Deep Of Discharge Meter

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Abstract : Battery is an energetic collector of solar cell system. Battery which is used in the system must have many qualities in the followings. The battery must be "Deep Cycle Battery " type. In addition ,the battery is Cleary indicated the percentage of DOD. The indication of DOD is used for calculation other valve used in solar cell system. Currently ,the percentage of DOD of battery is fixed by battery manufacture. If users would like to calculate is introduced % DOD ,the users have to check the battery at least 12 months. This article is introduced   battery deep of discharge meter by using theory of lead acid battery under deep cycle type and including the theory of DC. Current and internal resistance of battery. The data used for analyzing   are collected according to the theories. The data will be calculated by   monitor unit and controller systems.

Keywords : DOD = Deep of Discharge, Ah = Ampere – Hour , Sp.Gr. = Specific Gravity,

1. INTRODUCTION

Electrical generator of direct circuit or batter has been accepted and use as power supply that be able to keep energy in the form of electricity. Electrical generator of direct current will depreciate according to the time of usage and condition of usage. From the developed research and project of solar cell in Thailand and many countries, The system is not successful as it should be. The reason is that can not control how people use even though it is designed and developed by engineer. This article will suggest how to prevent user's behavior in controlling self discharging of battery in solar cell system. Battery Deep of Discharge meter checks energy of battery, stops self discharging of inverter, set or sending signal when battery discharges its self to the specific DOD. This system prevents over discharging of better . As the result, The life of battery is longer. We can conclude the life test of battery in solar cell system as table 1

Table 1 Life of Lead-acid battery in solar cell system.

Battery Type	Life of Battery (Month)		
	According To theory	According to actual usage	
		With care	With out care
Automotive Battery	9	7-8	6
Deep Cycle Battery	25-28	20-24	12-16
* Comparing the same currant and size of battery			

From table 1 The life of battery is depended on the maintenance and usage. If we can control the discharging of battery user's behavior will change. As the result, the life of battery will be longer. We must have battery DOD meter to check the remaining electrical energy in the battery to define the system usage.

2. . INDOCTRINATION OF SYSTEM

The system of battery DOD meter is the same as loading that connected in parallel with the battery for measuring such as electrical pressure, electrical current. The measured result is compared with the resistance within the battery and the degree of acid at different DOD and time. The output will be the usage of electrical energy per hour (Watt-Hour) and the controlled signal of solar cell system by indicating DOD of discharging battery.

2.1   The calculation of acid degree

In battery, acid is diluted sulfuric acid. The degree of acid is enough to react with chemical in battery, Battery used with solar cell or deep cycle battery use electrolyte with specific gravity 1.280 at 20°c. When it is fully charged, the specific gravity equals 1.320 at 20°c. When it is empty, the specific gravity equals1.080 at 20°c. The temperature of electrolyte will affect the acid degree as follows;

$$Sp.Gr._{20}{}^{o}{}_C = Sp.Gr._R + 0.00073 (T_R - 20). \qquad (1)$$

From the equation (1), the specific gravity will change 0.0073 at energy 1°c and the acid degree will also effect the electrical current in the battery.

2.2   Calculation of electrical current and energy in solar cell system.

From the researched in formation found that Thailand has sun energy about 4.5 $Kw.h/m^{2}/day$ [3][4] . The energy starts from 08.00 AM - 4.00 PM. (8 hours). The solar cell can receive energy the most during 09.30 AM -2.30 PM. (5 hours). For this article, we will use government solar home system as case study. We can calculate as follow;
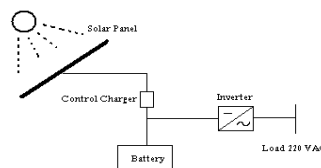
Picture 1 The follow of solar cell system
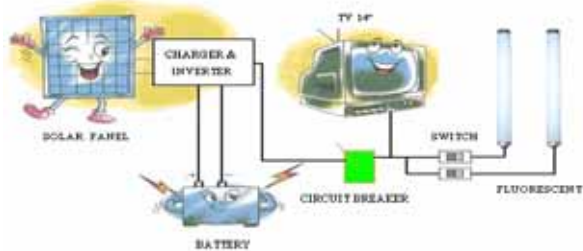
Picture 2 The flow of Solar Home System

- Solar panel size 120 Wp, the highest received energy in 1 day equal to

$$W_{total} \quad = \quad 120 \text{ W x 5 Hr.} \quad = \quad 600 \quad \text{W-h / Day}$$

- Controlling equipment Charger & Inverter the loaded electrical set must have electrical current of 10 A and single phase inverter of 150W with more than 80 % of efficiency.

