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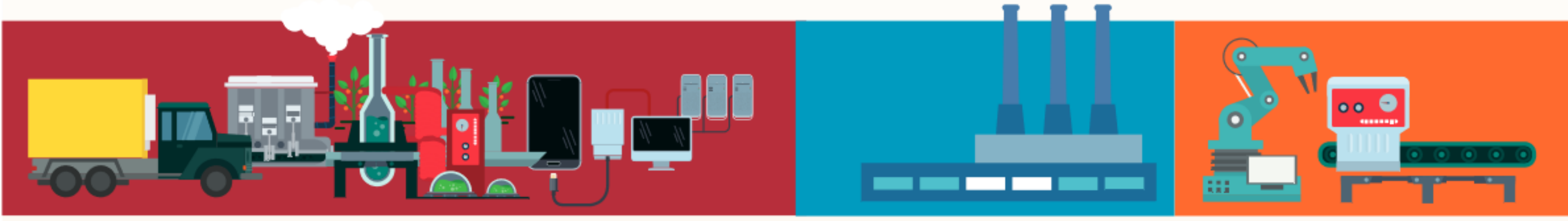

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Towards Industry 4.0: Challenges and Opportunities for Industrial Technology and Other Sectors

January 28 - 30, 2020
Faculty Building, 3rd floor
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PREFACE
WELCOME FROM THE RECTOR
INSTITUT TEKNOLOGI NASIONAL BANDUNG

Dear speakers and participants,
Welcome to Bandung and welcome to Itenas campus!
It is great pleasure for me to welcome you in campus of Itenas Bandung at the 2^{nd} Faculty of Industrial Technology International Congress (FoITIC) 2020.
The theme for the 2^{nd} FoITIC (FoITIC 2020) “Towards Industry 4.0: Challenges and Opportunities for Industrial Technology and Other Sectors”, is very relevant and we are sure that presently the term of “industry 4.0” is one hot issues in over the world.
We believe that scientists and researchers will hand in hand with industrial experts, to create and develop new concept/system related to technologies that enable human to make products and services more efficient in various sector.
I am deeply grateful appreciative to the Faculty of Industrial Technology Itenas, Szent Istvan University Hungary, Universiti Malaysia Pahang Malaysia, Universiti Teknikal Malaysia Melaka, Indonesian Society Reliability, delegates, organizing committee and many others who have contributed to the success of this conference.
I am confident that this event will serve to promote much valuable communication and information exchange among scientist – researcher and industrial expert.
May we have a successful, stimulating, fruitful and rewarding the conference.
Again, thank you for visiting our campus, and let’s hand in hand together to overcome the challenges today, and ready to meet the next challenges.

Dr. Iman Aschuri
Rector
Institut Teknologi Nasional Bandung

PREFACE

WELCOME FROM THE DEAN OF FACULTY OF INDUSTRIAL TECHNOLOGY, INSTITUT TEKNOLOGI NASIONAL BANDUNG

Dear distinguished Guest, Ladies and Gentlemen,

Welcome to the 2nd Faculty of Industrial Technology International Congress (FoITIC) 2020, which is organized by Faculty of Industrial Technology, Institut Teknologi Nasional (Itenas), Bandung – Indonesia, with supported by Szent Istvan University (SZIU) – Hungary, Universiti Malaysia Pahang (UMP) – Malaysia, Universiti Teknikal Malaysia Melaka (UTeM) – Malaysia and Indonesian Society for Reliability (ISR).

The main theme for the 2nd congress is ‘Towards Industry 4.0: Challenges and Opportunities for Industrial Technology and Other Sectors’.

The aim of the Congress is inviting academics, researchers, engineers, government officers, company delegates and students from the field of industrial technology and other disciplines (such as electrical, mechanical, industrial, chemical, informatics, civil, architect, physics, environment, social, economic, design and etc.), to gather, present and share the results of their research and/or work and discuss the future and impact of industry 4.0.

Taking this opportunity, I would like to convey my sincere thanks and appreciations to our keynote speakers and invited speakers from Szent Istvan University Hungary, Universiti Malaysia Pahang, ProcodeCG, Indonesian Society for Reliability, and Industrial Engineering Department Itenas, and national and international scientific committee for their support of this important event. I would also like to invite all participants in expressing our appreciation to all members of the FoITIC 2020 organizing committee for their hard work in making this conference success.

Finally, we wish you all fruitful networking during conference, and we do hope that you will reap the most benefit of it.

Do enjoy your stay in Itenas Bandung campus, and thank you very much!

