International Journal of Electrical, Electronics and Computer Engineering 5(2): 16-22(2016)
ISSN No. (Online): 2277-2626

Modeling and Control Strategies for Renewable Based Energy

Tarun Prakash* and Prof. P.K. Sharma**
**Research Scholar, Department of Mechanical Engineering, NIIST, Bhopal, (Madhya Pradesh), INDIA*
***Professor, Department of Mechanical Engineering NIIST, Bhopal, (Madhya Pradesh), INDIA*

(Corresponding author: Tarun Prakash)
(Received 29 June, 2016 Accepted 12 August 2016)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Renewable Energy applications that depend on battery power as part of the system operation must be at maximum performance at all times. To ensure this high rate of performance, the charging system must be set properly. A battery that is undercharged or overcharged will affect the performance of the entire system. The below list of requirements for setting inverter / charge controllers to properly charge East Penn lead-acid batteries should be followed. It is important to compare these requirements with the setting(s) on your inverter / charge controller.

Keywords: Battery Charging, Renewable Energy

I. INTRODUCTION

Generated is generally with a variable frequency and unstable voltage so it will be converted to DC power. The DC power either is used to serve the load directly or converted to good quality AC power supply to AC loads. Due to uncertainties of the renewable energy availability, battery storage is adopted. So the electricity energy will be saved to the battery when the excessive electricity is generated and the stored energy will supply electricity to the load while there is no enough electrical power being generated. As we know, frequent charging and discharging will shorten the life time of a battery. With such a system, the problem is how to determine when the battery should be charged to provide the best energy efficiency and to prolong the life time. Many works such as the modeling of the wind turbine, the control strategies for the three-phase generator and the optimization of the DC-DC converter etc., have been reported in many publications [4].

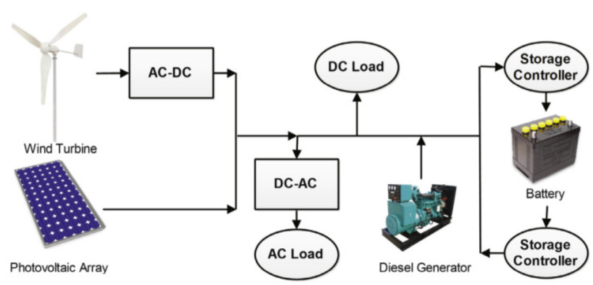

Fig. 1. A typical renewable energy generation system.

Various research papers identified with modeling and control method are accessible in literature. In this paper, renewable energy based half and half models and control systems are mulled over. What's more, different issues identified with half breed displaying are additionally tended to. It has been found that the specialists have attempted to accomplish two expansive results as specified previously. This paper is sorted out as follows: the methodologies and techniques embraced by various authors or researchers to accomplish an optimal hybrid design are discussed

II. CONTROL STRATEGY & OPTIMIZATION

In this section, renewable energy based hybrid models and control strategies are taken into consideration. In addition, various issues related to hybrid modeling are also addressed. It has been found that the researchers have worked to achieve two broad results as mentioned above.

A. Design Optimization

As discusses earlier, the researchers worked under two broad optimization objectives.

One such category is the design of an optimal sizing of hybrid energy sources. This includes the selection of proper renewable energy sources with proper sizing, so that an optimized hybrid energy system could be developed, depending on the availability and feasibility of renewable energy power required of each source. In recent days power generation using renewable energy sources gained more attraction. The most commonly available and used energy resources are solar and wind. The objective presented here is charging of low power electronic gadgets using the wind energy available during travelling. A DC generator with a Sepic converter provides voltage required for charging the gadgets when the vehicle speed exceeds 40km/hr. Even though the speed fall is observed, the gadgets will get continuously charged by the external battery source which is connected to the proposed circuit. This could be used as emergency source for charging electronic gadgets while travelling in a vehicle.

Batteries in solar applications have to meet the demands of unstable grid energy, heavy cycling (charging and discharging) and irregular full recharging. There's a variety of battery types fitted for these unique requirements. Considerations for choosing a battery include cost, cycle life and installation and maintenance.

Here's a look at these aspects of each technology, as well as some best practices when selecting batteries for a solar installation.

B. Solar battery technologies

Lead acid. Deep-cycle, lead-acid batteries have been employed in renewable energy and reliably used in off-grid applications globally for decades.

Cost: Typical deep-cycle, lead-acid batteries cost about half as much as lithium-ion.

