POTENSI PENERAPAN NANOGENERATOR UNTUK MENINGKATKAN KEMANDIRIAN ENERGI DI BANDAR UDARA: OPTIMALISASI SUMBER ALTERNATIF ENERGI HIJAU

LAPORAN HASIL PENELITIAN

[1]Direstu Amalia, [2]Viktor Suryan, [3]M. Indra Martadinata, [4]Almuzani,
[6]M.Alamsyah, [7]Nabilah Hasna Arinda, [8]Made Putra Darsana

direstu@poltekbangplg.ac.id, viktor@poltekbangplg.ac.id,
indrakoe@poltekbangplg.ac.id

PUSAT PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT
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LEMBAR PENGESAHAN HASIL PENELITIAN

1	Judul Penelitian	Potensi Penerapan Nanogenerator Untuk Meningkatkan Kemandirian Energi di Bandar Udara: Optimalisasi Sumber Alternatif Energi Hijau
2	Bidang Kajian	Smart Airport
3	Ketua Peneliti	
	a. Nama Lengkap	Ir. Direstu Amalia, S.T., MS. ASM
	b. NIP/NIK	198312132010122003
	c. NIDN	42131283
	d. Pangkat/Golongan	III/c
	e. Jabatan Fungsional	Dosen-Lektor
	f. Program Studi/Jurusan	Sarjana Terapan-Teknologi Rekayasa Bandar Udara
	g. Telp/Faks/Email	0811-6111331
	h. Sinta Author id	6741807
	i. Scopus author id/H-Indeks	57211433043/h-index 1
4	Anggota Peneliti 1	
	a. Nama	Ir. Viktor Suryan, S.T., M.Sc
	b. NIDN	42081086
	c. Program Studi	Sarjana Terapan-Teknologi Rekayasa Bandar Udara
	d. Perguruan Tinggi	Politeknik Penerbangan Palembang
5	Anggota Peneliti 2	
	Nama	Ir. M.Indra Martadinata, S.SiT, M.M
	NIDN	4206038101
	Program Studi	Sarjana Terapan-Teknologi Rekayasa Bandar Udara
	Perguruan Tinggi	Politeknik Penerbangan Palembang
	Anggota Peneliti 3	
	Nama	Almuzani, S.T.
	NIDN	-
	Program Studi	Sarjana Terapan-Teknologi Rekayasa Bandar Udara
	Perguruan Tinggi/Institusi	PT. Angkasa Pura Indonesia
	Anggota Peneliti 4	
	Nama	Yeti Komalasari
	NIDN	42250587
	Program Studi	Diploma III-PPKP
	Perguruan Tinggi	Politeknik Penerbangan Palembang
6	Lama Penelitian	6 Bulan
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Menyetujui,
Ketua Program Studi,

Ir. M. Indra Martadinata, S.ST. Msi
NIP. 19810306 200212 1 001

Palembang, Oktober 2024
Ketua Peneliti,

Ir. Direstu Amalia, S.T., MS.ASM
NIP. 19831213 201012 2 003

Mengetahui,
Kepala Pusat PPM



Yeti Komalasari, S.SiT, M.Adm.SDA
NIP. 19870525 200912 2 005

KATA PENGANTAR

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PENERAPAN *PIEZOELECTRIC ENERGY HARVESTING* DI BANDAR UDARA: SUMBER ENERGI, MATERIAL DAN DESAIN

APPLICATION OF PIEZOELECTRIC ENERGY HARVESTING AT AIRPORTS: ENERGY SOURCES, MATERIALS AND DESIGN

Direstu Amalia[1], Viktor Suryan[2], M. Indra Martadinata[3], Almuzani[4], M. Alamsyah[5], Nabila Hasna Arinda[6], Made Putra Darsana[7]
[1,2,3,4,5,6,7]Politeknik Penerbangan Palembang
direstu@poltekbangplg.ac.id

ABSTRACT

Airports have many areas with intensive activities that can be potential sources for Piezoelectric Energy Harvesting because airports are places that produce much mechanical energy that has not been realized. This mechanical energy comes from various sources, such as passenger and visitor traffic, vehicle movement, elevator and conveyor use, and aircraft activity on runways and taxiways. The research methodology used is a Literature Review. This article reviews the factors that affect PEH, namely energy sources, materials, and design, and it is a literature study article related to smart airport technology. This article aims to establish hypotheses of influence between variables as a reference for further research. This literature review article will produce: 1) Energy source affects Piezoelectric Energy Harvesting; 2) Materials affect Piezoelectric Energy Harvesting; and 3) Design affects Piezoelectric Energy Harvesting. This research will produce a deeper understanding of the potential mechanical energy utilized at airports and how energy harvesting technology can be applied to optimize these mechanical energy sources. Hopefully, this article will provide an overview of designing Piezoelectric Energy Harvesting suitable for airports.