Dr. Dani Rusirawan

Dean Faculty of Industrial Technology – Institut Teknologi Nasional Bandung

Chairman of FoITIC 2020

ACKNOWLEDGEMENT

The completion of this undertaking could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. The contributions are sincerely appreciated and gratefully acknowledged. However, we would like to express our especial deep appreciation and gratitude to the following:

1. Institut Teknologi Nasional Bandung (Itenas) – Indonesia
2. Szent Istvan University (SZIU) – Hungary
3. Universiti Malaysia Pahang (UMP) – Malaysia
4. Universiti Teknikal Malaysia Melaka (UTeM) – Malaysia
5. Indonesian Society for Reliability (ISR) – Indonesia
6. ProCodeCG – Indonesia

KEYNOTE AND INVITED SPEAKERS INTERNATIONAL CONFERENCE

Prof. Dr. Istvan Farkas (Szent Istvan University)

Prof. Dr. Istvan Farkas is Director of Institute for Environmental Engineering System, Szent Istvan University (SZIU), Godollo – Hungary. He is also Head of Department Physics and Process Control and head of Engineering Doctoral School, at SZIU. He got Doctoral Degree from Technical University Budapest (1985). Presently, a lot of his activities devotes on International professional societies such as: International Solar Energy Societies (ISES), International Federation of Automatic Control (IFAC), European Federation of Chemical Engineering (EFChE), European Thematic Network on Education and Research in Biosystems Engineering, European Network on Photovoltaic Technologies, FAO Regional Working Group on Greenhouse Crops in the SEE Countries, Solar Energy Journal Associate Editor, Drying Technology Journal Editorial Board, etc. He was a visiting Professor in several universities: Solar Energy Applications Laboratory, Colorado University State University, Fort Collins - USA; Department of Energy, Helsinki University of Technology, Espoo - Finland; Institut for Meteorology and Physics, University of Agricultures Sciencies, Vienna - Austria; Laboratory of Bioprocess Engineering, The University of Tokyo - Japan.

Prof. Dr. Rizalman Mamat (Universiti Malaysia Pahang - Malaysia)

Prof. Dr. Rizalman Mamat presently is a Professor of Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang, Malaysia. Previously he was Dean of Faculty of Mechanical and Automotive Engineering Technology. He got Doctoral degree from University of Birmingham, United Kingdom in fuel and energy. Previously, he obtained his BSc and MSc from University Teknologi Malaysia (UTM). His field research interest is Heat transfer, Combustion, Internal Combustion Engine, Alternative Energy, Computational Fluid Dynamics, Propulsion System. Prof. Dr. Rizalman Mamat was visiting Professor at Karlsruhe University of Applied Science Germany (2017), Faculty of Engineering Universitas Abulyatama Aceh, Indonesia (2017), Faculty of Engineering Universitas Gajah Putih Aceh, Indonesia (2017), Department of Mechanical Manufacture & Automation Ningxia University, Yinchuan, China (2016), Department of Mechanical Manufacture & Automation Ningxia University, Yinchuan, China (2015).

Ahmad Taufik, M.Eng., Ph.D (Indonesian Society for Reliability)

Ahmad Taufik, M.Eng, Ph.D (Graduated from Georgia Institute of Technology, USA – 1996) is a lecturer and a professional trainer and consultant. He is member of American Society for Metals (ASM) and American Society for Mechanical Engineer (ASME). He performs research in fatigue and fracture mechanics of oil and gas pipeline. Dr. Ahmad Taufik highly experienced in providing industrial training and consulting work more than 20 projects related to Pipelines Failure Analysis, Risk and

Reliability Assessment, Repair Design, Pipeline Corrosion Protection in Oil and Gas Industries. Dr. Ahmad Taufik has been chairman and speakers for many Oil and Gas International Conferences in Indonesia, (INDOPIPE, MAPREC), Malaysia (ASCOPE), Singapore and China (IPTEC) for the last five years. He is founder of Indonesian Society Reliability (ISR) and presently he is a chairman of the ISR. Since 2006, he was work as part time lecturer at Dept. of Mechanical Engineering, Itenas.

Dr. Marisa Paryasto, ST., MT. (ProCodeCG)

Dr. Marisa Paryasto is a profesional part-time at Electrical Engineering Department – Computer Engineering – Telkom University. She earned the bachelor degree in Electrical Engineering from ITENAS Bandung and the master and doctoral degree in Electrical Engineering from STEI – Institut Teknologi Bandung. She is a member of IEEE and actively reviewing papers for international/national journal and conferences. She is currently an active researcher at Institut Teknologi Bandung and also running several businesses. She is the founder of ProCodeCG, a start up focusing education and research on programming and Information technology, mostly for teaching kids to be able to deal with future’s challenges and technology. She is very experienced in teaching and computer engineering. She is familiar and expert in programming, cryptography, security, Internet of Things, artificial intelligence, machine learning, BlockChain technology and recent technology implementations.

