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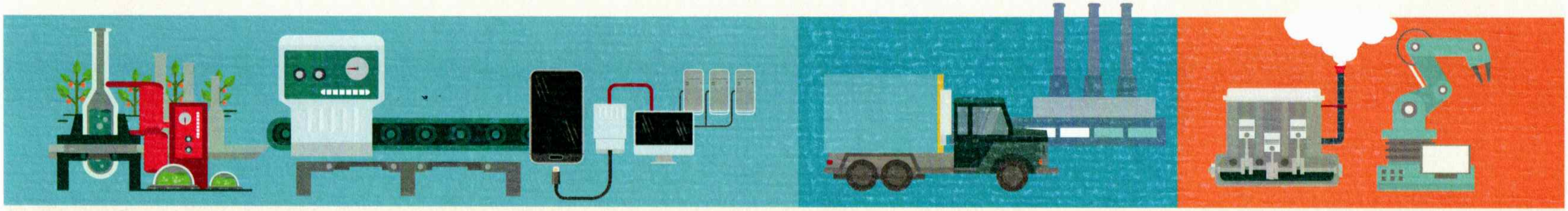

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Towards Reliable Renewable and Sustainable Energy Systems: Challenges and Opportunities

October 9 - 11, 2017 at Faculty Building, 3rd floor, Campus of Itenas Bandung – Indonesia

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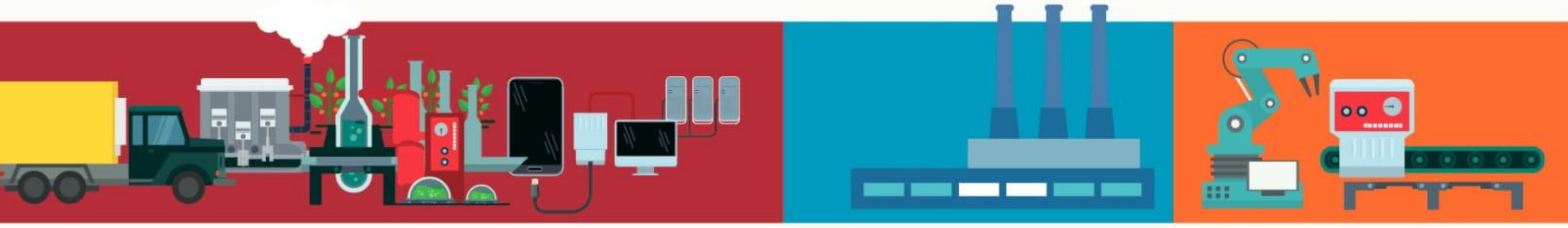

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Conference Proceedings

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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 1st Faculty of Industrial Technology International Congress (FoITIC) 2017.

The theme for the 1st FoITIC 2017 "Toward Reliability Renewable and Sustainable Energy Systems: Challenges and Opportunities", is very relevant with the current hot issues about climate change, growing populations and limited fossil fuel resources.

We believe that scientists and researchers will hand in hand with industrial experts, to create and develop new renewable and sustainable technologies that enable human to make products and services more efficient, protect environment and keep people healthier.

I am deeply grateful appreciative to the Faculty of Industrial Technology Itenas, Indonesian Society Reliability, Institute of Electrical & Electronics Engineers Indonesia Society on Social Implication of Technology Chapter, IEEE CAS Hyderabad, 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.

Thank you.

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 1st Faculty of Industrial Technology International Congress (FoITIC) 2017, which is organized by Faculty of Industrial Technology, Institut Teknologi Nasional (Itenas) Bandung, in conjunction with Indonesian Society for Reliability (ISR) and Institute of Electrical & Electronics Engineers Indonesia Society on Social Implication of Technology Chapter (IEEE Indonesia SSIT Chapter). In our Faculty, we have agreed that FoITIC event will be held every two years (biennial program).

The main theme for the 1st congress is "Towards Reliable Renewable and Sustainable Energy Systems: Challenges and Opportunities". The congress will divide into 2 (two) main programs i.e. International Conference and international workshop.

The aim of the International Conference is invites academics, researchers, engineers, government officers, company delegates and students from the field of energy and other discipline to gather, present and share the results of their research and/or work, and discuss strategies for the future utilization of renewable and sustainable energy system.

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, IEEE Indonesia SSIT Chapter, Indonesian Society for Reliability, University Malaysia Pahang and Indonesian Wind Energy Society, workshop facilitators i.e. IEEE Circuits and Systems (IEEE CAS) Hyderabad – India) 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 2017 organizing committee for their hard work in making this conference success.

