The14th International Conference on QiR
(Quality in Research)

QiR

Lombok Indonesia

In conjunction with :

4th Asian Symposium on Material Processing (ASMP)

International Conference in Saving Energy in Refrigeration and Air Conditioning (ICSERA)

PROCEEDING

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STMIK LOMBOK

PREFACE

WELCOME FROM THE RECTOR OF UNIVERSITAS INDONESIA

It is both a pleasure and honor for me to welcome you all to the 14th International Conference on QiR (Quality in Research) 2015. Globalization today results in very competitive atmosphere in all aspects. This flourishing competition should consider the harmony and balance between human needs and the environment quality for creating favorable sustainable future. Steps to ensure the preservation of the environment for our future generations are slowly but surely taken. This fragile balance between the development and innovation of mankind as an effort to enhance their quality of life with its harmony with nature must be maintained as a way to achieve sustainable future - helping us make products and services more efficient, design better buildings, produce safer cars and keep people healthier.

Nowadays, scientists and researchers, hand in hand with industrial experts are creating and developing new green technologies that give us hope for a Sustainable Future. Great minds in Engineering, Architecture and Design areas especially has came up with ideas such as Green Architecture that has the capability to cut down urban resource use dramatically, and making urban expansion sustainable; New Nuclear Material; Waste-Sourced Biofuel/Pyrolysis, where technology is now able to turn biomass waste such as paper, grass or wood chips into gas and eventually ethanol; Biomimicry, that has given the rise to self-healing materials. This in turn will give longer lives to most consumer goods, and thereby reducing the demand for raw materials and waste; and many more innovations that should be encouraged for the motivation of current and future development.

These Green and Smart Technologies can help protect, conserve and even restore our precious shared environment. To develop this technology, we need to combine engineering, scientific or technological approaches, with ecology, economics and the social sciences and humanities. The Green and Smart Technologies innovation field is now wide open and offers exciting new territories to explore and develop. Creative thinking by our top technical and scientific researchers is giving us a more and more treasures of new workable ideas. However, innovations require more than just brilliant ideas. Innovations require resources, skills, technology, knowledge, tools, techniques and so much more. But most of all, innovations require people. People are the driving force behind every need of change, changes that are aimed to improve mankind's quality of life, to enhance their living conditions or to simply make life easier and more comfortable.

This conference is about learning of the fundamental aspects which can transform the world and society, thinking ahead to possible challenges facing the globe, discovering innovations related to opportunities for industry, and most importantly, this conference is about bringing together interdisciplinary people to accelerate activities in many areas simultaneously. This is what makes the conference exceptional this year in terms of potential impact from this networking.

I extend my sincere thanks to the Faculty of Engineering Universitas Indonesia, supporting parties and institutions for their participation and contributions in QiR 2015. I would also thank the people of Mataram especially our colleagues from Universitas Mataram and STMIK Lombok for their gracious support and hospitality. Additionally, I extend a hearty thank you to the members of the organizing committees for dedicating their valuable time so that each one of us enjoys an exceptional conference program over the next several days. May we have a successful, stimulating, fruitful and rewarding conference.

Prof. Dr. Ir. Muhammad Anis, M.Met.
Rector
Universitas Indonesia

PREFACE

WELCOME FROM THE DEAN OF FACULTY OF ENGINEERING UNIVERSITAS INDONESIA

Welcome to the 14th International Conference on QiR (Quality in Research) 2015. The Faculty of Engineering Universitas Indonesia is proud that this year we could once again held an international conference of this grand scale. This two-day, biennial conference is presented together with our co-hosts Universitas Mataram and STMIK Lombok and speaks to the importance of fostering relationships among national and international front liners, thinkers, academics, executives, government and business officials, practitioners and leaders across the globe in an effort to share knowledge and best practices as part of a worldwide network.

For almost twenty years, the first definition of sustainable development and sustainability includes sentences like 'much remain to be done in the areas of sustainability' or 'the underlying science is still far from exact and we all still need to make a big effort' are common introducing and/or concluding phrases in both literature and scientific forums. I envisioned that QiR will be a platform where academicians, scientists, researchers and practitioners from engineering, architecture, design, and community services to share, discuss, and move forward with their findings and innovations. I hope that the intellectual discourse will result in future collaborations between universities, research institutions and industry both locally and internationally. In particular it is expected that focus will be given to issues on innovations for the enhancement of human life and the environment.

In accordance to this year's theme, this conference will cover a wide range of green and smart technology issues, especially state of the art information and knowledge of new innovations, ideas, creative methods or applications which can be implemented to enhance the human life with various smart technologies developed to improve mankind's quality of life and green technologies to make sure that we make a contribution to keeping our environment for our future generations. The itinerary for the two days has been carefully planned to ensure a lively exchange of ideas and the development of innovative strategies and there will be many opportunities for everyone in attendance to share their expertise with, and learn from, peers from around the world.

We foresee more and more challenges in our future. Challenges in how to improve our life, how can we enhance our society, how can we make our lives and the lives or our society better? These challenges should be answered together by developing collaborations for future research in various engineering and design areas. Let's make this conference an international media for exchange of knowledge, experience and research as well as the review of progress and discussion on the state of the art and future trend of prospective collaboration and networking in broad field of eco-based technology development.

My deepest appreciation to our sponsors, supported parties and various contributors for their never ending supports of this conference. I would also like to convey my gratitude to all of our distinguished speakers for making the time to share their knowledge with us. To our fellow researchers and/or practitioners from Indonesia and overseas, welcome and enjoy your stay in this amazing island, Lombok. I would also like to invite all participants in expressing our appreciation to all members of the QiR 2015 organizing committee for their hard work in making this conference another success.

Prof. Dr. Ir. Dedi Priadi, DEA
Dean Faculty of Engineering
Universitas Indonesia

WELCOME FROM THE QiR 2015 ORGANIZING COMMITTEE

Welcome to the 14th International Conference on QiR (Quality in Research) 2015. It is a great pleasure for Faculty of Engineering Universitas Indonesia to be hosting this biennial event with Faculty of Engineering Universitas Mataram and STMIK Lombok, in the spirit of strengthening of cooperation and mutual growth to be world class institution. For the first time, the QiR 2015 is held in Lombok Island, one of Indonesia's beautiful paradise islands. It is with our utmost pleasure to hold this year's QiR 2015 in conjunction with 4th Asian Symposium on Material Processing (ASMP), and International Conference in Saving Energy in Refrigeration and Air Conditioning (ICSERA).

The aim of this International Conference with our selected theme, "Green and Smart Technology for Sustainable Future", is to provide an international forum for exchanging knowledge and research expertise as well as creating a prospective collaboration and networking on various fields of science, engineering and design. We hope this conference can be a kick-off for the strengthened action and partnerships on creating a platform for us; national and international thinkers, academics, government officials, business executives and practitioners, to present and discuss the pivotal role of engineers in innovative products which will reduce environmental impacts, applications in sustainable planning, manufacturing, architecture, and many more to grow and ensure the rising prosperity of our society going into the future. Under this theme, the conference focuses on the innovative contributions in green and smart technology to encourage and motivate current and future development for achieving sustainable future.