Dr. Fahmi Arif, ST., MT. (Institut Teknologi Nasional Bandung)

Dr. Fahmi Arif has received his Bachelor of Engineering in Mechanical Engineering (ITENAS Bandung, Indonesia), Master of Engineering in Industrial Engineering (ITB Bandung, Indonesia), and PhD in Industrial Computing (UTeM Melaka, Malaysia). Along with his formal education, he also earned several professional certifications. He is a Certified Data Science Professional (certification by IBM). After several years working overseas in the field of education and consultancy as well, currently, he is working in his hometown as a Head of Graduate Program in the Department of Industrial Engineering at Institut Teknologi Nasional Bandung. Along with his career, he has published various articles in some international conferences and journals. He also serves as a reviewer in some local and international journals such as the Journal of Information and Organizational Science and the editorial board for the Journal of Intelligent System. His research interest is in data science, artificial intelligence, and machine learning especially for its application in industrial automation. Currently, he is working in some research projects in the field of Industrial Information Integration and Cyber-Physical System in Industry 4.0 environment.

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Effect of nanofluid concentration on the performance of PV/T collector under the tropical climate of Indonesia

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Abstract

Solar energy is a very potential and most abundant source energy available and it is free of cost in consuming this type of energy. Flat plate solar collector is a device that can transform solar energy into the thermal energy and can be implemented to PV/T solar collector. In this study, a modified flat-plate PV/T solar collector was built by attaching the thermal collector underneath the PV collector surface. The application of nanofluid in the PV/T solar collector as a heat-absorbing medium needs to be developed and characterized in different environments condition. The effect of nanofluid concentration on the performance of the PV/T collector was investigated according to EN 12975-2 standard. The volume fraction of the nanoparticles used in the present study were 0.3%, 0.6% and 0.9%, respectively. The efficiency of the system was compared to the water as a base fluid performed in low latitude tropical region (Bandar Lampung climate). The experimental result shows that an increase of zero thermal efficiency up to 18% which is obtained by using nanofluid at the volume fraction of 0,9%.

Keywords: Solar, collector, PV/T, nanofluid, PV/T, tropical

1. Introduction

The sun is a renewable energy source that has several advantages such as being easily available, free of pollution and available in considerable quantities. A flat plate solar thermal collector is a device used to harness solar energy. This type collector is widely used to absorb solar radiation and transform it into heat energy which produces domestic hot water. In other applications, this type collector also can be implemented to absorb the excess heat collected on the surface of solar cell (Photovoltaic). Therefore, the attaching the two surfaces between the thermal collectors and the solar cells is a good way to solve the problem with respect to the excess heat on the solar cell surface. In particular, this type collector is called as a hybrid Photovoltaic/Thermal (PV/T) collector.

The PV/T collector can generate thermal and electricity energy simultaneously. Another advantage of using this type of collector is that the electrical efficiency remains stable even increases due to absorbing the excess heat by the working fluid on the surface temperature of the PV. Besides producing electricity, the PV/T collectors also produce hot working fluid so that they can be used for various purposes such as the heating process in industry and the health sector, household needs and other needs. Investigations have been carried out and reported over the last 25 years by several researchers (Abdelrazik et al. 2018, Amrizal et al. 2010, 2012, 2013, 2017) those are related to the evaluation of thermal and electrical output. They present experimental work, analytical, numerical models, simulation and the development of performance testing processes.

Concerning to the traditional working fluids of the PV/T solar collector, in fact, water or oil based fluids used in the PV/T collector have low thermophysical properties in term of thermal conductivity and specific heat capacity. Nanofluid shall be alternatively applied to this type collector in enhancing the performance of the collector. In this context, Das et al. (2006) introduced nanofluid that contain a small quantity of nanoparticles which have diameter usually less than 100 nm. It is mixed with conventional fluids providing more heat transfer ability. The solid particle dispersed in base fluid such as thermal oils, refrigerant, ethylene glycol or water (Yazdanifardet et.al 2017, Bellos et al. 2018, Khanafer and Vafai 2018. This could be important because by implementing nanofluid, the heat transfer of the fluid can be increased significantly (Mahbubul, 2019).

Significant findings have obtained by several researchers for metal oxide nanoparticles added into different base fluids which are called it as nanofluids. Sardarabadi and Passandideh (2016) presented an experimental study and a numerical of a PV/T collector with several types of nanoparticles. Al_2O_3, TiO2 and ZnO are used in this study were as nanofluids. The authors concluded that ZnO nanofluid and TiO2 nanofluid have the higher electrical efficiency than Al_2O_3 nanofluid.