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

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

Dr. Dani Rusirawan

Dean Faculty of Industrial Technology – Institut Teknologi Nasional Bandung
Chairman of FoITIC 2017

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. The 1st International Conference on FoITIC (Faculty of Industrial Technology Congress) Organizing Committee wishes to express its gratitude and deep appreciation to the following:

1. Dr. Imam Aschuri, Rector of Institut Teknologi Nasional Bandung;
2. All keynote and invited speakers, moderators, conference speakers, all participants and others who have in one way or another contributed for their valuable participation;
3. Institute of Electrical & Electronics Engineers Indonesia Society on Social Implication of Technology Chapter (IEEE Indonesia SSIT Chapter);
4. Institute of Electrical & Electronics Engineers Circuits and Systems (IEEE CAS), Hyderabad India;
5. Indonesian Society for Reliability (ISR);
6. Universiti Malaysia Pahang;
7. Indonesian Wind Energy Society (IWES).

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.

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.

Prof. Dr. Soegijardjo Soegijoko (Institut Teknologi Nasional Bandung)

Soegijardjo Soegijoko (born in Yogyakarta, 1942) earned his Engineer Degree in Telecommunication Engineering from the Department of Electrical Engineering, Institut Teknologi Bandung (ITB), Indonesia, in 1964. His Doctor Degree (*Docteur Ingenieur*) was obtained from USTL (*Universite des Sciences et Techniques du Languedoc, Montpellier, France*) in 1980. Additionally, he has also completed a number of non-degree or post-doctoral programs, such as: tertiary education (UNSW, Australia, 1970), VLSI Design (Stanford University – 1986; UNSW- 1991; Tokyo Institute of Technology-1984, 1985, 1990).

Since 1966, he joined ITB as a teaching staff at the Department of Electrical Engineering, (currently School of Electrical Engineering & Informatics) ITB, and appointed as a Professor on Biomedical Engineering in 1998. During his academic services at ITB (from 1966 – 2007), he has actively involved in the developments and operations of various units, e.g.: Electronics Laboratory, Master Program on Microelectronics, Inter University Center on Microelectronics, Biomedical Engineering Program (Undergraduate, Master & Doctorate programs), and Biomedical Engineering Laboratory. Although he has been officially retired in 2007, he has appointed as an adjunct Professor at ITB for some years. At present (August 2017), he is an adjunct Professor at the Department of Electrical Engineering, Institut Teknologi Nasional (ITENAS) Bandung (Indonesia). His current research interests include: Biomedical Engineering Instrumentation, e-Health &Telemedicine Systems, and Biomedical Engineering Education.

He has published more than 100 international papers in the above-mentioned research interests. Moreover, he (and his colleagues) have also authored five different book chapter titles (on biomedical engineering, ehealth & telemedicine) published by Jimoondang (Korea, 2008), Springer (Singapore, 2014), CRC Press – Taylor Francis (2016), and Springer (2017).

Currently, he actively involves in various societies within the IEEE that include: EMBS, SSIT, CASS, Computer, and Education, as well as SIGHT (Special Interest Group on Humanitarian Activities). He is currently the IEEE Indonesia SSIT Chapter Chair, EMBS Chapter Chair and actively involves in the Indonesian eHealth & Telemedicine Society (IeHTS) as well as the Indonesian Biomedical Engineering Society (IBES).

Prof. Dr. Ir. Soegijardjo Soegijoko is a *Life Senior Member* of the IEEE, and can be reached through: soegi@ieee.org

Prof. Dr. Rizalman Mamat (Universiti Malaysia Pahang)

Prof. Dr. Rizalman Mamat presently is Dean of Faculty Mechanical Engineering, Universiti Malaysia Pahang, Malaysia. 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).

Mr. Soeripno Martosaputro (Indonesia Wind Energy Society)

Soeripno Martosaputro, graduated from Universitas Sebelas Maret (Bachelor) and University of Pancasila (MSc.). Presently, he is worked at PT UPC Renewables. Moreover, he is Chairman of Indonesia Wind Energy Society (IWES) and Chairman of Expert Board of Indonesia Wind Energy Association (IWEA). Previously he worked as a researcher at the National Institute of Aeronautics and Space (LAPAN), Aerospace Technology Center, particularly in the field of technology development and engineering of the Wind Energy Conversion Systems. He is active in the field of science and technology utilization in particular wind energy technology as speakers and resource persons in seminars nationally and internationally. He is member of the Asia Pacific Wind Energy Forum (APWEF), Indonesia National Committee World Energy Congress (KNI-WEC), Indonesia Renewable Energy Society (METI), and National Research Council (DRN). In 2012 – 2016, he was act as National Project Manager of WHYPGEN (Wind Hybrid Power Generation market initiatives Project) – UNDP Project.