Over the period of 18 years, this biennial international conference started from annual national conference and now has become an important place of encounter between scholars and practitioners from different countries, cultures and backgrounds discussing contemporary engineering and design issues dealt in their hometown, country or even region. Serving as a platform for an engineering and design dialogue, this conference will have 21 invited speakers and has gathered more than 500 papers from more than 17 countries all over the world:
86 papers on International Symposium on Civil and Environmental Engineering
129 papers on International Symposium on Mechanical and Maritime Engineering
121 papers on International Symposium on Electrical and Computer Engineering
107 papers on International Symposium on Materials and Metallurgy Engineering
36 papers on International Symposium on Architecture, Interior and Urban Planning
56 papers on International Symposium on Chemical and Bioprocess Engineering
74 papers on International Symposium on Industrial Engineering
21 papers on International Symposium on Community Development

This year, we have a special talkshow planned as a special session within our plenary lecture. This talk show was planned by our alumni with the theme "***Serve Our Country***". After more than five decades of existence, FTUI has in its library hundreds if not thousands undeveloped innovation ideas and research from its faculties, graduates and students, all of which are aimed at enhancing the quality of human life and the environment, especially in Indonesia. We feel that it's time we contribute more to our country by making sure that these innovations and research can be implemented and produced for a better future of our nation. The talk show will feature some of the most prominent figure in Indonesia's government and will discuss how these innovations can be used by the government in areas such as: electrical, oil and gas, IT, mining, design, manufacture and how the industry can be a part of it.

My deepest gratitude: to all of our speakers, participants, contributors, partners, exhibitors and professional associations, who have given this conference their generous support. I would also like to thank all members of the Organizing Committee, our International Advisory Board and distinguished Reviewers for all of their support and advice. We also

owe our success to the full support of the Rector of Universitas Indonesia and the Dean of Faculty of Engineering. Last but not least, a special thanks to our co-hosts, Universitas Mataram and STMIK Lombok for all of their immense supports in making this conference a success.

Allow me to wish all of you a meaningful and rewarding conference. We wish you a pleasant and memorable stay in Lombok. Thank you and we hope to see you again at the QiR 2017.

Dr. Fitri Yuli Zulkifli, ST., MSc.
General Chair of QiR 2015 Organizing Committee

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for consenting to be the guest of honour

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Prof. Antonio Gomes Correira, Univ. of Minho, Portugal

Prof. Francesco Picchioni, Rijksuniversiteit Groningen, The Netherlands

Prof. Hero Jan Heeres, Rijksuniversiteit Groningen, The Netherlands

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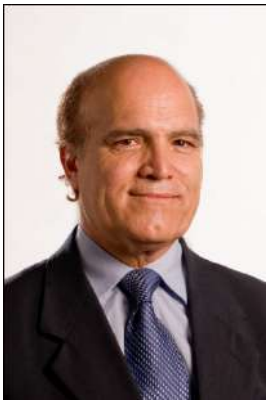

Professor Correia graduated in Civil Engineering from the Technical University of Lisbon - IST in 1977, and received a Doctor-Engineer Degree by "Ecole Nationale des Ponts et Chaussées"- Paris in 1985. In 1987 he also received the Doctor degree in Civil Engineering by the Technical University of Lisbon – IST and also in 1998 the "Habilitation in Civil Engineering.

In 1987 he gained the specialist degree at the National Laboratory of Civil Engineering (LNEC), distinguished with Manuel Rocha Award. In 1998, he created the Geotechnical Research Centre at the Technical University of Lisbon – IST and he served as its President until 2000. In 2001 he gets the degree of specialist in Geotechnique attributed by the Portuguese Association of Engineers.

Professor Correia is registered as an expert (external member) of "Agência de Avaliação e Acreditação do Ensino Superior" (Agency for Assessment and Accreditation of Higher Education - A3ES) for the scientific area of Civil Engineering, starting from 2013 when he served as a panel member in the evaluation of undergraduate and graduate courses for three institutions

Since 2003, he is a Full Professor at the University of Minho and from 2010 to 2013 Director of the Research Centre of Territory, Environment and Construction. He is also from 2010 chair of the Doctoral program in Civil Engineering and from 2013 Vice-Dean of School of Engineering of the University of Minho. From September 2013, He served as the Editor-in-Chief of the International Journal on Transportation Geotechnics published in Elsevier's Engineering Journals.

PROF. FRANCESCO PICCHIONI
RIJKSUNIVERSITEIT GRONINGEN, THE NETRHERLANDS
(f.picchioni@rug.nl)

Francesco Picchioni was born in 1971. He is a professor of chemical product technology at the University of Groningen (RuG). His research interests include synthesis and application of bio-based and renewable polymeric materials for a variety of industrial applications. He studied and graduated from the University of Pisa. In 2010 he was elected Lecturer Gold 2010: a prize from the Royal Dutch Chemical Society to promote initiatives and innovation in chemistry education.

In 2000 Prof. Picchioni moved from Italy to Eindhoven and since 2003 he has worked at the Rijksuniversiteit Groningen University where he's currently teaching: Interfacial Engineering, Polymer Chemistry (for Industrial Engineering and Management), Polymer Products, and From bacteria to plastic, In collaboration with other teachers (responsible for only a part of the course).

INVITED SPEAKER

PROF. HERO JAN HEERES
RIJKSUNIVERSITEIT GRONINGEN, THE NETHERLANDS
(h.j.heeres@rug.nl)

H.J. (Erik) Heeres (25-06-1963) carried out his Ph.D. research at the University of Groningen on the development of novel homogeneous lanthanide catalysts for the conversion of unsaturated hydrocarbons and graduated in 1990. Afterwards, he performed a post-doc at the University of Oxford in the group of Prof. J. M. Brown on asymmetric catalysis.
From 1991-1999, he was employed at Shell Research B.V. (Amsterdam and Pernis, the Netherlands) and worked on a range of applied catalysis topics. He joined the chemical engineering department of the University of Groningen in 1999 as an assistant professor. In 2003 he was appointed here as a full professor in green chemical reaction engineering. His research interests concern the development of efficient catalytic technology for acid- and metal-based catalytic biomass conversions, with an emphasis on biofuels (catalytic pyrolysis, pyrolysis oil upgrading), platform chemicals (levulinic acid, hydroxymethylfurfural) and performance materials from biomass (starch modifications).
The group is actively involved in national and international consortia. Heeres (h-index 36) is the (co-) author of 155 papers in international peer reviewed journals and 13 patents in the field of (applied) catalysis and chemical reaction engineering. Heeres supervised 30 PhD students and up to 50 master students. He was nominated twice for the teacher of the year award of the Chemistry bachelor and master program and once for the Faculty teacher of the year award. He is currently an editorial board member of the journal Sustainable Chemical Processes.Heeres is a member of the Koninklijke Hollandsche Maatschappij der Wetenschappen..