Cycling: Valve-regulated lead-acid (VRLA) batteries include absorbed glass mat (AGM) and gel models. Many AGMs batteries available in the market are primarily built for dual-purpose or standby applications like emergency backup, but not deep cycling. However, new deep-cycle AGM designs have increased performance and total energy output making them a good choice for renewable energy applications at a lower price point than gel batteries.

Replacement/maintenance: Many factors including initial design and ongoing maintenance influence battery life so it's difficult to put a time frame on when the batteries will need replacement. Flooded lead-acid batteries have to be refilled regularly because the electrolyte that fully submerges the battery plates evaporates during charging. The battery enclosure needs ventilation to keep hydrogen gas from accumulating to dangerous levels.

AGM and gel technologies, however, are recombinant, meaning they internally convert hydrogen and oxygen into water and do not require maintenance. As there is no free acid inside these batteries, they can be installed in any position other than upside down. Because solar applications can be in hard-to-reach or remote areas, the ability to install the batteries and let them operate over long periods without maintenance is a benefit.

Disposal: Proper disposal of lead-acid batteries is important because they are toxic. Thankfully, the automotive industry organized to recycle lead early on. Plastic containers and covers of old batteries can also be neutralized, reground and used in new battery cases. In some cases, the electrolyte is cleaned, reprocessed and sold as battery-grade electrolyte. In other instances, the sulfate content is removed as ammonium sulfate and used in fertilizers. The separators are often used as a fuel source for the recycling process. Old batteries may be returned to the battery retailer, automotive service station, a battery manufacturer or other authorized collection centers for recycling.

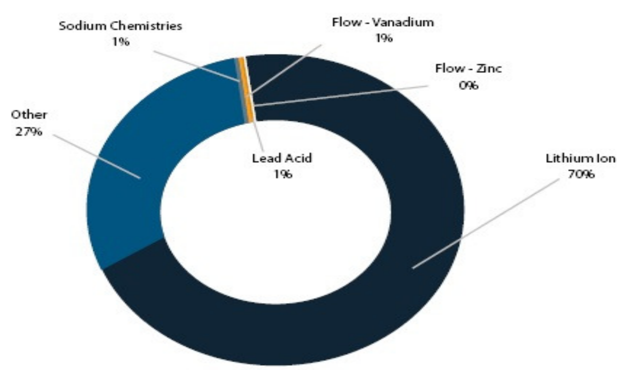

Fig. 2. Disposal of lead-acid batteries.

Lithium-ion. According to a U.S. Solar Energy Monitor report, lithium-ion batteries are the most common storage technology, regardless of application. There are three types: pouches such as in smartphones and tablets, cylindrical such as in power tools, and prismatic (which come in various shapes) such as in electronic vehicles. Prismatic types often have corrugated sides, which create air gaps between adjacent cells and can aid in cooling. The prismatic can have applications in solar energy storage, specifically lithium iron phosphate (LFP) batteries.

Part of this cost comes from needing a battery management system to monitor the voltage and temperature of each cell to prevent excessive charging and discharging. However, some manufacturers note that, if sized correctly, lithium-ion cells can reduce the cost of peripheral devices like charge controllers, offsetting its higher initial price and lowering cost-of-ownership.

Cycling: Lithium-ion batteries can typically deliver more cycles in their lifetime than lead-acid. This makes them a good choice for applications when batteries are cycled to provide ancillary services to the grid. The most important benefit lithium-ion provides for solar is its high charge and discharge efficiencies, which help harvest more energy. Lithium-ion batteries also lose less capacity when idle, which is useful in solar installations where energy is only used occasionally.

Replacement/maintenance: Lithium-ion batteries can be lighter and more self contained than lead-acid batteries, so may be easier to install and change out. They can be wall-mounted and located indoors or outdoors. They are solid, so don't require refills or maintenance.

Disposal: Lithium-ion batteries can use organic or inorganic cells. Organic-based batteries are free from any toxins. Inorganic-based cells are much more difficult to dispose of. Inorganic lithium-ion is toxic so it must be disposed of properly. Manufacturers encourage recycling, but there is often a price. Spent lithium-ion cells have little commercial value. Lithium-ion manufacturing involves lengthy preparation and purification of the raw material. In recycling, the metal must go through a similar process again, so it's often cheaper to mine virgin material than retrieve it from recycling.