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Effect of Air Gap on Armature Voltage on Axial Flux Permanent-Magnet Generator ac by Using NdFeB 52

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Department of Electrcial Engineering, Universitas Siliwangi, Tasikmalaya - INDONESIA
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Abstract

There is an increase in the development of Axial Flux Permanent Magnet Generator (AFPMG) which is proven by numerous types of machine variations which are developed and studied. AFPMG has advantages in terms of lossless and thinner construction and its use in various fields of micro electromechanical system and domestic utilities. In the implementation of this design, we used ANSYS software to design the construction, flux distribution, and the expected voltage. In the design of this AFPMG, we made dual-rotor permanent magnet constructions clamping the stator containing an armature winding with a three-phase AC output voltage with a star winding configuration. The design process also included a simulation of the effect of gap distance differences on the electromotive force generated by the armature winding. The design results were implemented then tested with varying rotation and significant changes in air gap from 2 mm until 6 mm to produce the performance of the machine. Based on the test results, the maximum voltage in the zero-load condition, in which the air gap was at 2 mm, was 10.7. In the loaded test with rpm variation, the voltage regulation was with a range of 32.96% and 43.75% for a 2 mm air gap.

Keywords: Axial Flux Permanent-Magnet Generator, Various Speed, air gap, NdFeB 52

1. Introduction

The development of electricity generation by converting mechanical power continues to grow on a small scale known as the micro-electromechanical system (MEM). MEM with the use of magnetic material as a conversion medium one of which by using axial flux permanent magnet generator (Holmes et al. 2005)

The use of AFPMG is applied to the needs of wind farms(Ashraf & Malik 2017)with 1,200 watts or low power by either using single(Nur et al. 2013) or double savinous turbines (Alqodri et al. 2015). The other uses of AFMG are related to the need for small mechanical motions such as electromagnetic launchers(Sezenoglu & Balikci 2015) also used in vehicles and trains (Gör & Kurt 2015).

The output voltage of the AFPMG is an alternating voltage normally get into the grid but some researches suggest that adding a rectifier generated the DC output used to fill the accumulator(Wijaya et al. 2016). Similarly, continuous developmental construction starts with single-rotor single-stator (Alqodri et al. 2015) single-stator double-rotor (Gör & Kurt 2015) or with TOROS-S Structure (Taran & Ardebili 2014). Various studies suggest that the speed will affect the output voltage as well as the frequency generated which are in accordance with the law of EMF. Therefore, in order to generate AC voltage that can get into the grid, the generator frequency must equal to the frequency of the system.

In line with the high demand of permanent magnets, nowadays, the growth of the permanent magnet industry is becoming a promising industry, especially the NdFeB permanent magnet. Fig 1 shows the growth of permanent magnet production from several country producers. The demand of NdFeB-type magnets is projected to be significantly increased, especially between 2015 and 2020 reaching more than 120 (kt). Currently, China is the largest producer of permanent magnets compared to Japan, Europe and other countries including USA (Fig.1.a). While the world's need for permanent magnets is dominated by the Nd-type permanent magnet (Fig. 1.b).