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Professor Umemuro received his Bachelor of Engineering in Control Engineering, Faculty of Engineering, Tokyo Institute of Technology in 1987, Master of Engineering in Control Engineering, Graduate School of Science and Engineering, Tokyo Institute of Technology in 1989, and his Doctor of Engineering in Industrial Engineering and Management, Graduate School of Decision Science and Technology, Tokyo Institute of Technology in 1998. He is currently Professor at the Department of Industrial Engineering and Management, Graduate School of Decision Science and Technology, Tokyo Institute of Technology.

Professor Umemuro is also members of the following Professional Societies: International Society for Gerontechnology, Japan Ergonomics Society (a member of International Ergonomics Association), Japan Industrial Management Association, Japanese Cognitive Science Society, Japanese Society for Artificial Intelligence, The Japan Society for Management Information. He also serves as Trustee for the Japan Ergonomics Society since 1999 till today, served as President for the International Society for Gerontechnology Japan Chapter, 2006-2012 and Editorial Board of the Japan Society for Management Information 2002-2004. Professor Umemuro has published 25 publications in Prefereed Journals, 50 publications in Edited Conference Proceedings, 5 Publications as Invited Contributions, 4 books publications, and 3 books translations.

PROF. HWATAIK HAN
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Professor Han received his Bachelor Degree in 1980 at Mechanical Engineering from Seoul National University. In 1982, he received his Master in Mechanical Engineering from Seoul National University and in 1988 he finished his Ph.D in Mechanical Engineering, University of Minnesota, USA. He currently serves as the Director of BKplus-Energy ODA Center, Kookmin University, Director of Energy Engineering Human Development Center, Kookmin University, and Director of Well-being Environment Research Center, Kookmin University.

Professor Han holds a certification as Professional Engineer from Minnesota State Board of AELSLAGID, Registration No. 21924 (since 1992). He is the President of the Society of Air-conditioning and Refrigerating Engineers in Korea (SAREK) since 201; the Central Construction Committee, Ministry of Land, Infrastructure and Transportation, Korea since 2013; the Editor-in-Chief, Koran Air Cleaning Association (KACA) from 2004; Member of the Korean Society of Automotive Engineering (KSAE) from 2001; Arbitrator for The Korean Commercial Arbitration Board from 1998. He is also a member of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) from 1990 and member of American Society of Mechanical Engineers (ASME) from 1988.

PROF. JOSAPHAT TETUKO SRI SUMANTYO
CHIBA UNIVERSITY, JAPAN
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Prof Josaphat Tetuko Sri Sumantyo was born at Bandung, West Java, Indonesia in 1970. He received the B.Eng. and M.Eng. degrees in Electrical and Computer Engineering from Kanazawa University, Japan in 1995 and 1997, respectively (Subsurface Radar Systems) and the Ph.D. degree in Artificial System Sciences (Applied Radio Wave and Radar Systems) from Chiba University, Japan in 2002.

He was an Associate Professor (permanent staff) at the Center for Environmental Remote Sensing (CEReS), Chiba University from 2005 to 2013, then Full Professor (permanent) at the same center from 2013 to now, member of international and domestic organizations, reviewer of journals, and organizations. His main interests are theoretically scattering microwave analysis and its applications in microwave (radar) remote sensing. He manages Josaphat Microwave Remote Sensing Laboratory (JMRSL), Center for Environmental Remote Sensing (CEReS), Chiba University, Japan.

His laboratory promotes the education and research to develop the internationally technologies and sciences. He always encourages the undergraduate and postgraduate students to know the microwave phenomenon and to be familiar with the interaction between microwave and natural matters (i.e. vegetation, artificial materials, earth surface, and snow), therefore they could develop original methods or sensor during studying in the courses.

INVITED SPEAKER

PROF. DR. K.U. (KATJA) LOOS
UNIVERSITY OF GRONINGEN, THE NETHERLANDS
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Professor Loos is a Professor at the Faculty of Mathematics and Natural Sciences, University of Groningen, Netherlands. Her fields of disciplines are: Polymer Science, Chemistry, Applied, Materials Science, and Multidisciplinary. Her main research interests are focused on the design, synthesis and characterization of novel tailor made macromolecules as well as on the development of sustainable, eco-efficient and competitive production methods of polymeric materials. By utilizing modern polymer synthesis techniques including biocatalysis and other controlled polymerization methods her research aims to expand fundamental scientific knowledge towards advanced technologies.

She is a Member of the board of the study group Macromolecules (studiegroep macromoleculen) of the chemistry section of the Dutch Science Foundation (NWO), Member of the board of the National Dutch Graduate School of Polymer Science & Technology (PTN), Member of the program committee of the Dutch Belgian Beamline (DUBBLE) at the European Synchrotron Research Facility (ESRF) in Grenoble, France, Member of the Scientific Evaluator Board of the German Academic Exchange Service (DAAD). She currently serves as Associate Editor Europe of the Journal of Renewable Materials, Member of the Editorial Board of Journal of Renewable Materials, Member of the Editorial Board of Polymer, Member of the Editorial Board of Polymers, Reviewer for scientific journals, Reviewer for grant proposals (national and international), Scientific advisor of Dutch and German courts, Industrial consulting and Contract Research.

PROF. LISELOTTE SCHEBEK
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Professor Liselotte Schebek is a Professor for the Faculty of Civil and Environmental Engineering as well as Chair of Material Flow Management and Resource Economy, Technische Universität Darmstadt. She was born on May 19th, 1957 in Bensheim / Bergstraße. She completed her Dipl.-Ing from Technische Universität Darmstadt in Study of Chemistry in 1983 and completed her Doctoral Oral Examination from University of Mainz in 1990.

She was employed as Project Manager Lahmeyer International, Frankfurt (since 1998, ERM Lahmeyer International, Niederrad) from 1990-1999 and also as a Lecturer on Environmental Management, University of Applied Sciences, Wiesbaden. From 1999-2012 she was the Head of Department of Technology-Induced Material Flow/Institute for Technology Assessment and Systems Analysis (ITAS-ZTS), Karlsruhe Institute of Technology (KIT). Professor Schebek continued on as Professor of Industrial Material Cycles, Technische Universität Darmstadt, Faculty of Civil Engineering and Geodesy between 2000-2009/2013 and Professor of Material Flow Management and Resource Economy, Technische Universität Darmstadt, Faculty of Civil and Environmental Engineering since 2010. Her research interest include: Closed substance cycle and resource management, Material flow management and environmental protection, Material and energetic use of biomass, and Energy technologies and energy systems

PROF. MAKOTO HIRANO
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Professor Hirano finished his Bachelor of Engineering in 1977 from Waseda University Japan and continued on to finished his Master of Science in 1979 and Ph.D in Engineering in 1990 from the same University. He went to Temple University Fox School, PA, USA to pursue his Executive MBA degree and finished in 2002 when he returned to Waseda University to take his Ph.D in International Business Management and finished them in 2007. He is currently a Professor at the Graduate School of Engineering Management, Shibaura Institute of Technology and a Guest Professor for the Kochi University of Technology, Japan.