Hashim et al. (2015) conducted an experimental work of the effect of using Al_2O_3 nanofluid as a cooling medium for the PVT collector system based on forced convection. Several different concentrations of Al_2O_3 nanofluid were tested (0.1, 0.2, 0.3, 0.4 and 0.5%). The results show that the temperature decreased significantly to 42.2°C and the electrical efficiency increase 12.1% at a concentration of 0.3%.

The experimental and numerical studies of a PVT system cooled by nanofluids was introduced by Rejeb et al. (2016). Nanoparticles (Al_2O_3 and Cu) are tested by the authors at three different concentrations (0.1, 0.2, and 0.4 wt %) with fluids (ethylene glycol and water) on the performance of the system. The results show that the thermal and electrical efficiencies of water as a base fluid is more effective than ethylene glycol.

Concerning several literatures, they studied the size, arrangement, location, and type of fluid used for cooling in PV/T collector. However, studies by using nanofluid as a coolant under the tropical climate is still limited in Indonesia, for that it is necessary to investigate the behavior of the PV/T collector in the present study since it enhances heat transfer process substantially.

2. Experimental methods

The collector utilized in this work was performed by attaching the solar thermal collector under the surface of PV cell as presented in Figure 1. This type collector was tested in Bandarlampung, at the Department of Mechanical Engineering, Universitas Lampung – Indonesia. Bandarlampung is the capital of the Lampung Province, Indonesia and the geographical coordinates are 5.25 °S and 105.17 °E. The Bandarlampung zone has a typical tropical climate which is characterized as dry and rainy seasons. The effect of nanofluid concentration on the thermal performance was investigated according to EN 12975-2 (2006) standard. The volume fraction of the nanoparticles used in the present study were 0.3%, 0.6% and 0.9%, respectively. The performance of the system was compared to the water as a traditional working fluid performed under low latitude tropical region (Bandar Lampung climate) and the average ambient temperature of 27 ^{o}C.

2.1. Experimental procedures

The collector must be tested under incident radiation more than 500 W/m^2. Data collection were recorded for inlet and outlet fluid temperatures, ambient temperature and incident radiation, respectively. Then, the temperatures and radiation were measured using K-type Thermocouples and Solar Power Meter SPM 1116SD, respectively. According to EN 12975-2 standard, the mass flow rate of the working fluid was regulated by using a valve at a constant flow rate of 0.02 kg/m^{2}s. Electrical heaters were used in order to vary inlet fluid temperatures during the tests.

Fig. 1: PV/T collector

2.2. Characterization of PV/T solar collector

In generally, equations of solar thermal collector performance are given as follows.

$$q_u = F^{'}[(\tau\alpha)G \quad - U_L(T_m - T_a)] \tag{1}$$

$$q_u = \dot{m}c_p(T_m - T_a)/A_c \tag{2}$$

The above equations are based on the energy balance in which equation (1) is known as The Hottel-Whillier-Bliss equation (Dufie et al. 2006) where $F^{'}(\tau\alpha)$ is the zero loss efficiency, $F^{'}U_L$ is the overall heat loss coefficient, respectively. From equation (2) $\dot{m}$ is the mass flow rate of fluid, c_p is the heat capacity of fluid, $(T_m - T_a)$ is the temperature difference and A_c is the area of absorber plate. Furthermore, electrical efficiency of the PV/T collector is obtained from equation 3

$$\eta = \frac{P}{GA} \tag{3}$$

where P is electrical power given by PV/T collector during the tests (P = VI), G is solar radiation and A is area of the collector.

3. Result and Discussion

Several performance tests were conducted in relation to the different nanofluid volume fraction and the inlet fluid temperature, respectively. Table 1 presents the results of the surface temperature and electrical power. Furthermore, the electrical efficiency is shown in Figure 2. Four types of working fluid were implemented such as water only and three different concentrations of TiO_2 nanofluid.