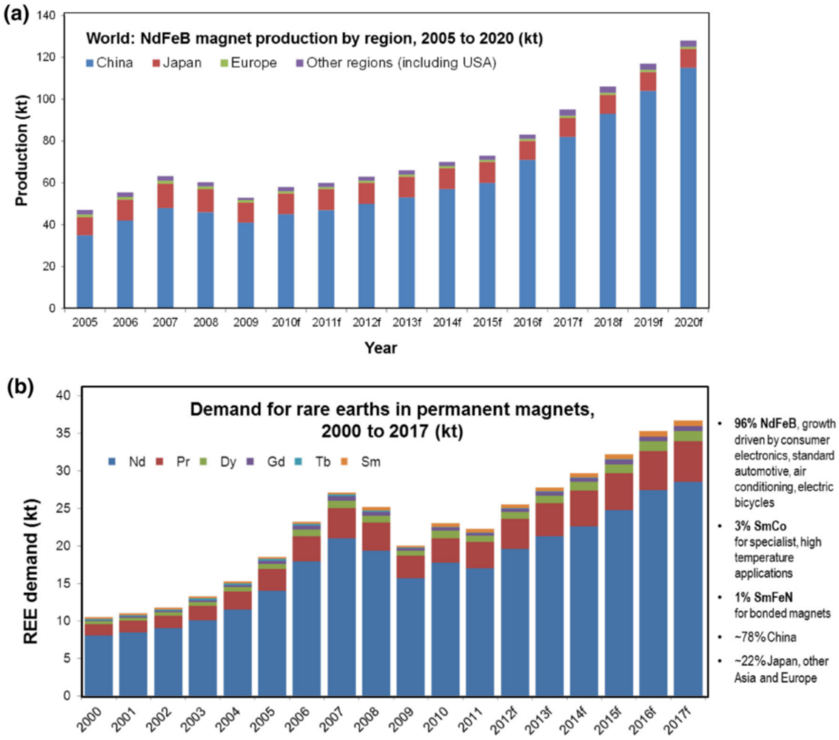


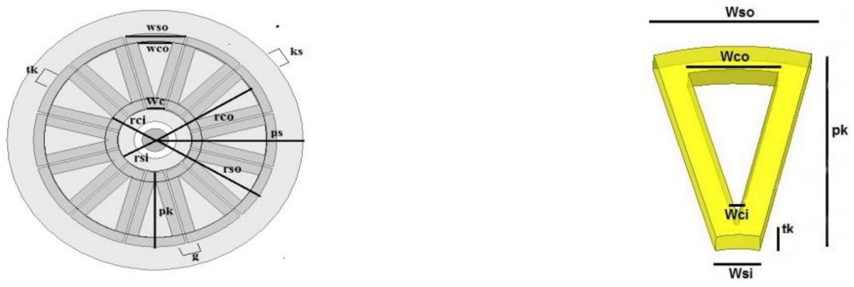
Fig.1: Global production of NdFeB permanent magnets and the demand for the REEs (Shaw S 2012)**,** (Yang et al. 2016)**. (a) Total global NdFeB magnet production and prediction: 2005–2020, (b) Total global REE demands for permanent magnets** (Yang et al. 2016)

This study focuses on preparing simulations for analyzing Air Gap Effect on Armature Voltage on Axial Flux Permanent Magnet AC generator by using NdFeB 52. NdFeB 52 magnets are used because NdFeB 52 magnets have a unique character that is the Maximum Energy Product (Bhmax) is 50 -52 MGOe (398-422 MGO (KJ / m3) (Shaw S 2012)(Yang et al. 2016).

2. Method

The design of Axial Permanent Magnetic Flux Generator was done by using ANSYS in order to find out the finite element distribution and also the magnetic field (Holmes et al. 2005). The use of ANSYS was also carried out to find out the design parameters (Sadeghierad et al. 2008) so that the rotor dimension, big stator winding, and other things are known.

In this design, the dimension of the stator winding that would use was a type of stator that has no iron core on the coil. This is because the type of stator with no iron core was more suitable to the low axial generator. We used 12 coils of armature winding to produce three-phase AC voltage, in other words, in every phase there were 4 coils.



a. The shape of stator disk with 12 coils **b. The shape of stator disk with 1 coil**

Fig. 2: The stator disk with a winding shape

The shape of the armature winding itself is a type of trapezoidal winding with the number of coil windings per phase was 150 winding or 38 winding per coil with non-overlapping windings form. The designed coil was a non-overlapping type aimed at maximizing the induction of the magnetic field on the coil and avoiding the addition of thickness to the stator. We used copper wire with a diameter of 1 mm. As for the dimensions of the stator itself, it can be seen in table 1.

Table 1: The Size of the Stator

No	Description	Size (mm)
1	Stator Diameter	280
2	Stator Length (ps)	140
3	Stator Thickness (ks)	25
4	Distance Between Stator (g)	2
5	Outer Width (wso)	57.5
6	Inner Width (wsi)	16
7	Width of Stator Foot (wc)	2
8	Coil Length (pk)	80
9	Coil Thickness(tk)	10

The type of permanent magnet to be used in the design of the rotor was a Neodynium-Iron-Boron Permanent Magnet (NdFeB). This type of permanent magnet has larger magnetic field value and magnetic flux density than other permanent magnets that is 1.43 tesla. The use of permanent neodynium-iron-boron (NdFeB) permanent magnet (specifically the type of magnet used was N52) aimed at obtaining the maximum magnetic flux value so as to obtain maximum induction voltage.