Professor Hirano currently serves as the Vice-Chairperson of IEEE Technology and Engineering Management Society, Chairperson for Entrepreneur Engineering Society, Director & Secretary-General for the Japan MOT Society, and Member of Committee for The Japan Society for Science and Research Management, and holds membership several other notable societies and associations.

His research interest includes: Innovation Management, MOT (Management of Technology), SME Clustering in Manufacturing Industry, Regional Development, and Entrepreneurship. Professor Hirano was awarded the President Award for NTT Science and Core Technology Laboratory Group and NTT Basic Research Laboratories. He is the holder of 52 patents; one of them is the Method of fabricating circuit elements on an insulating substrate (US Patent 787136).

PROF. MASAFUMI YOHDA
TOKYO UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, JAPAN
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Professor Masafumi Yohda served as a professor since May 2003 in the Department of Biotechnology and Life Science, Tokyo University of Agriculture and Technology. Before that he was a researcher for the Institute of Physical and Chemical Research (RIKEN) since 1991. He finished his Bachelor, Master and Doctor from Department of Chemical Engineering, The University of Tokyo in 1982, 1984, and 1987 respectively. In 1999 he was awarded the Excellent paper award of Journal of Bioscience and Bioengineering.

His research field includes Biochemistry, Molecular Biology, Biophysics, System Engineering, and Environmental Science. Professor Yohda is the Councilor of the Japanese Biochemical Society, Director of the Protein Society of Japan, Director and Manager of East Japan Branch of the Society of Biotechnology, Director of the Chem-Bio Informatics Society. He is also a member of the Molecular Biology Society of Japan, The Society of Chemical Engineers, Japan, Japan Society for Environmental Biotechnology, to name a few.

INVITED SPEAKER

PROF. MICHIHARU TABE
SHIZUOKA UNIVERSITY, JAPAN
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Michiharu Tabe received the B.S. and M.S. degrees and the Ph.D. degree in engineering from Keio University, Japan, in 1973, 1975, and 1984, respectively. He joined Nippon Telegraph and Telephone Corporation in 1975, and had been engaged in research on Si processes for high-speed bipolar transistors and ultra-small MOSFETs. In 1984-85, he was a visiting researcher at Stanford University and studied oxidation of Si surfaces by Synchrotron Radiation. In 1990, he started to work on Si nanodevices, primarily single electron transistors.

Since 1994 up to now, he has been a Professor at Research Institute of Electronics, Shizuoka University, Japan. He is currently working on a new research area of “Single Dopant Atom Devices”. Recently, two papers published from his group have been officially adopted as Emerging Technologies in “International Technology Roadmap for Semiconductors”.

He is also an Adjunct Professor of University of Indonesia and an Honorable Professor of Obuda University, Hungary. In 2012, he received Prize for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology of Japanese Government, the 20th TakayanagiKenjiro Memorial Award in 2006, and a Fellowship of Japanese Society of Applied Physics in 2008.

PROF. MING YANG
TOKYO METROPOLITAN UNIVERSITY, JAPAN

Prof. Ming Yang is a Professor in the Faculty of System Design Graduate School of System Design, Dept of Intelligent Mechanical Systems, Tokyo Metropolitan University, Tokyo, Japan. His Research Topics include: Micro-Forming and Micro-Fabrication.

INVITED SPEAKER

DR. MIOARA MANDEA
CENTRE NATIONAL D'ETUDES SPATIALES, FRANCE
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Dr. Mioara Mandea is General Secretary of the European Geosciences Union and Program Manager for the Solid Earth Observation/Directorate for Strategy and Programs of Centre National d'Etudes Spatiales (French Space Agency), Paris. She graduated in Engineering in Geology and Geophysics from the University of Bucharest before earning doctorates from the University of Bucharest in geophysics and geophysical prospecting in 1993 and from the Institut de Physique du Globe de Paris in internal geophysics in 1996. In addition, she earned the Habilitation à Diriger des Recherches from the University Paris VII in 2001.

Her research interests mainly concern measuring, mapping, and understanding the multitude of magnetic fields encountered in near Earth and near Earth-like planets. Her fields of research also include geo-potential field mapping, on global or regional scales, with important implications for the understanding of rapid changes within the Earth's system. Dr. Mandea has published more than 200 papers. She is currently General Secretary of the European Geosciences Union. She has been awarded the Van Straelen prize (French Geological Society) and the Hepites prize (Romanian Academy), and is also a Titular Member of the Academy of Romanian Scientists.

PROF. MUHAMMAD IDRUS ALHAMID
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Professor Alhamid finished his Bachelor Degree from the Mechanical Engineering Departement, Universitas Indonesia in 1978 and continued on to finished his Doctorate from Katholieke Universiteit, Leuven, Belgium in 1989. He is currently a Professor and Researcher in the Mechanical Engineering Department, Universitas Indonesia, Head of Energy Conversion Division and Head of Refrigeration and Air Conditioning Laboratories in said University.

He teaches Ventilation System and Air Conditioning, Refrigeration Technology, Energy and Safety inside Building, Drying Technology, Kapita Selecta, and Engineering Design. Professor Alhamid is also involved and head several researches as follow: Development of Renewable Energy for Organic Rankine Cycle using Eco-Friendly Fluid, Capillary Expansion Device Development for Cascade Refrigeration System with New Alternative Refrigerant: Azeotropis Mixing Carbon Dioxide and Ethane, Design of Methane Storage Prototype with Activated Carbon (AC) from Indonesian Coal as Adsorbent, Development of Freeze Vacuum Dryer with Condenser Heat and Vibration, Solar Thermal Cooling System (Kawasaki, Waseda Univ & MoE Japan), Potential NAMAs for Building Energy (UNEP).

He is a member of the Indonesian Engieeners Association (PII) since 1985, a member of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) since 1990, a member of the Air System and Refigeration Expert Association since 1999 and member of the International Solar Energy Society (ISES) since 2008.

INVITED SPEAKER

PROF. MOHAMMAD NASIR
MINISTER OF RESEARCH, TECHNOLOGY AND HIGHER EDUCATION REPUBLIC OF INDONESIA
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HE Mr. Prof. H. Mohammad Nasir, Ph.D., Ak was born in Ngawi, East Java Indonesia in 27 June 1960. He was awarded his Bachelor for the Economic Faculty University of Diponegoro in Semarang in 1988. He later finished his Master in the University of Gadjah Mada (UGM), Yogyakarta in 1993 and earned his Ph.D in Accounting from the University of Science, Malaysia.

After experiencing work in the private sector, Prof. Nasir went back to his roots and started teaching at his alma mater, the Faculty of Economy, University of Diponegoro. His areas of teachings include: Management Control Systems, Management Accounting, Strategic Management, Organizational Behaviour, Behavioural Accounting, and Property Management.

Professor Nasir was appointed Vice Rector of Finance and Resources from 2006-2010 and Dean for the Faculty of Economic and Business from 2011-2014. He was elected as Rector on September 2014, however before his inauguration as Rector he was appointed as the Minister of Research, Technology and Higher Education by the President of the Republic of Indonesia.