Keywords: *Piezoelectric, Energy Harvesting, Energy Sources, Materials and Design.*

ABSTRAK

Bandar udara memiliki banyak area dengan aktivitas intensif yang dapat menjadi sumber potensial untuk Piezoelectric Energy Harvesting karena bandar udara adalah tempat yang menghasilkan banyak energi mekanis yang selama ini belum disadari kebermanfaatannya. Energi mekanis ini berasal dari berbagai sumber, seperti lalu lalang penumpang dan pengunjung, pergerakan kendaraan, penggunaan elevator dan conveyor, serta aktivitas pesawat di runway dan taxiway. Metodologi penelitian yang digunakan adalah literature review sehingga artikel ini melakukan review terhadap faktor-faktor yang mempengaruhi Piezoelectric Energy Harvesting, yaitu Sumber Energi, Material dan Desain, sebuah artikel studi literatur terkait smart airport technology. Tujuan penulisan artikel ini untuk menegakkan hipotesis pengaruh antar variabel sebagai acuan bagi riset lanjutan. Artikel literature review ini akan menghasilkan: 1) Sumber Energi berpengaruh terhadap Piezoelectric Energy Harvesting ; 2) Material berpengaruh terhadap Piezoelectric Energy Harvesting ; dan 3) Desain berpengaruh terhadap Piezoelectric Energy Harvesting . Penelitian ini diharapkan menghasilkan pemahaman yang lebih mendalam tentang potensi energi mekanis yang dapat dimanfaatkan di bandara dan bagaimana teknologi energy harvesting dapat diterapkan untuk mengoptimalkan sumber energi mekanis tersebut. Harapannya, artikel ini memberi gambaran dalam melakukan perancangan Piezoelectric Energy Harvesting yang sesuai dengan bandar udara.

Kata Kunci: Piezoelectric, Energy Harvesting, Energy Source, Material, Design.

PENDAHULUAN

Airports require large amounts of energy for various purposes, such as lighting, cooling, operation of security systems, navigation equipment, and others. With the increasing number of passengers and flight frequency, this energy demand also continues to increase. It encourages airport managers to find solutions to increase energy supply efficiently and sustainably. Using conventional energy sources, such as fossil fuels, creates negative environmental impacts, including greenhouse gas emissions and air pollution, and global pressure to reduce carbon footprints and adopt cleaner energy sources. On the other side, we can find several energy sources that we can harvest

from the ambient. Piezoelectric Energy Harvesting can be part of the solution, as it utilizes mechanical energy converted into electrical energy without harmful emissions (Sezer & Koç, 2021). Piezoelectric Energy Harvesting is a mechanical energy harvesting system derived from the most ubiquitous environmental energy that can be captured and converted into useful electrical power. Piezoelectric transduction is a prominent mechanical energy harvesting mechanism. Several studies mentioned potential energy sources for Piezoelectric Energy Harvesting such as wind, vibration from buildings, friction from equipment, friction from skin or and pressure from footsteps (Abadi et al., 2018; Bairagi et al., 2023; Orrego et al., 2017; Sharma et al., 2022; Tianchen et al., 2014; N. Wu et al., 2021; Y. Wu et al., 2021), and categorized the types of piezoelectrics used according to the energy source.

Piezoelectric types are generally divided into three classes: ceramic, polymer, and composite (Kováciková et al., 2023; Zhao & Wang, 2020). The ceramic type is the strongest in piezoelectric properties but is stiff and brittle compared to polymer and composite, so this type is most widely applied (Habib et al., 2022; Sapkal et al., 2022). However, when implemented in medical equipment and textiles, the polymer type is more suitable, while composite materials are more suitable for tactile sensors and gait energy harvesting. Energy harvesting at the airport has been done by modifying the runway pavement structure, utilizing the energy source in the form of vibrations from aircraft taking off on the airside (Kováciková et al., 2023; Zhao & Wang, 2020). The indicators of Piezoelectric Energy Harvesting are its high electromechanical coupling factor and piezoelectric coefficient compared to electrostatic, electromagnetic, and triboelectric transduction.

Piezoelectric Energy Harvesting is also described as an energy harvesting technique based on the properties of piezo materials in generating electric fields when mechanical force is applied. *Piezoelectricity* is a phenomenon that shows the ability of a material or several materials to produce electric voltage when given input in the form of pressure or voltage. This phenomenon is known as the direct piezoelectric effect (Covaci & Gontean, 2020). The dimensions or indicators of applying Piezoelectric Energy Harvesting are the energy source, energy harvesting mechanism, and place where PEH is implemented.

Piezoelectric Energy Harvesting is a new energy solution and piezoelectric mechanism, a new idea regarding piezoelectric energy harvesting from environmental vibrations and natural resources which explains that the dimensions or indicators of Piezoelectric Energy Harvesting are the mechanism and flexibility of piezoelectric energy generation materials. Factors that also affect Piezoelectric Energy Harvesting are the type of material and installation technique (Pradeesh et al., 2022). The application of Piezoelectric Energy Harvesting has been widely studied by previous researchers, including (Abadi et al., 2018; Febrawi & Wonoyudo, 2013; Lee & Youn, 2011; Sharma et al., 2022; Yang et al., 2018).

Based on the movement data 2023 at Sultan Mahmud Badaruddin II Airport Palembang, an average of 305,783 passengers arrived and departed. The average take-off aircraft amounted to 2,137 aircraft per month, and the total baggage recorded by passengers passed on the conveyor amounted to 2,319,826 baggage. By installing piezoelectric materials in strategic areas, energy from the pressure generated by passenger footsteps or vehicle wheel movements can be converted into electrical energy. This energy can then be used for various purposes at the airport, such as lighting, charging electronic devices, and monitoring systems. Considering the