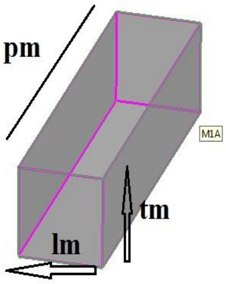


Fig. 3: Dimmension of permanent magnet

The design of the rotor consisted of 8 magnetic poles on each inner side of the rotor. The design of the maximum number of coils and permanent magnets would increase the value of the induced frequency and induced voltage. Installation combinations of magnetic poles were performed in accordance with the N-S type which aimed to increase the magnetic flux density value between the two rotors.

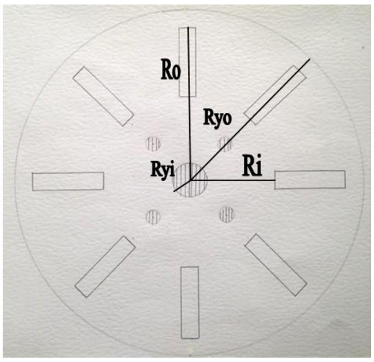


Fig. 4: The distribution of 8 pairs of N-S magnetic poles

As for the stator dimension, it can be seen in the table below:

Table 2: The Size of the Rotor

No	Description	Size (mm)
1	Rotor Diameter (dr)	210 mm
2	Rotor Thickness (kr)	5 mm
3	The outer radius of the rotor (ryo)	110 mm
4	The inner radius of the rotor (ryi)	9.5 mm
5	The outer radius of the magnet (ro)	105 mm
6	The inner radius of the magnet (ri)	65 mm

Then, when the rotor configuration and the three-phase axial stator flux permanent magnet generator with double rotor were set, they were as shown below

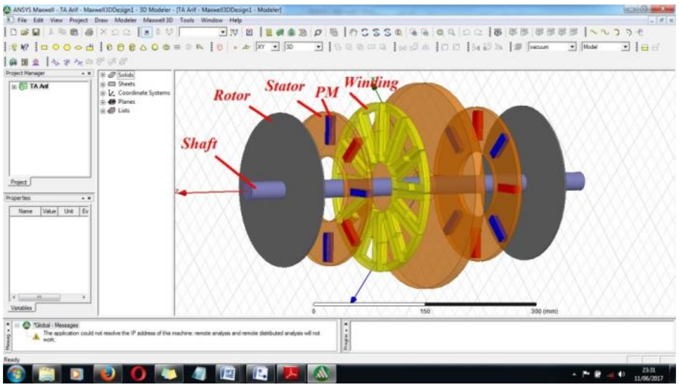


Fig. 5. Double rotor configuration and stator in AFPMG

The flux distribution test was carried out by doing a simulation on ANSYS to understand the spread and magnetization of the armature winding. The spread of this magnetization can be seen in the figure below

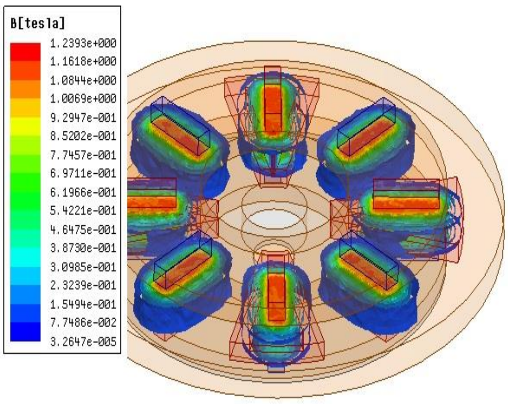


Fig. 6: The simulation of flux distribution by using ANSYS

It produced the flux quantities with the air gap variables with a range of 2 mm and 6 mm from each rotor to the stator as in the table below. There was a non-uniformity of the flux distribution in each winding phase due to the uneven distribution of flux to the position of each winding.

Table 3: The testing of the flux distribution

Phase	The Effect of Air Gap on Flux Distribution				
	2mm	3mm	4mm	5mm	6mm
Phase R	1.239 T	0.993 T	0.860 T	0.764 T	0.698 T
Phase S	1.189 T	0.988 T	0.866 T	0.765 T	0.663 T
Phase T	1.212 T	1.014 T	0.868 T	0.761 T	0.667 T

In the form of a flux distribution graph for the three-phase shown below, it can be seen that the larger the gap the smaller the flux distribution that occured due to the flux became the loss in the air gap, thus the optimum flux distribution was at 2mm. This distribution also did not occur uniformly on each phase windings R, S and T due to the uneven position of the magnetic field toward the winding.