PROF. OLIVER CARSTEN
UNIVERSITY OF LEEDS, ENGLAND
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Professor Oliver Carsten is a Professor of Transport Safety at the Institute for Transport Studies (ITS), University of Leeds. Professor Carsten did his undergraduate studies at the University of Oxford and obtained his PhD from the University of Michigan. Subsequently he worked at the University of Michigan Transportation Research Institute (UMTRI) for ten years. He joined the Institute for Transport Studies in 1987.

He has been project coordinator of several European projects, including HOPES which examined the safety impacts of various field trials, VRU-TOO which applied new technologies to improve the safety and mobility of pedestrians, HINT which examined the human implications of new technologies, and HASTE which has studied the effect on driving performance and safety of using in-vehicle information systems.

Currently he is coordinator of the European ecoDriver integrated (large) project on green driving support systems. He has led the development of the advanced driving simulator at Leeds and has directed projects to examine techniques for reducing unsafe driving on rural arterial roads and for investigating the benefits of Intelligent Speed Adaptation (ISA). He has been chair of the DRIVE I safety and behavioral group, was a member of the DRIVE Safety Task Force, is chair of the Road User Behavior Working Party of the Parliamentary Advisory Council for Transport Safety and has been a member of several expert groups of the European Transport Safety Council. He is editor-in-chief of the academic journal Cognition, Technology and Work.

PROF. DR. RAINER LEISTEN
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Professor Leisten studied mathematics and business administration at the University of Cologne, Germany. He received his Ph.D. in business administration from the University of Cologne in 1984 with a thesis on scheduling problems with limited buffer capacities under the supervision of Prof. Dr.-Ing. Dr. Theodor Ellinger. Afterwards, Prof. Leisten gained three years experience as a controller in the headquarter of Commerzbank AG in Frankfurt.

Moving back to academia, he earned his postdoctoral lecturer qualification (habilitation) in business administration from the University of Heidelberg in 1995 with a thesis on aggregation and disaggregation in planning. In 1995 he became full professor at the University of Greifswald and held the chair of Production Management. In 1999 he was appointed as a full professor at the University of Duisburg (now University of Duisburg-Essen) to hold the chair of Production and Operations Management. Prof. Leisten is currently the chair of Business Administration and Operations Management.

His primary areas of research interests include: Scheduling in Manufacturing, Coordination Aspects in Multi-Level/Multi-Stage (Production) Planning and Control Systems, and Supply Chain Management. He has published continuously in international journals and is conducting continuously research projects with business partners as well as international partners from academia.

DR. ROKIAH OMAR
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Rokiah Omar received her Bachelor of Optometry degree from the Universiti Kebangsaan Malaysia (UKM). After completing her BOptom in 1990, she was employed as an Optometrist with a private practice in Kuala Lumpur before joining UKM as a tutor in 1994. She obtained her PhD. in Low Vision from University of New South Wales, Australia in 2002. She is a Fellow in Low Vision of the American Academy of Optometry, Fellow of Association of Malaysian Optometrists, Founding members of Malaysian Academy of Optometry and Associate Fellow Academy of Science Malaysia.

Dr Rokiah became the first optometrist in the Asia region to be inducted as an International Blind Sports Federation International (IBSA) and International Paralympics Committee (IPC) Visually Impaired Classifier. She classifies visually impaired athletes at many disable sports/games locally and internationally. She was selected to represent Asia's continent to provide classification for visually impaired athletes at the London Paralympics Games 2012.

She is currently the Classification Director for the Asian Paralympic Committee (APC) and was in charged for classification of disable athletes at the Incheon Asian Para Games 2014 for 23 disable sports involving 44 countries. Her research interests include low vision rehabilitation, special population needs, quality of life and Public Health Optometry. She received many research and innovation awards at national and international levels.

INVITED SPEAKER

PROF. SANGKWON JEONG
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Professor Jeong finished his Bachelor and Master degrees from Seoul National University at 1985 and 1987 respectively. He received his Ph.D from MIT at 1992 where he continued to work in their Cryogenic Engineering Laboratory as visiting engineer and MIT Plasma Fusion Center from 1992-1995 as a research Engineer. Professor Jeong returned to Korea where he took up a position with the Korea Advanced Institute of Science and Technology where he is currently a Professor for the Department of Mechanical Engineering.

His research interests include the following: Cryogenics, Cryocooler design, applied superconductivity system, Cryogenic heat transfer, and Refrigeration. He was awarded the JSPS Fellowship in 1999 from Korea Science and Engineering Foundation, Overseas Research Fellowship for 2000 from Korea Research Foundation, Outstanding Research Paper Award by KIASC in 2004 and Overseas Research Fellowship for 2005 by SBS Foundation. Professor Jeong has 5 registered patents and 4 claimed patents between the year 2001-2006.

He is a member of the Korean Society of Mechanical Engineers (KSME), Korea Institute of Applied Superconductivity and Cryogenics (KIASC), American Society of Mechanical Engineers (ASME), and International Institute of Refrigeration (IIR). Professor Jeong is the Associate Editor for: the Journal of the Korea Institute of Applied Superconductivity and Cryogenics, Journal of Mechanical Science and Technology, and Cryogenics.

VERONICA SOEBARTO, PH.D.
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Veronica Soebarto is an Associate Professor and Deputy Head and Associate Head (Research) at the School of Architecture and Built Environment, The University of Adelaide. She holds a PhD in Architecture and Master of Architecture, both from Texas A&M University (College Station, Texas), and a Bachelor of Architectural Engineering from the University of Indonesia. Prior to joining The University of Adelaide in 1998, she was a Post-Doctoral Research Associate at Texas A&M University, a part-time lecturer at The University of Indonesia and an architect in Jakarta.

At The University of Adelaide, she teaches sustainable design, technology and environment courses at the undergraduate and postgraduate levels. Her main research interests include human thermal comfort, building thermal/energy simulation, environmental monitoring, and sustainable building design and assessments, and she supervises Honours, Masters and PhD students in these areas.

Veronica received a Faculty of the Professions' Executive Dean's Research Award in 2014. She has published more than 80 publications in journals, book chapters and conference proceedings. She is a member of the Editorial Board of Journal of Building Performance Simulation and an Associate Editor of Architectural Science Review. She is the 2014-2015 President of Architectural Science Association (ANZAScA).

