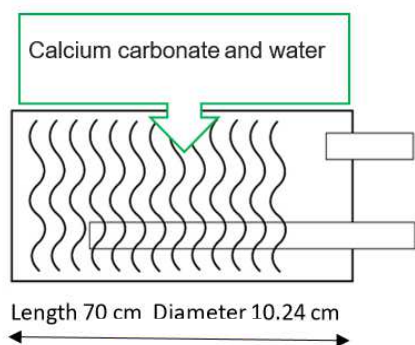


Fig. 3 CO₂ filter

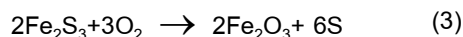
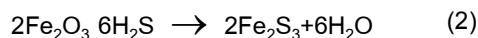


Fig. 4 Water vapour filter

2.2.1.3 Hydrogen Sulfide (H₂S) Filter Part

This part is the final part of the scrubbing system, in which hydrogen sulphide in raw biogas will be removed with catalyst iron oxide in the form of oxidized steel wool inside this

device, made from PVC pipes of 5.12 cm in diameter and 50 cm in length. The biogas from the second part will flow past and make contact with this steel wool and iron oxide, then be converted to elemental Sulphur. The chemical equation is as follows [4]: (2) and (3).



The H₂S scrubbing design includes a transparent fiber container filled with steel wool to act as an H₂S scrubber, as shown in Fig. 5. The container has two passages, one for the inlet tube and the other for the outlet tube. Both of these two passages are sealed with a sealing agent. The biogas will flow through these passages before entering the compression system, and the pump will act as the driving force to move the gas through the steel wool.

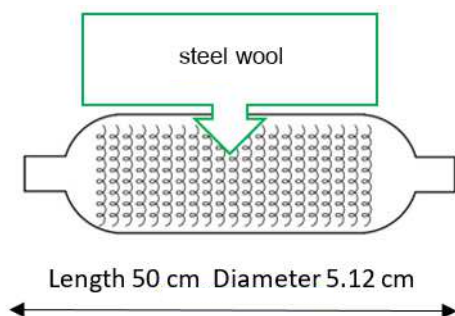


Fig. 5 H₂S filter

2.2.2 Compressing System

The air compressor in refrigerators has been selected as a part of the compressing system, along with an electrical control device, shown as a single-line diagram in Fig. 6 and 7 [8]. The scrubbing and gas compressor for biogas in OTOP Duang Thong District was shown in Fig. 8.

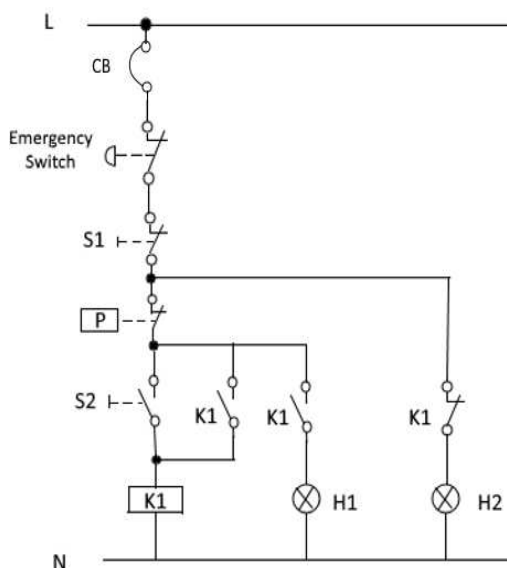


Fig. 6 Single line circuit of the compressor control system [9]

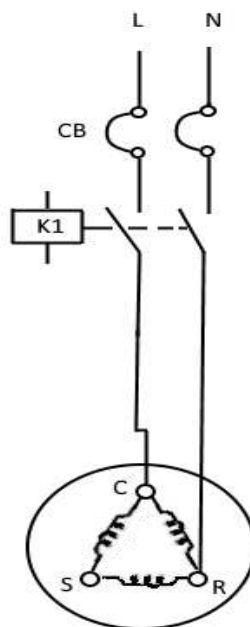


Fig. 7 Power Circuit of compressor biogas [10]



Fig. 8 Complete scrubbing and gas compressor for biogas in OTOP Duang Thong District

3. Result and Discussion

3.1 The Result of Compressing System Test

In this experiment, raw biogas will be fed into the 15-kilogram gas tank via the compressing system with the air compressor. It is done through a system device consisting of a check valve to protect the gas return, a pressure switch, and a pressure gauge before being compressed into the gas tank. After the gas tank was filled, it could be used to boil water for steaming the sour tamarind. The 200-liter baking tank, which weighs 125 kilograms, has a capacity of 20 liters of water each time. In comparison, LPG gas is normally used with a 5-inch gas burner as fuel to boil water for heating the tamarind. The result of the test is shown in Table 2.

Table 2 The result of the gas compressing unit test for 5.0 times

| Descriptions | Result |
|--|--------------------|
| Average Weight of gas contained in the gas tank | 0.2 kg. |
| Average Energy of gas compressor | 0.037 kWh |
| Average total time for compressing gas contained in the gas tank | 12 mins and 23 sec |
| Average total time for boiling 125 kg. of tamarind. | 1 hour and 20 mins |

Based on the data from Table 2, the average time of compressing gas into the gas tank is about 12 minutes for a 15-kilogram gas tank. The average electrical power consumption for compressing is only 0.03 kilowatts per hour, which is very little for this system. The average weight of biogas contained in the gas tank each time is 0.2 kilograms, which can be used as fuel for boiling 125 kilograms of tamarind in 1 hour and 20 minutes.

