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PERFORMANCE TEST OF REGENERATIVE EQUIPMENT WITH SOLID-LIQUID SEPARATION

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ABSTRACT

In order to solve the problems of high heat loss, low fermentation temperature and low gas production in biogas engineering in winter. In this paper, the annual thermal energy loss of biogas project is systematically analyzed, and a regenerative mass recovery device with solid-liquid separation is developed. Finally, the heating effect of the device at different temperatures is tested through experiments. The results showed that under the condition of good heat preservation measures, the heat loss of the fermentation tank accounted for 89.3% ~ 93.2% of the total heat loss of the anaerobic fermentation system. Under the ambient temperature of 18 ℃, the feed at 16.2 ℃can be heated to 26.6 ℃ by regeneration and mass recovery. The waste heat of the biogas slurry recovered accounted for 51.9% of the heat required for constant temperature fermentation. At ambient temperature of 0 ℃, the feed at 2.5 ℃ can be heated to 18.9 ℃ by regeneration and mass recovery. The waste heat of the biogas slurry recovered accounted for 47.2% of the heat required for constant temperature fermentation. The remaining heat is supplied by a collector array consisting of 14 groups of solar collectors, which can ensure the constant temperature fermentation of biogas engineering at 37 ℃ in winter. And the system has good economic and environmental benefits.

Keywords: small and medium-sized biogas project；Solid-liquid separation;heat and mass recycle;; solar heating area; economic benefits

NONMENCLATURE

Abbreviations	
APEN	Applied Energy
Symbols	
n	Year

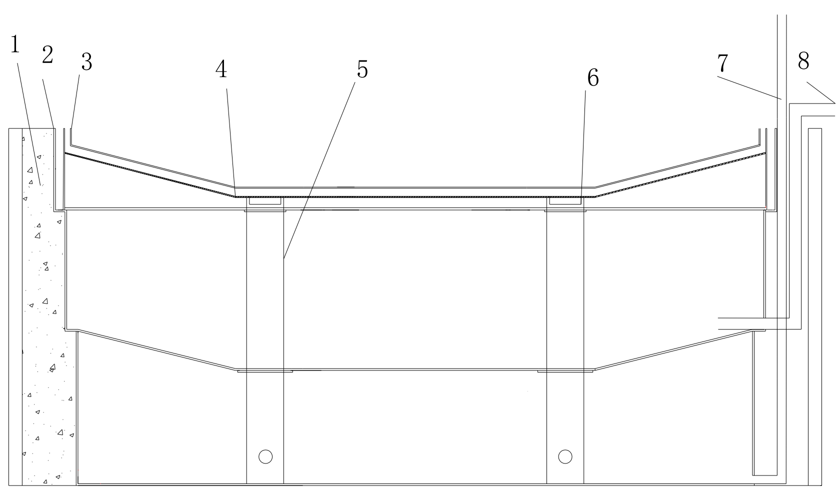
1. INTRODUCTION

With the depletion of fossil energy and the worsening of environmental problems, biogas engineering has attracted more and more attention due to its advantages of being able to process waste in large quantities and produce clean energy[1]. In recent years, China's biogas industry has made remarkable achievements in the world. However, there are still problems of waste and high idle rate of biogas projects[2]. On the one hand, the fund channel is single and the market mechanism is not perfect[3-5]. On the other hand, there is lack of sufficient heat source to ensure constant temperature fermentation throughout the year[6-8]. Biogas project discharge takes away a large amount of heat, which is usually directly discharged and wasted.At the same time, the heating and feeding load accounts for more than 90% of the total heat load of the biogas project[9]. Reference source not found, so heating and feeding with biogas slurry waste heat plays an important role in the stable operation of the biogas project.

Research on the utilization of biogas slurry waste heat at home and abroad is currently focused on the selection of biogas slurry waste heat exchanger and heat exchange mechanism analysis[10-11].Chen Jingjing[12]Reference source not found used numerical simulation method to study the performance of waste heat recovery in Scraped surface heat exchanger.It is concluded that recovering biogas slurry waste heat not only reduces the heat required for constant temperature fermentation, but also improves the net gas production rate of biological raw materials. Pei Xiaomei [13] Reference source not found designed a solar-biogas slurry waste heat pump high-temperature anaerobic fermentation heating system. The heat recovered from the biogas slurry waste heat in this system accounts for 70% of the total heat required by the anaerobic fermentation device[14] Reference source not found By comparing and analyzing the gas production performance of Sweden high-temperature fermentation and Jiangsu medium-temperature fermentation on the same scale, it is concluded that high-temperature fermentation and waste heat recovery can improve the fermentation gas production efficiency. Wang Shuxia[15] reference source not found analyze the net capacity characteristics of biogas project by energy efficiency ratio and net capacity.It is concluded that the recovery of biogas slurry waste heat can raise the average fermentation temperature of biogas project from 28.9℃ to 36.5℃. Under the same feed concentration, the maximum net production capacity before and after biogas slurry waste heat recovery can increase by 11.5%, and its corresponding energy efficiency ratio increases by 53.1%.According to the rheological characteristics of biogas slurry, Han Jingyi[16] designed a regenerator with an arcuate structure. Numerical simulation showed that the waste heat recovery of biogas slurry in the system accounted for 61% of the total heat demand of the system.And that stability of the biogas engineer system is improved.