PROGRAM AT GLANCE

Date	Time	Program	Venue
10 August 2015	04.00-06.00 pm	Registration and Welcome Drink	Pre-function Hall
11 August 2015	07.30-08.00 am	Registration	Pre-function Hall
	08.00-08.40 am	Opening Ceremony	Rinjani Room I, II, III
	08.40-09.00 am	Photo Session	
	09.00-09.30 am	Keynote Speech 1	
	09.30-10.30 am	Talk show: Serve the Country	
	10.30-10.45 am	Coffee break	
	10.45-12.00 am	Keynote Speech 2 and 3	
	12.00-01.00 pm	Lunch	Restaurant
		Poster Session	Pre-function Hall
		Exhibition	
	01.00-03.00 pm	Parallel session	Meeting Rooms
	03.00-03.30 pm	Coffee Break	Pre-function Hall
		Poster Session	
		Exhibition	
	03.30-05.00 pm	Parallel session	Meeting Rooms
	05.00-07.00 pm	Poster Session	Pre-function Hall
		Exhibition	
	07.00-09.00 pm	Banquette Dinner	Rinjani Room I, II, III
12 August 2015	08.00-10.00 am	Parallel session	Meeting Rooms
	10.00-10.30 am	Coffee Break	Pre-function Hall
		Poster Session	
		Exhibition	
	10.30-12.00 am	Parallel session	Meeting Rooms
	12.00-01.00 pm	Lunch	Restaurant
		Poster Session	Pre-function Hall
		Exhibition	
	01.00-03.00 pm	Parallel session	Meeting Rooms
	03.00-03.30 pm	Coffee Break	Pre-function Hall
		Poster Session	
		Exhibition	
	03.30-05.00 pm	Parallel session	Meeting Rooms
	05.00 - 06.00 pm	Closing Ceremony	Selaparang Room
13 August 2015	08.00 am-08.00 pm	Social Tour Lombok	

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A Review of Torque Ripple on Permanent Magnet Generator for Wind Turbine Applications

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Keywords: torque ripple; permanent magnet generator.

Abstract. Permanent magnet generators have been gaining importance for wind turbine applications because they have the advantage of higher power density and/or torque density than machines with electromagnetic excitation. Torque pulsations such as torque ripple produce magnetic vibration and noise in permanent magnet machines. Thus, it is important to minimizing the torque ripple in permanent magnet generator design. To reducing the torque ripple, there are several ways to do, e.g. skewing of the stator and/or rotor, choosing the right combination of pole and slot numbers and adjusting some design parameters such as the permanent magnet pole arc width and/or the slot opening width.

Introduction

The use of environment friendly renewable energy sources are getting rapidly higher, due to the reasons like energy needs, pollution and green house gasses. Providing reliable access electricity to all and reducing environmental impacts has been recognized as the key challenge of the global electricity sector. For reducing the environmental impacts, renewable energy sources such as wind energy can be an alternative to generate electricity. To convert wind power into electricity, wind turbines have an electric machine called a generator as a major component.

Permanent Magnet Generator

Electrical machines have a huge influence on the reduction of energy consumption. The consumption of electrical energy can be saved by designing the construction of electrical machines with better efficiency. The use of PMs in construction of electrical machines can improve the efficiency and reliability of the machines by eliminating the excitation losses [1, 2]. By eliminating gearbox, direct drive PM machines have many advantages such as higher reliability and efficiency, reduced maintenance, noise and weight [3].

PM machines have been widely used, such as electric and hybrid electric vehicles, pumps, and wind generators. That's because they have the advantage of higher power density and/or torque density than machines with electromagnetic excitation [1, 4].

There are various types of machine topology for the application of PM generator to the wind power generation systems has been developed to maximize the electrical energy, improve power quality and minimize costs. According to the flux direction in the air gap, PM machines can be divided into radial-flux permanent magnet (RFPM) machine, axial-flux permanent magnet (AFPM) machine and transverse-flux permanent magnet (TFPM) machine [2,3]. The flux of RFPM machine flows radially through the air-gap while the current circulates in the axial direction (Fig. 1). In AFPM machine (Fig. 2), the flux flows axially through the air-gap while the current flows in the radial direction. Fig. 3 shows the basic topology of TFPM machine [3]. TFPM machine does not seem very common yet in wind power generation [2].

In [2], the authors provided a comparison among seven configurations consisting both radial flux machines and axial flux machines.

Conventional PM machines are generally of the radial-flux type. The rotor configuration may be classical configuration (Fig. 4a), interior magnet type (Fig. 4b), surface magnet type (Fig. 4c),

inset magnet type (Fig. 4d), rotor with buried magnets symmetrically distributed (Fig. 4e) and rotor with buried magnets asymmetrically distributed (Fig. 4f) [1].

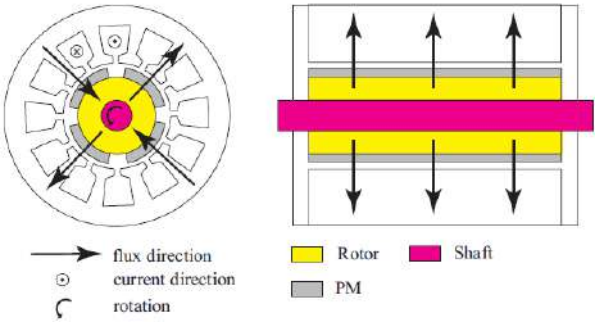

Fig. 1. Flux and current directions of RFPM machine

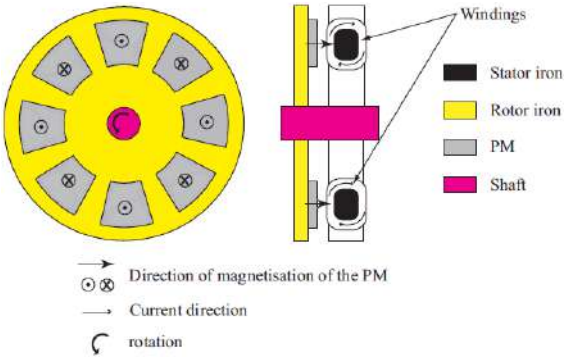

Fig. 2. Flux and current directions of AFPM machine

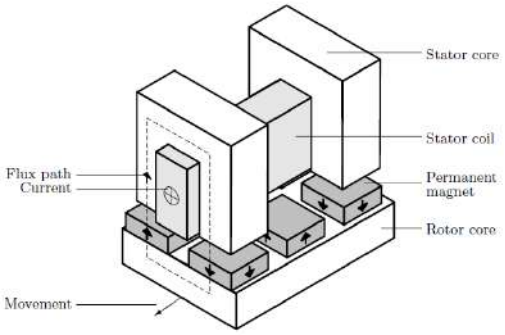

Fig. 3. Basic single-phase transverse flux topology

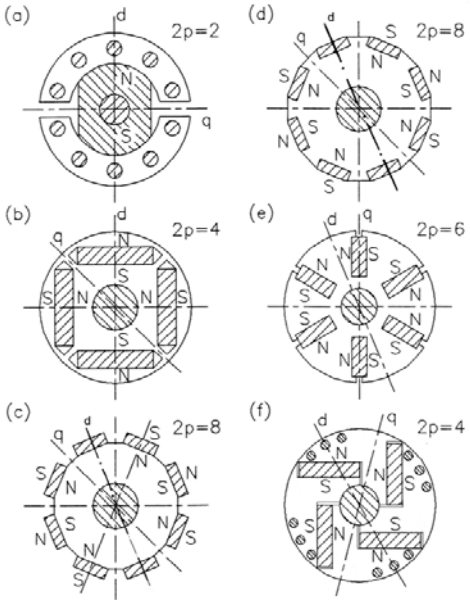

Fig. 4. Rotor configurations for PM machines: (a) classical configuration; (b) interior-magnet rotor; (c) surface-magnet rotor; (d) inset-magnet rotor; (e) rotor with buried (spoke) magnets symmetrically distributed; (f) rotor with buried magnets asymmetrically distributed

The design and analysis of a dual-rotor radial flux permanent-magnet (DRRFPM) generator is presented in [9-11]. The purpose of the optimal design is to maximize the output voltage [11] and to reduce cogging torque [10, 11]. The design was calculated by finite element analysis (FEA).