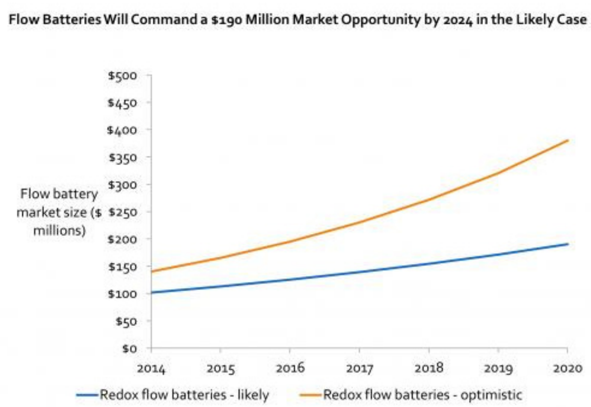

Fig. 3. Flow batteries.

Redox flow batteries are emerging as another storage option. Lux Research reports that falling costs will lead to a 360-MWh market in 2020, worth $190 million. The vanadium redox flow battery (VRFB) is the most mature technology in this area.

VRFB developers say that sourcing vanadium from flyash (a by-product of coal-fired electric generating plants) will reduce costs from over $500/kWh to $300/kWh at scale by 2024. VRFB developers are developing ways to boost power density, which will further drive down costs. Integrated power electronics manage the charging and discharging processes, providing a low cost-of-ownership. But the complexity of flow battery chemistry often requires ancillary equipment such as pumps, sensors, control units and secondary containment vessels. This infrastructure takes up appreciable installation space. However, one manufacturer has eased the complexity of ancillary equipment by including all required components within the container itself thereby offering a complete built-in solution.

Replacement/maintenance: VRFB manufacturers note the vanadium electrolyte doesn't degrade over time, so they can last much longer than other technologies. With other technologies, adding more batteries is the only way to increase hours of storage.

A benefit of VRFB architecture is that you can increase battery size by simply adding more electrolyte. *Cycling:* VRFB developers say the technology has no cycling limitations, and batteries can be charged and discharged completely without impact on their lifespan. *Disposal:* The recycled vanadium in flow batteries is not toxic and can be reused repeatedly for other purposes, such as in making steel. Flow batteries contain an aqueous-based electrolyte that can't get hot or catch fire and thus are intrinsically safe.

Choosing the right battery. Use a sizing calculate or Battery sizing is essential but often overlooked by users and installers. Batteries in PV systems are routinely undersized due to cost or because the system loads were underestimated. It's important to know the customer's power needs and correctly plan. Many online calculators provided by battery manufacturers and other software simplifies determining battery capacity for load requirements.

Consider cost of ownership. There are several factors that should be taken into account when determining the total cost of ownership over the life of the battery.

• *Price:* A battery with a low price is always attractive, but if low price comes at the expense of quality and battery life, the need for frequent battery replacements could boost the cost over time. That's why it's important to consider issues other than price when making the decision.

• *Capacity:* Battery capacity is important because it's a measure of the amount of energy stored in the battery.

• *Voltage:* The battery bank voltage must be considered to ensure it matches the system requirements. The battery bank voltage is often determined by the inverter specifications if installing a DC-to-AC system or by the voltage of the loads in a DC system. *Cycle Life:* The most critical consideration is cycle life, which provides the number of discharge/charge cycles the battery can provide before capacity drops to a specified percentage of rated capacity. Batteries from different manufacturers may have the same capacity and energy content and be similar in weight. But design, materials, process and quality influence how long the battery will cycle.

Battery ratings. The nameplate rating on a battery is the fully developed capacity, so it can be misleading to test a battery immediately after it is purchased because it may take up to 100+ cycles for it to reach its full capacity. Beware of batteries that promise full capacity at the time of purchase or those that reach full capacity after only a few cycles. Batteries with a 100+ cycle warm-up will always outlast thos touting a high initial capacity. A charge controller is an essential part of nearly all power systems that charge batteries, whether the power source is PV, wind, hydro, fuel, or utility grid. Its purpose is to keep your batteries properly fed and safe for the long term. The basic functions of a controller are quite simple. Charge controllers block reverse current and prevent battery overcharge. Some controllers also prevent battery over discharge, protect from electrical overload, and/or display battery status and the flow of power. Let's examine each function individually. Blocking Reverse Current Photovoltaic panels work by pumping current through your battery in one direction. At night, the panels may pass a bit of current in the reverse direction, causing a slight discharge from the battery. (Our term "battery" represents either a single battery or bank of batteries.) The potential loss is minor, but it is easy to prevent. Some types of wind and hydro generators also draw reverse current when they stop (most do not except under fault conditions).In most controllers, charge current passes through a semiconductor (a transistor) which acts like a valve to control the current. It is called a "semiconductor" because it passes current only in one direction. It prevents reverse current without any extra effort or cost. In some controllers, an electromagnetic coil opens and closes a mechanical switch. This is called a relay. (You can hear it click on and off.) The relay switches off at night, to block reverse current. If you are using a PV array only to trickle-charge a battery (a very small array relative to the size of the battery), then you may not need a charge controller. This is a rare application. An example is a tiny maintenance module that prevents battery discharge in a parked vehicle but will not support significant loads. You can install a simple diode in that case, to block reverse current. A diode used for this purpose is called a "blocking diode."