Waste heat recovery and biogas slurry reflux should be completed after solid-liquid separation in the discharge of biogas project, so it is very important to select a reasonable solid-liquid separation device.At present, there are three main technologies used for solid-liquid separation in biogas projects at home and abroad: centrifugal, filter pressing and sieving. Among them, spiral extrusion separators with low energy consumption and high reliability are widely used in the fields of livestock manure treatment and biogas slurry and residue separation[17-18]. However, these solid-liquid separation methods have high fixed investment and require a lot of maintenance costs, and are only suitable for biogas projects above 200 m^3The discharge of small and medium-sized biogas projects usually selects farmland for digestion and nearby discharge after sedimentation. However, due to the reasons of planting season, biogas slurry that cannot be completely digested in farmland not only increases the cost of sewage discharge, but also causes environmental pollution.

To sum up, this paper has developed a regenerative mass recovery device with solid-liquid separation, and tested its warming performance through experiments, so as to provide a selection basis for the actual operation of small and medium-sized biogas projects.



1-Thermal insulation layer 2-Stainless steel body 3-Press plate 4-Grille 5-Dispensing column 6-Dispensing port 7-Regenerative heat and mass return pipe 8-Feed pipe

Fig.1 Schmatic diagram of the overall structure of the device

2. PAPER STRUCTURE

2.1 Overall Structure

The regenerator with solid-liquid separation consists of a stainless steel main body, a grid, a pressing plate, a separating column, an insulating layer, an electric hoist suspension device, a self-suction sewage pump, a stirrer and the like.The device has a drawer-type structure, and is divided into a biogas residue layer, a feed layer and a biogas slurry layer from top to bottom. The middle of the device is provided with four Uniform distribution liquid separation columns, which are fixed at the bottom of the feed layer to ensure that the biogas slurry after solid-liquid separation flows into the biogas slurry layer through the liquid separation columns, and then is recycled by a self-suction sewage pump.The overall structure is shown in fig. 1.

2.2 Working principle

Biogas slurry retrogradation refers to the introduction of biogas slurry after solid-liquid separation into fermentation tank according to a certain proportion for reuse.Biogas slurry contains a large number of methanogenic bacteria and incompletely decomposed organic matters. After being recycled, the decomposition rate of organic matters can be improved, the gas production rate can be accelerated, and the biogas yield can be increased.At the same time, biogas slurry recycling plays an important role in saving water and reducing emissions for biogas projects.The biogas slurry discharge and water demand can be reduced by 40% through retrogradation.On the one hand, the heat recovery of biogas slurry is through recovering the residual heat of biogas slurry retained by the recycled biogas slurry;On the other hand, high-efficiency heat exchange is adopted to recover the heat in the residual biogas slurry, increase the feed temperature, realize waste heat utilization and reduce the heating load of the system.

During the operation of the heat and mass return device with solid-liquid separation, the top laminate is suspended by the electric hoist, and the discharged materials are discharged to the upper part of the grid, with the aperture of the grid being 70 mesh.Put down the pressing plate, and carry out solid-liquid separation under the action of extrusion pressure and gravity. The separated biogas slurry flows to the biogas slurry layer through four liquid separation columns, and the biogas residue remains in the biogas residue layer to complete solid-liquid separation.After the solid-liquid separation is completed, the biogas residue layer is suspended, the feed is introduced into the feed layer, and 40% of biogas slurry is returned to the feed layer through a self-suction sewage pump to complete the quality return.The remaining biogas slurry heats the feed through a direct heat exchange mode, and the heated feed is introduced into the fermentation tank through a single screw pump.After heat exchange, the sewage is pumped into the outside under the action of a self-suction sewage pump to be absorbed by farmland.tate the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

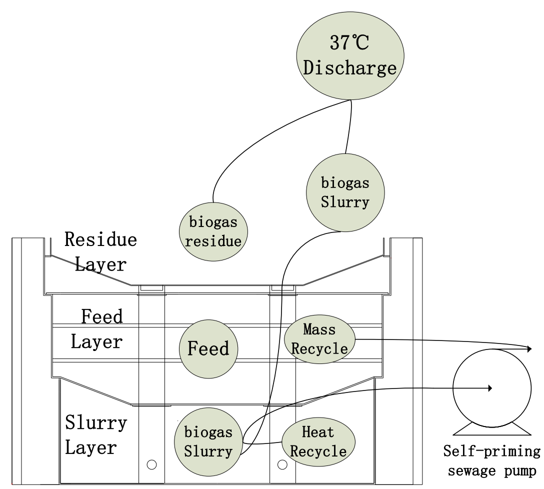


Fig.2 schematic diagram of regenerative mass recovery device

2.3. Results

2.3.1 Test Analysis

According to the biogas slurry regeneration test, 40% of the regeneration ratio was selected for regeneration test. Through the change of regeneration time and feed temperature, the proportion of feed temperature rise and heat recovery to the heat required by the system to maintain constant temperature fermentation at 37℃ was calculated to determine the improvement of the operation stability and reliability of the biogas project by the regeneration regeneration device.

