SOLAR HEATING SYSTEM USING PARABOLIC COLLECTOR FOR THERMAL OPTIMUM CONDITIONS OF BIOGAS PRODUCTION IN WINTER

By

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B. Sc. Agric. Sc. (Agricultural Engineering), Ain Shams University, 2013

A Thesis Submitted in Partial Fulfillment

Of

The Requirements for the Degree of

MASTER OF SCIENCE
in
Agricultural Sciences
(Farm Machinery and Power Engineering)

Department of Agricultural Engineering

Faculty of Agriculture

Ain Shams University

2019

Approval Sheet

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ABSTRACT

Sara Mohamed Gamal El-Din Hassan: Solar Heating System Using Parabolic Collector for Thermal Optimum Conditions of Biogas Production in Winter, Unpublished M.Sc. Thesis, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University, 2019.

Due to the growing demand of energy, a lot of studies were directed to anaerobic digestion. Anaerobic digestion is influenced by several factors. Fermentation temperature is one of these factors. Both temperature range and temperature fluctuations affect greatly biogas production. It is difficult to attain the required optimum temperature in cold climates. Therefore, the digester needs to be supplied with external thermal energy to reach the desired temperature.

The aim of this study is to enhance the fermentation temperature inside the digester by supplying the required thermal energy to be within the optimum range (mesophilic range) for biogas production during winter "cold days" via solar energy technique.

The experiment was carried out at Solar Energy Laboratory, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University through December 2018 and January 2019. Two 50 L digesters were used in the experiment. One was insulated and connected to a parabolic trough (treatment), while the other operated at the ambient temperature (control). The temperature in the treatment digester was raised by pumping water, which was heated via solar radiation, into a simple heat exchanger that was installed inside the digester. The treatment digester is also equipped with a mechanical stirring shaft to maintain a hemogenic slurry and to guarantee the thermal distribution throughout the digester. A simple tracking circuit was used to navigate the parabolic trough collector automatically towards the sun throughout the day. The results show that the average temperature in the control digester through the experiment was 21.5 °C, while it was 27.08 °C in the treatment digester. This means that the parabolic trough collector enhanced the fermentation temperature in the

treatment digester by 20.6%. The accumulative biogas yields of the control digester and the treatment digester through the experiment were 9684.7 mL/kg. T.S. (0.0304 m^3) and 24649.69 mL/kg. T.S. (0.0774 m^3) respectively. By comparing both productivities, it was found that the productivity of the treatment digester was 2.5 times more than the productivity of the control digester.

Keywords: Anaerobic digestion, Biogas productivity, Fermentation temperature, Solar energy, Parabolic trough, Heat exchanger, Solar tracking, Control unit.

ACKNOWLEDGEMENT

First and foremost, thanks to Allah for everything.

My sincere thanks and gratitude are due to **Prof. Mubarak Mohammed Mostafa** (Prof. Emeritus of Agricultural Engineering, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University) for his kindly supervision and valuable advice. His continuous suggestions, discussions, support and guidance helped me throughout this work. I could not have imagined having a better advisor and mentor.

My deep gratitude and appreciation are due to **Prof. Abdel-Ghani El- Gindy** (Prof. Emeritus of Agricultural Engineering, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University) for his exceptional support, encouragement, and his nonstop guidance. Also, his constructive criticism and his crucial comments assisted me a lot to improve my work.

Also, I would like to gratefully acknowledge **Dr. Ashrf Abdel-Galil Anwar** (Lecturer of Agricultural Engineering, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University) for his priceless suggestions, pivotal advice, insightful comments, and for granting his precious time to review the thesis.

Special thanks to Agricultural Engineering staff members, and lab mates for their support and help throughout the experiment.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
A	Surface area
Aa	Aperture area
AD	Anaerobic digestion
Ar	Receiver area
C	Specific heat
CRg	Geometrical concentration ratio
D	Parabola width
Dout	Evacuated tube outer diameter
dout	Serpentine outer diameter
ET	Evacuated tube
f	Focal length
Gb	Incident solar beam radiation Heat transfer coefficient
h	Parabola depth
HRT	Hydraulic retention time
HTF	Heat transfer fluid
I_h	Solar radiation incident on horizontal surface
K	Heat conductivity coefficient
l	Absorber length
$\dot{m}$	Mass flow rate
n	Day number of year
PTC	Parabolic trough collector
Q	Heat load
Q_L	Rate of heat loss from digester
Q_s	Received solar energy
$\dot{Q}_u$	Useful energy gained in the working fluid
Q_w	Rate of heat transfer to manure
ta	Ambient temperature
ts	Solar time
R	Solar radiation

α	Solar altitude angle
β	Tilt angle of solar collector
δ	Solar declination angle
Φ	Latitude angle
ω	Hour angle
η_0	Overall thermal efficiency