Comparison between air-cored and iron-cored non overlap winding radial flux PM direct drive wind generators are investigated in [12]. Generators with air-cored windings have zero cogging torque. In [13], the authors presented the electromagnetic and mechanical design of the double rotor radial flux permanent magnet generator with non overlap air-cored (ironless) stator windings for direct drive wind generator applications. The purpose of the optimal design is to minimize the mass of active material of generator.

In [14], the authors proposed the methodology for the design, analysis, and optimization of coreless brushless permanent magnet machines especially for generator applications. The performance features and parameter of various ironless machine technologies are presented in this paper.

In [4-8], the authors proposed the optimal design of dual stator radial flux permanent magnet (RFPM) generator for reducing cogging torque. Fig. 5 shows the structure of RFPM generator. An inner-rotor type RFPM generator has a rotor located inside of the stator (Fig. 5a) and the outer-rotor type RFPM generator has a rotor positioned externally (Fig. 5b). The shape of proposed design of dual stator radial flux permanent magnet (DS-RFPM) generator, which is a combination of the inner and outer-rotor types, is shown in Fig. 5c.

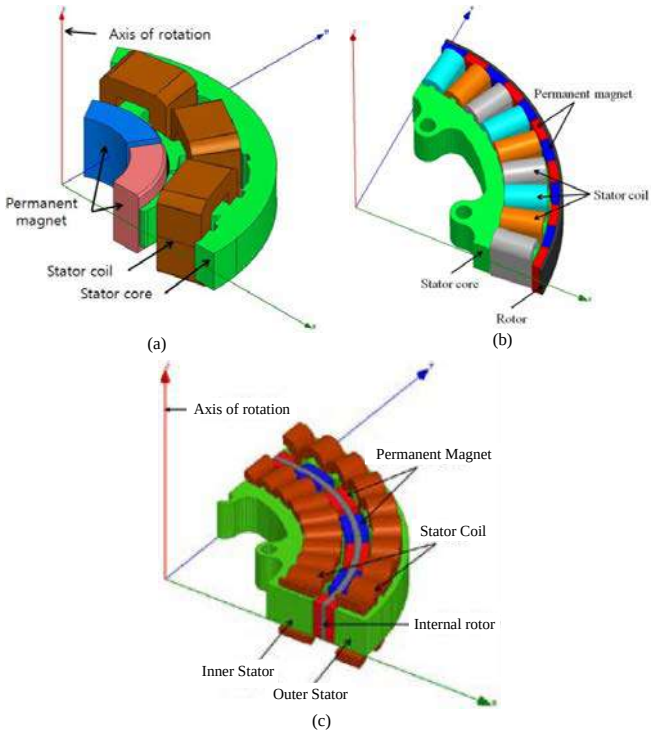

Fig. 5. The structure of RFPM generator: (a) inner-rotor type; (b) outer rotor type; and (c) the shape of proposed DS-RFPM

The AFPM machines are formed by pancake shape rotor and stator [1, 15]. From this basic shape, many various researches are possible including double side external slotted cores stator and inner rotor (double slotted cores stator with internal rotor) [15, 16], double side inner coreless stator (double rotor with coreless internal stator) [17-19], double side external rotor and a slotted stator [20-22] and single sided slotless/coreless stator [23, 24].

Torque Ripple

For designing a low speed direct drive generator, torque quality is one of the challenges. Torque distortions such as cogging torque and torque ripple produce magnetic vibration and noise. In direct drive applications they are transmitted directly to the load and drive shaft, which in return, affect the lifetime of the drive train. That's why in designing PM generators, it is important to minimizing the torque ripple. Cogging torque is given by the interaction between the rotor magnetic flux by PMs and reluctance variations due to the slotting of the stator (cogging torque also called "no current torque"). Torque ripple is caused by the non ideal distribution of flux density in the air-gap. It is generated by the interaction of the current fundamental harmonic and the EMF harmonics [25]. The torque ripple can be calculated from the harmonics in the back-EMF if the machine is supplied with a sinusoidal current [3]. Fig. 6 shows how cogging torque and torque ripple are calculated.

Basically, there are two approaches for reducing the torque ripple [26, 27]. One is to improve the magnetic design of the machines by changing the stator and rotor pole structures. The other one is to use the electronic control technique which is based on optimizing the control parameters such as supply voltage, turn-on and turn-off angles, and current level.

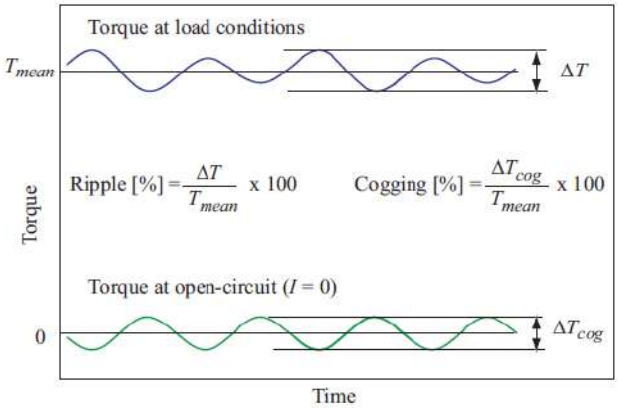

Fig. 6. Definition of cogging torque and torque ripple

But minimizing the torque ripple by electronic control techniques may caused the average torque reduced. The electronic control techniques are used in [25-29] to reducing the torque ripple. Improve the magnetic design of the machines are more effective on reducing torque ripple than the electronic control [30]. It is because the first method can also reduce cogging torque and optimize back EMF, whereas the electronic control techniques need precise real time excitation current profiles, depend on the reliability and accuracy of the sensors.

Design optimization for low torque ripple and cogging torque by changing the magnet arc and choosing an optimum flux barrier shape for interior PM machine using 2D FEA are presented in [31]. Table 1. presents the cogging torque value with different magnet arc length. It was found that minimum cogging torque produces when the magnet arc length is 40.84 mm. To investigate the torque ripple in the machine, the authors proposed three different flux barrier designs as shown in Fig. 7.

