10th Eco-Energy and Materials Science and Engineering Symposium


On December 5-8, 2012
Sunee grand hotel,
Ubon-ratchathani

Organized by

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PREFACE:
Message from the President of
Rajamangala University of Technology Thanyaburi

Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This international conference is not only giving an opportunity for Thai and foreign researchers to present and discuss their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Our program consists of six research tasks: (1) Energy Technology, (2) Environmental and Social Impact, (3) Nanotechnology and Materials Science, (4) Energy Economics and Management, (5) New Energy Technology and (6) Nuclear Technology.

I would like to take this opportunity to express our sincere gratitude to our two distinguished Plenary Speakers for kindly accepting our invitation. I deeply appreciate the very strong support given by Kyoto University. Thanks to the tireless works of the Organizing Committee, the Technical Program Committee, the invited speakers and paper and poster contributors, and excellent program been assembled to cover a broad spectrum of interesting topic.

We warmly welcome you to the 10th EMSES on December 5-8, 2012, Ubon Ratchathani, Thailand.

Numyoot SONGTHANAPITAK, Ph.D.
President of Rajamangala University of Technology Thanyaburi
Conference Chairman of 10th EMSES 2012
It is my great pleasure to have the 10th Eco-Energy and Materials Science and Engineering Symposium (EMSES) with Rajamangala University of Technology Thanyaburi (RMUTT) under the long-term collaboration between RMUTT and Kyoto University. The 1st EMSES was held in 2001 in Thailand and the symposium has been expanded in its scientific contents as well as the academic network. I believe that the 10th EMSES gives a good opportunity to all participants to exchange their knowledge and idea to realize eco-friendly energy system in society. I would like to express my welcome to all participants and sincere thanks to the 10th EMSES organizing committee and all supporting organizations to make us having this symposium. I hope that the symposium will be successful and lead to further progress in energy science and technology and also in friendships of participants.

Professor Yukio Ogata, Ph.D.
Director of Institute of Advanced Energy, Kyoto University
PREFACE:
Message from the Former Dean of
Graduate School of Energy Science, Kyoto University
Program Leader,
Global COE “Energy Science in the Age of Global Warming”

I want to express my hearty welcome to all participants of Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This symposium is aiming the realization of importance of energy and materials technology through the academic, science and technology network among the world communities. The symposium gives an opportunity for researchers to discuss their research works and also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the further cooperation work will be developed.

I would like also extend my sincere thanks to all who made the meeting possible, including the 10th EMSES organizers, the SEE forum committee members, and the Japanese Government, JSPS, for their kind support. I am looking forward to seeing you in Ubon Ratchathani, Thailand.

Professor Takeshi YAO, Ph.D.
Former Dean of Graduate School of Energy Science, Kyoto University
and Program Leader, Global COE “Energy Science in the Age of Global Warming”
Message from the Chairperson of
10th EMSES Organizing Committee

Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10th EMSES).

RMUTT has a major mission on encouraging and supporting all areas of research. One of the key reasons is to assist in developing capability in science and technology in order to cope with recent rapid change in this field. We have jointly set up an academic symposium on the 10th EMSES with the perception on the significance of exchanging knowledge and research experiences between researcher in the field of energy, materials technology and environmental science. This symposium is not only giving an opportunity for Thai and foreign researcher to present and discussion their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the closer future cooperation incorporate with joint-research works will be developed. Thus, to support the aforesaid role, the symposium working committee would like to invite you to participate in this academic symposium.

I would like to express our sincere thanks to the organizing committee, participants and contributors for your kind corporation to this symposium. I wish this symposium proceeding will be a useful reference for future scientific research development.

Somasvit Pivsa-Art, Ph.D.
Dean of Faculty of Engineering, RMUTT
Director of CoE on Sustainable Energy System (Thai-Japan)
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# Conference Program of 10th Eco-Energy and Materials Science and Engineering

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<th>6th December 2012</th>
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<tr>
<td>01:00-05:00 pm</td>
<td>Registration</td>
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<td>07:00-09:00 am</td>
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<td>09:00-09:40 am</td>
<td>Opening Ceremony at Taptim Siam 4 Hall</td>
<td>Keynote Speaker I: Japan Power Generation Mix and Energy Security after Fukushima Nuclear Accident, presented by Professor Dr. Kiyoshi Yoshikawa, Vice President of Kyoto University, Japan Co-Chairperson of 10th EMSES conference</td>
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<td>Lunch at Taptim Siam 5 Hall</td>
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<td>10:45-11:00 am</td>
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<td>11:00-12:00 am</td>
<td>Keynote Speaker II: Vertical Motions in Greater Bangkok Area after the 2004 Sumatra-Andaman Earthquake from GPS Observations and Its Prediction based on the Geophysical Modelling, presented by Professor Dr. Chalermchon Satirapod, Chulalongkorn University, Thailand</td>
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<tr>
<td>12:00-01:30 am</td>
<td>Lunch at Taptim Siam 5 Hall</td>
<td>Poster Session</td>
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## Room