3.2 Result of Scrubbing Test

The results of all 5 gas measurement tests are shown in Fig. 9. The results of technology transfer for biogas for use as fuel in the tamarind processing industry of Phetchabun province are based on an assessment by 20 members of the Duang Thong group. The evaluation was done in three aspects. The results of satisfaction are shown in Table 4.

3.2 Discussion

Twenty members from the Duang Thong Community Enterprise in Phetchabun Province participated in the knowledge and technology transfer project. These participants have three to eight years of experience in tamarind drying. The evaluation was done in three aspects, and the results of satisfaction are shown in Table 4.

Results of scrubbing test for raw biogas purify 5.0 times

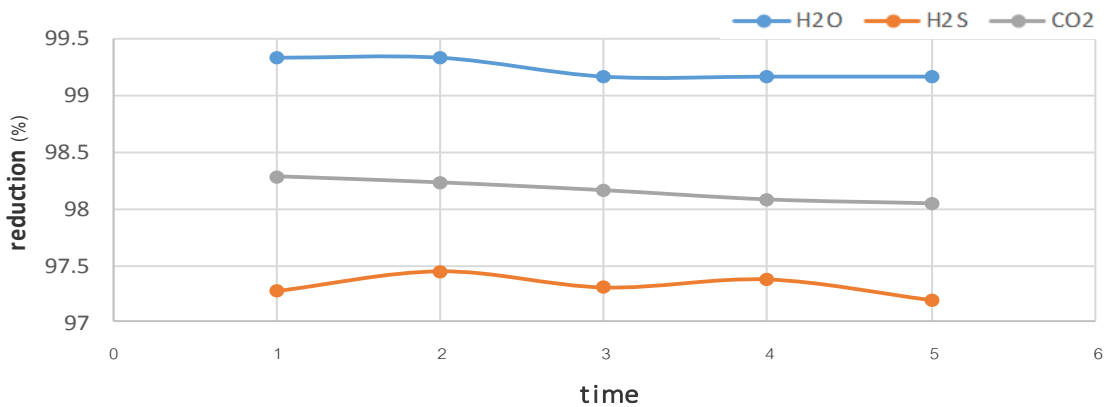


Fig. 9 The result of the gas compressing unit test for 5.0 times

Table 4 Results of satisfaction questionnaire.

| Assessment Details | Mean | S.D | Conclusion |
|--|-------------|-------------|-------------|
| Knowledge transfer process | | | |
| Trainers have knowledge and the ability to convey. | 4.58 | 0.52 | very |
| Trainers have easy-to-understand techniques and methods for transferring knowledge | 4.54 | 0.58 | very |
| Trainers can answer questions covering questions | 4.28 | 0.64 | very |
| Trainers have a variety of media to transfer knowledge | 4.38 | 0.58 | very |
| Trainers used the time for training and demonstration appropriately | 4.35 | 0.53 | very |
| Average | 4.44 | 0.57 | very |
| Usefulness | | | |
| Bring knowledge and technology to apply in daily life. | 4.48 | 0.55 | very |
| Biogas for the use as fuel used for increasing productivity. | 4.05 | 0.78 | very |
| Average | 4.25 | 0.67 | very |
| Satisfaction | | | |
| Satisfaction for Biogas for the use as fuel. | 4.58 | 0.57 | very |
| Satisfaction for transfer of knowledge and technology | 4.38 | 0.60 | very |
| Average | 4.46 | 0.55 | very |
| Total average | 4.38 | 0.60 | very |

It was found that the overall satisfaction was 4.38, and the standard deviation was 0.60. The scores were at a high level. When all three aspects are considered, satisfaction has the highest score with 4.46 for Mean and 0.55 for standard deviation, which is considered at a high level. Moreover, when summarizing the overall assessment of knowledge transfer for biogas for use as fuel, there were no points that were below the standard indicators (Key Results, or KRs) of the project. It shows that biogas for use as fuel in the manufacture of sour tamarind cubes meets the needs of the target audiences effectively.

However, in terms of biogas used as fuel to increase productivity, the mean was 4.05 and the standard deviation was 0.78, which was the lowest mean and the highest standard deviation in each assessment. It is possible that there was a different assessment weight score for this topic than for all other topics. According to the satisfaction findings, the sample population at Level 3 comprised 5 people with 5-8 years of work experience. It's conceivable that these samples are already dependent on commonplace devices [10].

4. Conclusion

This research aims to design and construct a gas purifying system and a gas compressing unit for the biogas used for eco-friendly fuel in sour tamarind cube manufacturing in OTOP Duang Thong district, Phetchabun Province. The result of

the test shows that the mechanism used in this project could purify raw biogas and turn it into pure biogas (97% of Methane gas), which could be fed into the 15-kilogram gas tank by compressing the pure biogas, which weighs 0.2 kilograms, into the 15-kilogram gas tank in 12 minutes and 23 seconds. Electrical power consumption for compressing pure gas into the 15-kilogram gas tank has an average power consumption of only 0.03 kilowatts per hour each time, considered very little for this process. The average weight of biogas that could be contained in the gas tank each time is about 0.2 kilograms, which could be used as fuel for boiling 125 kilograms of tamarind in about 1 hour.

5. Acknowledgement

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to enhance quality in producing seasoned sour tamarind. In the end, the research team would like to thank everyone for their beneficial advice and support towards achieving the purpose of this research.

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