Preventing Over charge. When a battery reaches full charge, it can no longer store incoming energy. If energy continues to be applied at the full rate, the battery voltage gets too high. Water separates into hydrogen and oxygen and bubbles out rapidly. (It looks like it's boiling so we sometimes call it that, although it's not actually hot.) There is excessive loss of water, and a chance that the gasses can ignite and cause a small explosion. The battery will also degrade rapidly and may possibly overheat. Excessive voltage can also stress your loads (lights, appliances, etc.) or cause your inverter to shut off.

Preventing overcharge is simply a matter of reducing the flow of energy to the battery when the battery reaches a specific voltage. When the voltage drops due to lower sun intensity or an increase in electrical usage, the controller again allows the maximum possible charge. This is called "voltage regulating." It is the most essential function of all charge controllers. The controller "looks at" the voltage, and regulates the battery charging in response.

Some controllers regulate the flow of energy to the battery by switching the current fully on or fully off. This is called "on/off control." Others reduce the current gradually. This is called "pulse width modulation" (PWM). Both methods work well when set properly for your type of battery.

A PWM controller holds the voltage more constant. If it has two-stage regulation, it will first hold the voltage to a safe maximum for the battery to reach full charge. Then, it will drop the voltage lower, to sustain a "finish" or "trickle" charge. Two-stage regulating is important for a system that may experience many days or weeks of excess energy (or little use of energy). It maintains a full charge but minimizes water loss and stress. The voltages at which the controller changes the charge rate are called set points. When determining the ideal set points, there is some compromise between charging quickly before the sun goes down, and mildly overcharging the battery. The determination of set points depends on the anticipated patterns of usage, the type of battery, and to some extent, the experience and philosophy of the system designer or operator. Some controllers have adjustable set points, while others do not. Control Set Points vs. Temperature. The ideal set points for charge control vary with a battery's temperature. Some controllers have a feature called "temperature compensation." When the controller senses a low battery temperature, it will raise the set points. Otherwise when the battery is cold, it will reduce the charge too soon. If your batteries are exposed to temperature swings greater than about 30° F (17° C), compensation is essential. Some controllers have a temperature sensor built in. Such a controller must be mounted in a place where the temperature is close to that of the batteries. Better controllers have a remote temperature probe, on a small cable. The probe should be attached directly to a battery in order to report its temperature to the controller. An alternative to automatic temperature compensation is to manually adjust the set points (if possible) according to the seasons. It may be sufficient to do this only twice a year, in spring and fall. *Control Set Points vs. Battery Type.*

The ideal set points for charge controlling depend on the design of the battery. The vast majority of RE systems use deep-cycle lead-acid batteries of either the flooded type or the sealed type. Flooded batteries are filled with liquid. These are the standard, economical deep cycle batteries.

Sealed batteries use saturated pads between the plates. They are also called "valve-regulated" or "absorbed glass mat," or simply "maintenance-free." They need to be regulated to a slightly lower voltage than flooded batteries or they will dry out and be ruined. Some controllers have a means to select the type of battery. Never use a controller that is not intended for your type of battery.

Typical set points for 12 V lead-acid batteries at 77° F (25° C) (These are typical, presented here only for example.)