### Pathumwan
- **Pathummat**
  - Energy Technology 1
  - Nano & Materials Technology 1
- **Pathumchart**
  - New Technology 1
  - IN15, NT01, NT02, NT03, NT05, NT06, NT10, NT12
  - IN05, ET60, ET62, ET64, ET69, ET71

### Room Location
- **Chair**
  - Prof. Dr. Padungsak Ratthanachai
  - Assoc. Prof. Dr. Wisanu Pecharapa
- **Co-Chair**
  - Dr. Wiratchai Roynarin
  - Dr. Sorapong Pavasupree

### Keynote Speakers
- **Keynote Speaker I**: Assoc. Prof. Dr. Numyoot Songthanapitak, President of RMUTT, Thailand and Chairperson of 10th EMSES conference
- **Keynote Speaker II**: Prof. Dr. Kiyoshi Yoshikawa, Vice President of Kyoto University, Japan Co-Chairperson of 10th EMSES conference
- **Keynote Speaker III**: Prof. Dr. DaeHee Park
- **Keynote Speaker IV**: Prof. Dr. Susumu Yoshikawa

### Poster Session
- **Chair**: Dr. Surawut Chuangchote
- **Co-Chair**: Nithiwatthan Choosakul
## Conference Program of 10th Eco-Energy and Materials Science and Engineering

### 7th December 2012

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<tr>
<td>Chair</td>
<td>Assoc. Prof. Dr. Thawatch Kerthuen</td>
<td>Dr. Seichi Aiba</td>
<td>Prof. Dr. Takeshi Yao</td>
<td>Asst. Prof. Dr. Somchai Hiranvarodom</td>
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<tr>
<td>Co-Chair</td>
<td>Asst. Prof. Dr. Wanchai Subsingha</td>
<td>Dr. Leong Yew Wei</td>
<td>Dr. Supaporn Tomson</td>
<td>Dr. Nathabhat Phankong</td>
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<td>10:30-10:45 am</td>
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<td>10:45-12:15 am</td>
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<tr>
<td>Chair</td>
<td>Dr. Arthit Sode-Yone</td>
<td>Assoc. Prof. Dr. Kawee Srikulkit</td>
<td>Prof. Dr. Jun Li</td>
<td>Prof. Dr. Hiroyuki Hamada</td>
</tr>
<tr>
<td>Co-Chair</td>
<td>Asst.Prof.Dr. Boonrit Prasartkeaw</td>
<td>Assoc. Prof. Dr. Yuji Aso</td>
<td>Dr.Sarocha Charoenvai</td>
<td>Dr. Narongchai O-Charoen</td>
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<td>12:15-13:30 pm</td>
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### 8th December 2012

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<td>Environmental&amp;Social Impact 1</td>
<td>Energy Economic &amp; Management 1</td>
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<td>ES09,ES10,ES11,ES13,ES14,ES15</td>
<td>EM02,EM03,EM04,EM07,EM08</td>
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<tr>
<td>Chair</td>
<td>Prof. Dr. Chul-Su Kim</td>
<td>Prof. Dr. Yuichi Anada</td>
<td>Prof. Dr. Keijichi N. Ishihara</td>
<td>Assoc. Prof. Dr. Natha Kuptashien</td>
</tr>
<tr>
<td>Co-Chair</td>
<td>Dr. Winai Chanpeng</td>
<td>Assoc. Prof. Dr. Kazushi Yamada</td>
<td>Asst. Prof. Dr. Sommai Pivsa-art</td>
<td>Dr. Boonyang Plangklang</td>
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<tr>
<td>03:15-04:00 pm</td>
<td>Closing Ceremony at Taptim Siam 4 Hall</td>
<td>Prof. Dr. Takeshi Yao, Leader of GCOE Program/Professor, Graduate School of Energy Science, Kyoto University</td>
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<table>
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<tr>
<th>Time</th>
<th>Excursion</th>
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</table>
Study of Generator Reaction on Permanent Magnet Synchronous Motor for Energy Regenerative Applications