Table 1. Cogging torque value with magnet arc variations

Magnet arc length (mm)	Cogging torque (Nm)
38.92	10.46
39.00	11.10
40.84	2.00
42.20	5.83

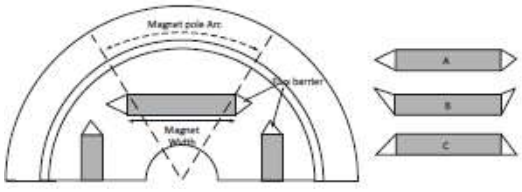

Fig. 7. Flat shape interior PM machine with variations of flux barrier shape

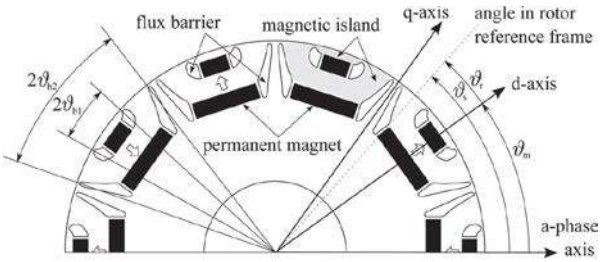

Fig. 8. Reference frame and rotor structure for interior PM analytical model

Optimizing flux barrier angles also used in [32] besides adopting a multilayer structure for stator windings to reduce the torque ripple in interior PM motor fractional-slot non-overlapping windings (also known as concentrated windings). Fig. 7 shows the rotor geometry structure with two flux barrier per pole. Analytical model results for 12 slot 10 pole machine shows that the torque ripple achieved lower than 1.5% at full load.

In [33], the authors using magnet pole shaping technique for torque ripple reduction on an 18 slot and 12 pole surface mounted PM Brushless DC (PM BLDC) motor. The performance parameters were computed and analysis by 2D FEA.

In [34], the authors investigated the effectiveness of skewing rotor method with/without

magnet shaping on the torque ripple for surface mounted PM machine. Although the cogging torque can be fully eliminated, it was proven that skewing not fully eliminated the torque ripple, because in this case the skewing angle should be 360° electrical, which is made the average torque will also be zero.

Skewing rotor also used in [35] for torque ripple and cogging torque reduction on surface mounted PM synchronous motor. However, the results show that skewing may cause the torque ripple increase if the magnet shape is not designed carefully. The authors used surface mounted PM synchronous motor with 9-slot/6-pole non-skewed and skewed for the test. Tests were also conducted on a 12-slot/10-pole non-skewed surface mounted PM synchronous motor.

The reduction of the torque ripple harmonics with the lowest orders (6^{th} and 12^{th}) for PM synchronous machines with fractional-slot non-overlapping windings by teeth widths adjustment is presented in [36]. The authors investigated the phenomenon of torque ripple in two type machine, outer rotor surface mounted PM synchronous machines and inner rotor interior PM synchronous machine. The optimization technique was carried out by FEA. Influence of the permanent magnet skewing on the torque ripple reduction and cogging torque elimination was also investigated.

Shaping the stator teeth for reducing the torque ripple also use in [37]. The authors compared three models of surface mounted PM motor with different stator teeth shape. Fig. 9 shows the three models of surface mounted PM motor with different stator teeth shape. The initial model is shown in Fig. 9a, in the second model (Fig. 9b), the top of the stator teeth is flat, and the third model (Fig. 9c) shows the air-gap becomes large toward the stator teeth tip. The analysis results show that the minimum value of cogging torque and torque ripple is not at the same point of design. Therefore, the design parameter should be chosen carefully.

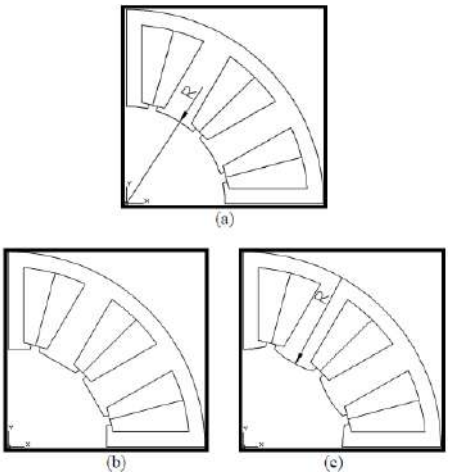

Fig. 9. Cross section shapes of: (a) Model 1; (b) Model 2; (c) Model 3

In [38], the authors investigated cogging torque minimization and torque ripple reduction in surface mounted PM synchronous machine using different magnet widths. Fig. 10 shows the different between normally magnet widths and the method that the authors proposed. It shown that normally the dimension of magnet and interval spaces between them are the same (Fig. 10a). Fig. 10b shows one magnet has different width from the other.

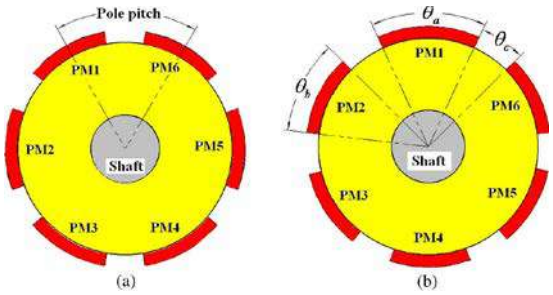

Fig. 10. Cross section of rotor: (a) uniform magnet widths; (b) different magnet widths method

An analytical approach for optimizing inner rotor surface mounted PM synchronous generator with concentrated windings design for wind power applications is presented in [39]. The authors using both the PM shape design and skewing stator to reducing the torque ripple and cogging. Fig. 11a shows the analytical model of skewing stator of PM synchronous generator to reducing the cogging torque. Fig. 11b shows analysis model for deriving the PMs magnetic field, where α, β, γ and y are the radian of each region. The performance of PM synchronous generator is experimentally verified under AC and DC load conditions.

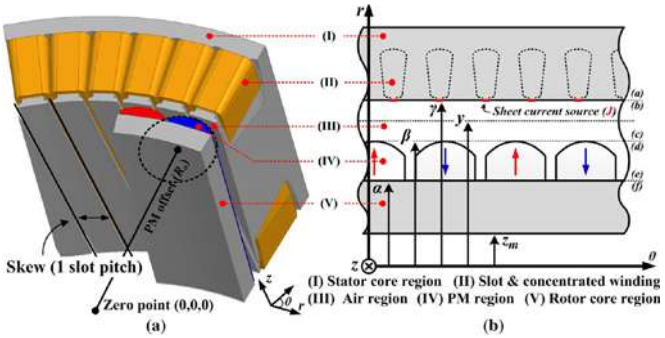

Fig. 11. (a) 3-D FE analysis model based on skewing; (b) analytical model based on PM shape

Conclusion

This paper provides a literature review on reducing the torque ripple in permanent magnet generator. There are several ways to minimize the torque ripple, e.g. skewing of the stator and/or rotor, choosing the right combination of pole and slot numbers and adjusting some design parameters such as the PM pole arc width and/or the slot opening width. It was found that torque ripple could not be always reduced by skewing, and a low cogging torque does not always guarantee a low torque ripple. Therefore, to reducing the torque ripple we should find the optimal design of permanent magnet generator by choosing the right combination of pole and slot numbers and also shaping the rotor magnet and stator teeth.

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