High limit (flooded battery): 14.4 V

High limit (sealed battery): 14.0 V

Resume full charge: 13.0 V

Low voltage disconnect: 10.8 V

Reconnect: 12.5 V

Temperature compensation for 12V battery:

-.03 V per °C deviation from standard 25° C

Low Voltage Disconnect (LVD)

The deep-cycle batteries used in renewable energy systems are designed to be discharged by about 80 percent. If they are discharged 100 percent, they are immediately damaged. Imagine a pot of water boiling on your kitchen stove. The moment it runs dry, the pot overheats. If you wait until the steaming stops, it is already too late! Similarly, if you wait until your lights look dim, some battery damage will have already occurred. Every time this happens, both the capacity and the life of the battery will be reduced by a small amount. If the battery sits in this over discharged state for days or weeks at a time, it can be ruined quickly. The only way to prevent over discharge when all else fails, is to disconnect loads (appliances, lights, etc.), and then to reconnect them only when the voltage has recovered due to some substantial charging. When over discharge is approaching, a 12 volt battery drops below 11 volts (a 24 V battery drops below 22 V).

A low voltage disconnect circuit will disconnect loads at that set point. It will reconnect the loads only when the battery voltage has substantially recovered due to the accumulation of some charge. A typical LVD reset point is 13 volts (26 V on a 24 V system).

All modern dc power inverters have LVD built in, even cheap pocket-sized ones. The inverter will turn off to protect itself and your loads as well as your battery. Normally, an inverter is connected directly to the batteries, not through the charge controller, because its current draw can be very high, and because it does not require external LVD.

If you have any DC loads, you should have an LVD. Some charge controllers have one built in. You can also obtain a separate LVD device. Some LVD systems have a "mercy switch" to let you draw a minimal amount of energy, at least long enough to find the candles and matches! DC refrigerators have LVD built in.

If you purchase a charge controller with built-in LVD, make sure that it has enough capacity to handle your DC loads.

For example, let's say you need a charge controller to handle less than 10 amps of charge current, but you have a DC water pressurizing pump that draws 20 amps (for short periods) plus a 6 amp DC lighting load. A charge controller with a 30 amp LVD would be appropriate. Don't buy a 10 amp charge controller that has only a 10 or 15 amp load capacity.

Overload Protection. A circuit is overloaded when the current flowing in it is higher than it can safely handle. This can cause overheating and can even be a fire hazard. Overload can be caused by a fault (short circuit) in the wiring, or by a faulty appliance (like a frozen water pump). Some charge controllers have overload protection built in, usually with a push-button reset. Built-in overload protection can be useful, but most systems require additional protection in the form of fuses or circuit breakers. If you have a circuit with a wire size for which the safe carrying capacity (ampacity) is less than the overload limit of the controller, then you must protect that circuit with a fuse or breaker of a suitably lower amp rating. In any case, follow the manufacturer's requirements and the National Electrical Code for any external fuse or circuit breaker requirements.

Displays and Metering. Charge controllers include a variety of possible displays, ranging from a single red light to digital displays of voltage and current. These indicators are important and useful. Imagine driving across the country with no instrument panel in your car! A display system can indicate the flow of power into and out of the system, the approximate state of charge of your battery, and when various limits are reached. If you want complete and accurate monitoring however, spend about for a separate digital device that includes an amp-hour meter. It acts like an electronic accountant to keep track of the energy available in your battery. If you have a separate system monitor, then it is not important to have digital displays in the charge controller itself. Even the cheapest system should include a voltmeter as a bare minimum indicator of system function and status. Have It All with a Power Center

If you are installing a system to power a modern home, then you will need safety shutoffs and interconnections to handle high current. The electrical hardware can be bulky, expensive and laborious to install. To make things economical and compact, obtain a ready-built "power center." It can include a charge controller with LVD and digital monitoring as options. This makes it easy for an electrician to tie in the major system components, and to meet the safety requirements of the National Electrical Code or your local authorities. Charge Controllers for Wind and Hydro A charge controller for a wind-electric or hydro-electric charging system must protect batteries from overcharge, just like a PV controller. However, a load must be kept on the generator at all times to prevent the turbine from over-speeding. Instead of disconnecting the generator from the battery (like most PV controllers) it diverts excess energy to a special load that absorbs most of the power from the generator. That load is usually a heating element, which "burns off" excess energy as heat. If you can put the heat to good use, fine. Is It Working? How do you know if a controller is malfunctioning Watch your voltmeter as the batteries reach full charge. Is the voltage reaching (but not exceeding) the appropriate set points for your type of battery? Use your ears and eyes-are the batteries bubbling severely? Is there a lot of moisture accumulation on the battery tops? These are signs of possible overcharge. Are you getting the capacity that you expect from your battery bank? If not, there may be a problem with your controller, and it may be damaging your batteries.