S. Kantawong A. Noppakant and B. Plangklang
Department of Electrical Engineering, Faculty of Engineering, Rajamangala University of Technology Thanyaburi, Klong 6, Thanyaburi, Pathumthani 12110
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Abstract—This article presents the operating principle of transformation from permanent magnet synchronous motor to function as Generator in Energy regenerative mode. From experiment it is observed that when voltage is fed into permanent magnet motor, the electric input energy is converted to mechanical energy. On the other way, when motor is rotated without supplying input power while no load or light load, it generated electric output energy. This situation is call "Regenerative". This electric output energy can be fed back to the system for replacement of the energy that has been used. The study is done by simulation using Matlab/Simulink program. The simulation used closed loop control. Motor is running at 1000 RPM, controlled by PI controller thought an inverter with PWM controller switching waveform from insulated gate bipolar transistor (IGBT). The characteristic of motor is observed while feeding both positive and negative load. When feed with positive load it behaves as motor and with negative load it suddenly behaves as generator. This experiment will lead to a proper design of Energy Regenerative Unit (ERU).

Keywords—Regenerative, Transformation of motor to generator, Permanent magnet synchronous motor

1. INTRODUCTION

Motor is an electrical device which converts electrical energy into mechanical energy. Motor is an appliance with daily life use tools. Such as fans, air conditioners, machine tool technology, education and many other types of motors used in machines [1].

Permanent Magnet Synchronous Motors (PMSM) are widely used in industries applications because the ratio torque to weight is high effectively respond to the speed control, low moment of inertia, small size with lightweight compared to the same size of electric motors and have a good heat dissipation. The low loss motor can be used in dangerous industries such as oil and gas or flammable without causing environmental problems [2].

Thus this paper will study the Synchronous permanent magnet motor that transform into generator. The 4 Quadrants will be described. By the content of this article will discuss the 4 Quadrant in section 2, the simulation of the system with Matlab/Simulink in section 3, the results in section 4 and conclusions in section 5.

2. THEORY AND IMPLEMENTATION.

2.1 PRINCIPLES OF FOUR - QUADRANT OPERATION.

Figure 1 shows a graph of the speed and torque control in both the positive and negative directions.

![Figure 1, the comparison between the various state motor speed and torque.](image)

From figure 1, progress in Quadrant 1,3 are defined as motor mode which means that the speed and torque is in the same direction. The progress in Quadrant 2,4 are assigned to be a generator, sometimes called regenerative mode.
Figure 2, A graph of the speed and torque of the motor during each time period.

This means that the speed and torque is in the opposite direction. The torque of the motor's and motor speed is in different direction of rotation. This will cause the motor to produce power. This energy is fed back into the electrical system or can continue to be able to use this power again.

Figure 3 illustrates the two engaged in a work which is being accelerated by the motor speed and torque in the positive direction. During the second phase, the speed still is a positive and a negative torque which the motor is stopped, but it turns out to be generator. The work of the third phase will work similar to the first phase, but the direction is opposite to the negative, which is still a function of the motor phase 4 is similar to the second phase but with the opposite direction [3].

2.2 PERMANENT MAGNET SYNCHRONOUS MOTOR

The characteristics of the permanent magnet motor according to equations (1) - (4), which is applied to test the program in MATLAB/SIMULINK

\[
\frac{di_d}{dt} = \frac{1}{L_d} v_d - \frac{R}{L_d} i_d + \frac{L_q}{L_d} p\omega \cdot i_q
\]

\[
\frac{di_q}{dt} = \frac{1}{L_q} v_q - \frac{R}{L_q} i_q - \frac{L_q}{L_q} p\omega \cdot i_d - \frac{\lambda p\omega}{L_q}
\]

\[
T_e = 1.5 p [\lambda i_q + (L_d - L_q) i_d i_d]
\]

\[
\frac{d\omega}{dt} = \frac{1}{J} (T_e - F\omega - T_m)
\]

Where:
- \(L_d, L_q\) be Inductance of the d and q
- \(R\) be Resistance of Stator
- \(i_d, i_q\) be current of d and q
- \(V_d, V_q\) be voltage of d and q
- \(\omega\) be velocity of Rotor
- \(\lambda\) be magnetics flux of motor
- \(p\) be number of pole
- \(T_e\) be torque produce by motor

2.3 PRINCIPLE OF SPEED CONTROL USING A PI CONTROLLER.

The system will measure the speed of the motor that is compared with speed Reference, the response of the system is controlled by a PI controller. Therefore, the design of PI controller system is very important part. The PI controller is designed and to find the parameters Kp and Ki for this simulation, both the Software Tool GUI, a tool called SISOTOOL in Matlab / Simulink is used to help in the transfer function as follows.

\[
PI(s) = \frac{K_p Ki(s) + 1}{Ki(s)}
\]

Figure 3, Speed control circuit with PI controller.