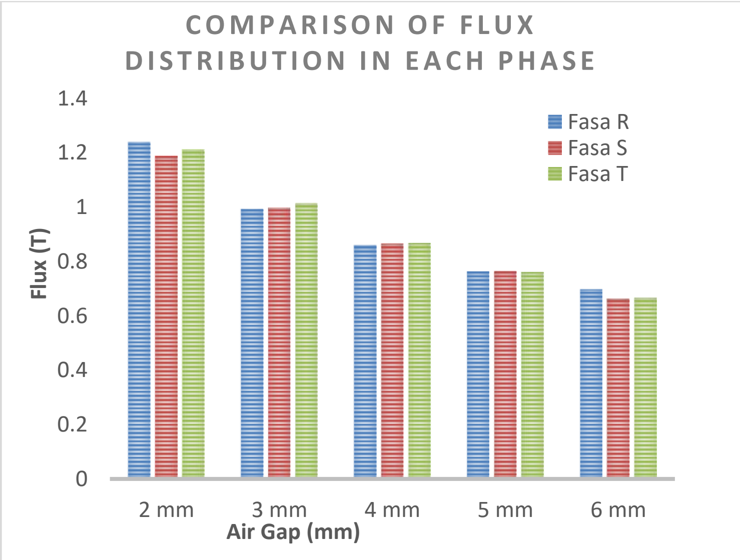


Fig. 7: Flux Distribution

3. Testing and results

The test was carried out by burdening the generator with varying resistance loads with changes in motor speed from 300 to 800 and with a variation of the air gap from 2 mm to 6 mm. This test showed the optimal gap of the generator to produce the greatest power.

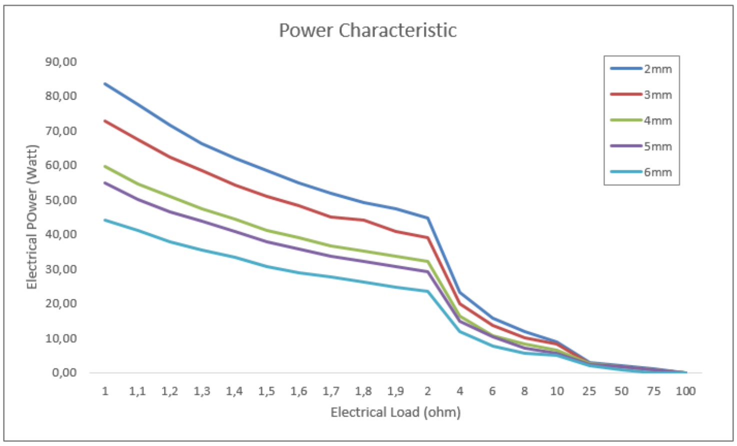


Fig. 7: The testing with variations of air gap with various load quantities

In this test, the rate of decline in electrical power decreases and inversely proportional to the load, as well as the air gap, it was known that the air gap that produced optimal power was at 2 mm. The larger air gap the smaller the power delivered.

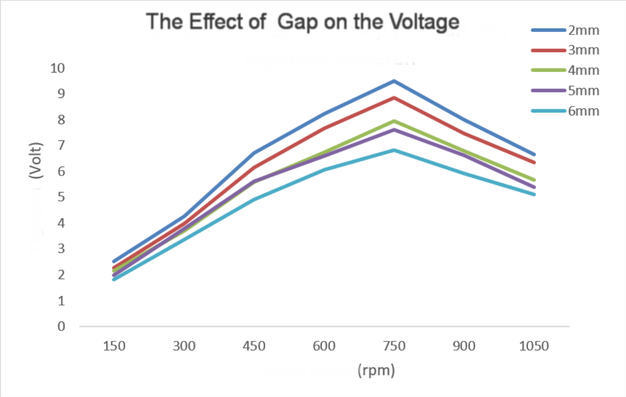


Fig. 8: The effect of air gap on rotation

4. Conclusions

Based on the experiments, it can be seen that optimal air gap was at 2 mm produces flux amounted to an average of 1.2 t. In the test with electrical load load produces the largest electrical power in the gap of 2mm, as well as on testing with variations of motor rotation gap 2 mm The greatest voltage because the air losses are less in comparison with other air gap.

5. References

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