III. RESULT

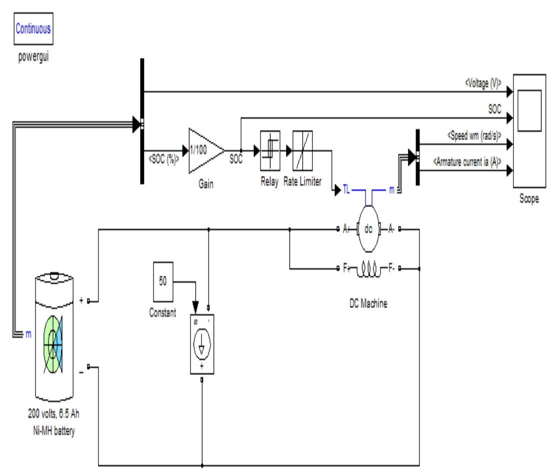

Fig. 4. Block diagram of battery charging.

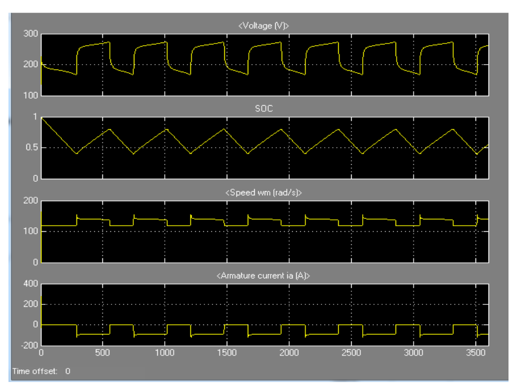

Fig. 5. The control of battery charging waveform.

IV. CONCLUSION

The control of battery charging is so important that most manufacturers of high quality batteries (with warranties of five years or longer) specify the requirements for voltage regulation, low voltage disconnect and temperature compensation. When these limits are not respected, it is common for batteries to fail after less than one quarter of their normal life expectancy, regardless of their quality or their cost. A good charge controller is not expensive in relation to the total cost of a power system. Nor is it very mysterious. I hope this article has given you the background that you need to make a good choice of controls for your power system.

REFERENCES

[1]. Renewable energy last modified on *Accessed on February, 2008.*

[2]. Z. J. Li, China's Wind Energy Potential Appears *Vast, November, 2005.*

[3]. J. Ke, J. H. Wang, L. Yang, N. Jia, and Q. H. Wu, Energy Efficiency Analysis and Optimal Control of Servo Pneumatic Cylinders, *IEEE Conference on Control Applications, Canada, August 2005.*

[4]. L. Yang, X. Luo and J. H. Wang, Energy Efficiency Analysis of Two Different Types of Air Motors, in *thirteenth International Conference on Automation and Computing (ICAC). Staffordshire University, England, 2007.*

[5]. N. Oneyama, Air compressor and its operation control, *The Journal of Energy Conservation Center,* Vol.**50**, No.2,pp. 65-731998.

[6]. Q. Zhao, Integrated Control of Load Power Tracking and Battery Charging for Stand-alone Small Scale Wind Power *Generating Systems, University of Inner Mongolia, Master's thesis. June, 2006.*

[7]. Northern Arizona Wind & Sun, Deep Cycle Battery *FAQ, Accessed on February 2008.*

[8]. I. Buchmann, the lead-acid battery, Created: April 2003, *Last February 2007, Accessed on February 2008.*

[9]. A. D. Kirchev, Pavlov and B. Monahov. Gas-diffusion approach to the kinetics of oxygen recombination in lead-acid batteries. *Journal of Power Sources*, Vol. **113**, pp. 245-254. 2003.

[10]. T. S Osaka. M. Rajamäki and T. Momma. Influence of capacity fading on commercial lithium-ion battery impedance. *Journal of Power Sources.* pp. 929-933. 2003.

[11]. Fuzzy control system, From Wikipedia, the free *encyclopedia, 2007.*

[12]. C. C. Lee, Fuzzy logic in control systems: Fuzzy logic controller - part I and II, *IEEE Transactions on Systems*, *Man and Cybernetics, 1990.*

[13]. H. D. Lee, S. K. Sul, Fuzzy Logic based Torque control strategy for parallel type HEV, *IEEE Transactions on Industrial Electronics, 1998.*

[14]. A. Lawrence, Berardinis. A Clear Thinking On Fuzzy *Logic, Machine Design, 23, April. 1992.*

[15]. B. Cai, D. Konik. Intelligent Vehicle Active Suspension Control Using Fuzzy Logic, *IFAC World Congress*, Sydney, Vol. **2**, pp.231-236. 1993.