3. A SIMULATION OF THE SYSTEM

As mentioned, in this paper, a simulation system of permanent magnet synchronous motors is done by Matlab/Simulink as shown in figure 4.
Figure 4, Circuit simulation in Matlab/Simulink.

From figure 4, it simulates the motor speed to maintain constant speed at 1000 RPM, and to simulate, the example values are selected from a typical PM motor which 625 Nm, 0 Nm, -625 Nm are entered. The configuration parameters used in the simulation are shown in Table 1 [5].

Table 1, parameters for the simulation.

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>0.5 Ohm</td>
</tr>
<tr>
<td>Ld, Lq</td>
<td>9 mH</td>
</tr>
<tr>
<td>Pole</td>
<td>20 pairs</td>
</tr>
<tr>
<td>Magnetic Flux</td>
<td>1.1 Vs</td>
</tr>
<tr>
<td>Torque</td>
<td>+/- 625 Nm</td>
</tr>
<tr>
<td>J</td>
<td>0.1 kg.m(^2)</td>
</tr>
</tbody>
</table>

Before the simulation as in figure 4, it must evaluate the Kp and Ki, then the results from table 1 is entered into the simulation program.

Figure 5, The response of the system design. Kp and Ki compared with amplitude and time

Figure 5 shows the response to find Kp, Ki. The response of the system is controlled by a PI controller and it is designing on the appropriate Kp and Ki. The result from figure 5, the curve is over steady line not more than 20% and slowly came back to normal (Steady State). The motor torque and current at DC input converter are positive. With a constant speed continues at 1000 RPM, the DC input converter current is still positive. This means the motor is working as the motor mode. But when the motor torque is negative, with a constant speed of 1000 RPM, the DC input converter current is negative. That means the motor become a generator. Power will change if the load of motor has change. The power can become a positive and negative power depending on load. If the power is negative, the power supply is restored back to the system grid, (as generator), the simulation results showed in figure 6 - figure 10.
From figure 6, the system is fed torque to a motor and then considered the behavior of permanent magnet synchronous motors while keeping constant speed. The current and voltage results are showed as figure 7 and figure 8.

4. RESULTS

Simulation results of permanent magnet synchronous motor are summarized in Table 2.

<table>
<thead>
<tr>
<th>Torque Load</th>
<th>DC Input Converter Current (A)</th>
<th>Voltage (V)</th>
<th>Motor Current (A)</th>
<th>Voltage (V)</th>
<th>Power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>625</td>
<td>19</td>
<td>5000</td>
<td>±19</td>
<td>±5000</td>
<td>160</td>
</tr>
<tr>
<td>0</td>
<td>1.5</td>
<td>4600</td>
<td>±1.5</td>
<td>±4600</td>
<td>+1.2 (max) -0.5 (min)</td>
</tr>
<tr>
<td>-625</td>
<td>-16</td>
<td>4300</td>
<td>±16</td>
<td>±4300</td>
<td>-115</td>
</tr>
</tbody>
</table>

By simulation program at different load, using Matlab Simulink, the motor speed is kept constant, the load for motor is 625, 0 Nm, motor is working and having both a positive and negative power. The motor current at DC input converter is a positive current. It means that the motor is running and remains to work as a motor. When the system input load is -625 Nm, the power measured from the motor is negative and the DC input converter voltage is also negative. It means that the motor is
operating as a temporary generator. It is happens practically at a time when the load is removed.

Normally for this regenerative energy, it can be controlled to feed back to the grid by a diode rectifier to flow the current direction. The paper proposes the new design conceptual model with regenerative drive in figure 11 which used IGBT to control the power flow in bi-directional. This means that one direction is feeding the power to motor and other direction is fed back to the system as a generator [4].

Therefore, this study can be able to support the idea and design to the Energy Regenerative Unit (ERU) as shown in Figure 11.

![Figure 11, proposed ERU integrated system](image)

5. CONCLUSIONS

The study of synchronous permanent magnet motor is performed via simulation to study the behavior of the motor in a generator mode called regenerative mode. If the motor is run in different load, when the motor has a positive speed and torque load, it can function to be as a generator. In generator mode, it can feed back the power to the system. This is the so-called “generative phenomenon”. Normally nowadays, this power is wasted via dump load resistor in order to protect the elevator system. This study proposed the regenerative energy to be used as Energy Regenerative Unit (ERU) that is fed waste energy from the elevator to the grid when the elevator moves upward, downward, and break.

REFERENCES