As shown in Figure 5, the temperature change diagram of biogas slurry during the regenerative operation of biogas project is shown. The regenerative regenerative device is installed in the feed room with good heat preservation effect, so it can maintain the ambient temperature higher than that of Homeostasis.The indoor temperature is 18.3℃, the fresh cow dung temperature is 18.7℃, the tap water temperature is 14.8℃, add appropriate amount of water and fresh cow dung into the feed layer, the temperature of the feed layer is 16.2℃ after uniform stirring, the temperature of biogas slurry obtained after discharging with fermentation temperature of 37℃ through discharging pipe and solid-liquid separation is 33.2℃.40% of the biogas slurry is introduced into the feed layer, and the rest of the biogas slurry is left in the biogas slurry layer to be heated and fed, the temperature of the feed layer is 25.9 ℃ after being recycled, the temperature of the feed layer reaches a maximum value of 26.6 ℃ after heat exchange for 220 minutes, and the heat of the biogas slurry waste heat recovery heating feed accounts for 51.9% of the heat required for maintaining constant temperature fermentation at 37 ℃.

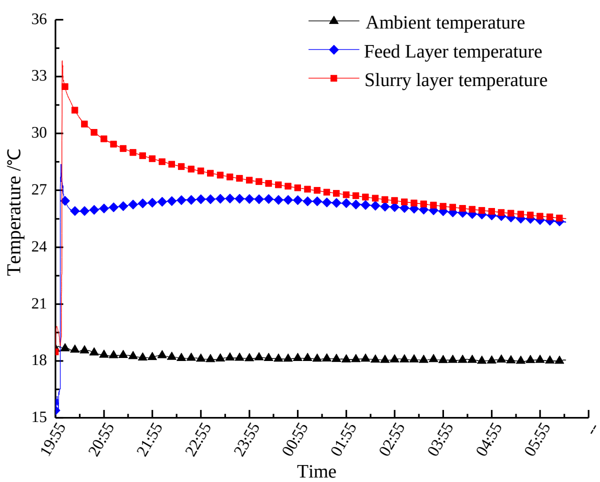


Fig.5 Diagram of temperature change under recycle mass before heat

2.3.2 Test Analysis of Regenerative Heat and Quality in Winter

As shown in fig. 6 is the temperature change diagram of return heat and mass under winter conditions, the indoor ambient temperature in winter can be relatively stably maintained at 35℃.The feed is placed outdoors and the feed temperature is close to the ambient temperature.

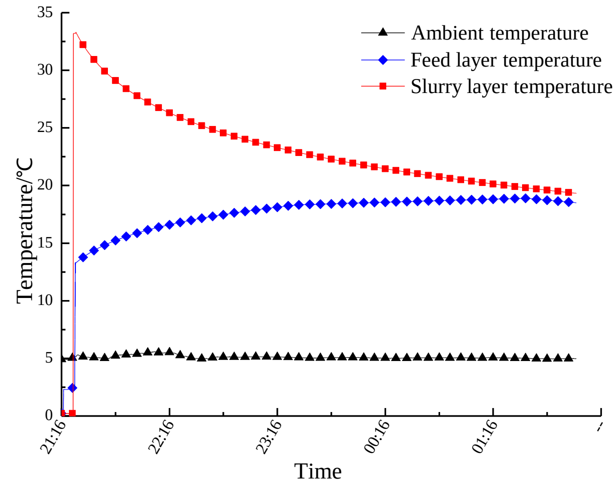


Fig..6 Diagram of temperature change of heat and mass recycle in winter

In this experiment, fresh cow dung at 0℃ is taken as the feed for the biogas project in winter, which accords with the actual operation conditions of the project. The tap water pipe is installed in the feed room, and the outlet water temperature is 3.2℃.After a proper amount of tap water and cow dung are uniformly mixed, the temperature of the feed layer is 2.5℃, 40% of biogas slurry is introduced into the feed layer, the temperature of the feed layer after uniform mixing is 13.3 ℃, and the temperature of the feed layer reaches 18.9 ℃ after reheating for 280 minutes.The heat recovered from waste heat of biogas slurry accounts for 47.2% of the heat required for maintaining 37℃ constant temperature fermentation in the biogas project in winter.Therefore, the regenerative quality has good benefits in winter and effectively improves the stability of the biogas project.

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

2.4 Conclusions

Under the condition of adopting good heat preservation measures, the heating feed load accounts for 89.3% and 93.2% of the total heat load of the system.Under the condition that the ambient temperature is 18℃, the feed at 16.2℃ can be heated to 26.6℃ by the regenerative regeneration, accounting for 51.9% of the heat required for constant temperature fermentation.Under winter conditions, the feed at 2.5℃ can be heated to 18.9℃ by regenerative heat and mass recovery, accounting for 47.2% of the heat required for constant temperature fermentation in winter.

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