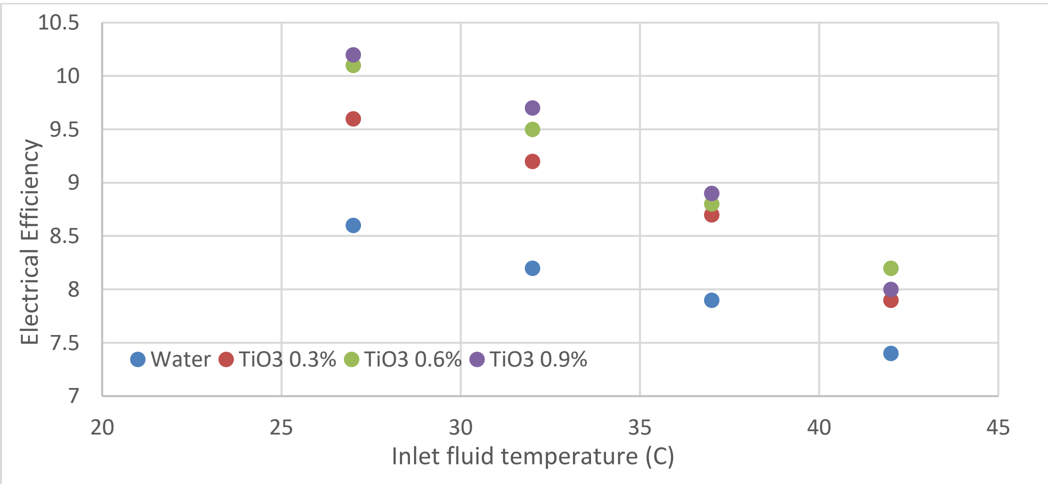

Fig. 2: Electrical efficiency versus inlet fluid temperature

Concerning the thermal performance in the current work, it describes the effect of water and TiO_2 nanofluid as a base fluid with different nanofluid volume fraction. The values of zero thermal efficiency parameter are 0.58, 0.71, 0.68, 0.66, 0.65 for water, TiO_2 nanofluid 0.3%, TiO_2 nanofluid 0.6%, TiO_2 nanofluid 0.9%, respectively. In comparison with the water only, there is an increase of zero thermal efficiency ($F'(\tau\alpha)_e$) up to 18% which is obtained by using nanofluid at the volume fraction of 0,9%. The significant different between the two results with and without nanofluid because of the heat transfer can be increased as well as the thermal performance of the whole system. Consequently, the nanofluid absorb more heat than that of the conventional fluid water.

In term of the electrical performance, as shown in Figure 2 the surface temperature of PV collector with 0.9% of TiO_2 nanofluid has lowest value in comparison with the others. Consequently, this might give the highest value of electrical efficiency about 10.2 %. Therefore, the nanofluid implemented on the PV/T collector has better thermal performance than the water only as a base fluid. In case of increasing the concentration in the current work, it does not significantly affect the electrical efficiency of the PV/T solar collector with respect to each others. The values for electrical power from different volume fraction of the TiO_2 nanofluid are almost constant and a small different is given in the values for electrical efficiency.

Table 1: average temperature of the PV surface and power based on the inlet fluid temperature different concentration of TiO_2 nanofluid

Inlet Fluid Temperature (^0C)	Water only		TiO_2 nanofluid (0,3%)		TiO_2 nanofluid (0,6%)		TiO_2 nanofluid (0,9%)	
	T_s (^0C)	Power (W)	T_s (^0C)	Power (W)	T_s (^0C)	Power (W)	T_s (^0C)	Power (W)
27	59,36	31,22	57,80	35,79	55,60	36,33	53,5	36,75
32	62,82	29,60	60,80	33,69	58,70	34,19	56,6	34,90
37	66,30	28,38	63,62	31,50	62,20	31,86	60,2	32,51
42	70,35	27,20	68,81	28,83	66,60	29,38	64,15	29,91

*T_s (C) : average temperature of the PV surface

4. Conclusion

Effect of nanofluid concentration on the behavior of PV/T flat-plate solar collectors has been characterized. The parameters that characterize the PV/T collector are zero thermal efficiency, the overall heat loss coefficient, average temperature of the PV surface and electrical efficiency. The performance of the system was compared to the water as a base fluid implemented in low latitude tropical region (Bandar Lampung climate). The experimental result shows that an increase of zero thermal efficiency up to 18% which is obtained by using nanofluid at the volume fraction of 0,9%. Furthurmore, the surface temperature of PV collector with 0.9% of TiO_2 nanofluid has lowest value in comparison with the others. The TiO_2 nanofluid absorbs more heat than that of the conventional fluid water. However, the values for electrical power from different volume fraction of the TiO_2 nanofluid are almost constant.

5. Nomenclature

F' collector efficiency factor m^2
G solar radiation W/m^2
T temperature C
$\dot{m}$ mass flow rate kg/s
q energy gain W
k thermal conductivity W/mC
c heat specific of fluid J/kgC
U overall heat loss coefficient W/m^2C
A area m^2
V Voltage V
I current Ampere

Greek letters

α absorbtivity -
τ transmissivity -

Subscripts

a ambient
m mean
s surface
u usefull
p pressure

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