The electrical energy from solar panel that pass through. The controlling equipment (charger and inverter) will have the remaining energy for charging as follows

$$W_{cha} = \quad W_{total} \quad x \quad \eta$$
$$= \quad 600 \text{ x } 0.80 = \quad 480 \text{ W-h/Day} \quad (2)$$

- Equipment for using in the system compare of fluorescent 10 watt @ 2 set and plug receptacle for TV 14 inches @ 1 unit.

The total load is as follows;

Fluorescent 10 watt @ 2 set	=	20	Watt.
TV 14 inches @ 1 unit	=	60	Watt.
Total	=	80	Watt.

In 1 day, we continuously use for 5 hours

$$= \quad 80 \text{ x 5 hr.} \quad = \quad 400 \quad \text{W-h /Day}$$

The actual energy and the lost energy in electrical wire 5% and the lost energy in inverter 20% equals the actual energy thst id used in the system as follows;

$$W_{use} = \quad 400 \text{ / } 0.95 \text{ / } 0.8 \quad = 526 \quad \text{W-h / Day} \quad (3)$$

From (2) and (3) Energy for charging the battery is 480 watt but the battery has to distribute the total electrical energy of 526 watt the remaining energy in battery is as follows;

$$W_{batt} \quad = \quad 12 \text{ V x} \quad 125 \text{ Ah} \quad = \quad 1500 \quad \text{W-h}$$

We allow the battery to distribute the electrical energy at DOD 60 %

$$= 1500 \quad \text{W-h} \quad x \quad 0.60 = \quad 900 \quad \text{W-h} \quad (4)$$
The received energy can be concluded as follows;

Picture 3 The distribution of battery

From picture 3 The battery is not fully charged since day 2 to 6. The remaining energy will not be enough to use in the next day. As the result the battery will be depreciated before its normal life. Therefore, we must set the amount of energy used per day.

We can set the amount by indicating DOD of battery. The amount compare the electrical current and pressure from battery with the resistance and specific gravity of acid at different time. From the discharging information at different DOD, micro controller will compute and display the result. If the result of DOD is more than the set amount, the warning sign will signal user to reduce the load of usage.

2.3   The electrical pressure and resistance in the battery

In checking battery, the electrical pressure is an variable that can be checked easiest. We can check the electrical current by connecting the load with the battery to discharge electricity out. For the electrical resistance can be checked by sophisticated and expensive equipment. When the battery is fully charged, Voltage is equal 12.75-12.95 V. According to the resistance of Deep cycle battery 12 V. When the battery is discharge, the voltage will decrease 10.5 V. or 1.75 V/cell or the battery is out of electricity. On the other hands, the resistance in thebattery increases continuously or from equation $E = IR$ .From the equation the capacity of battery will effect the life of battery

3. DESIGNING

The designing of battery Deep of Discharge Meter use the principle of direct electrical current and DC watt meter. The result of energy is in the from of Watt-Hour. We compare the result with the resistance and acid degree in the battery. This method   will result in the amount of DOD showing on the monitor.
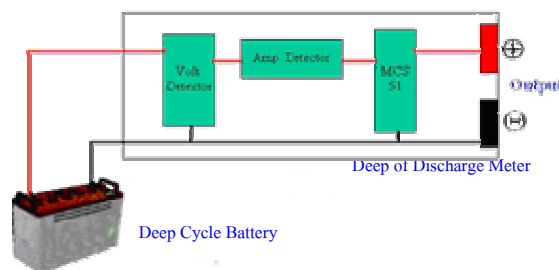
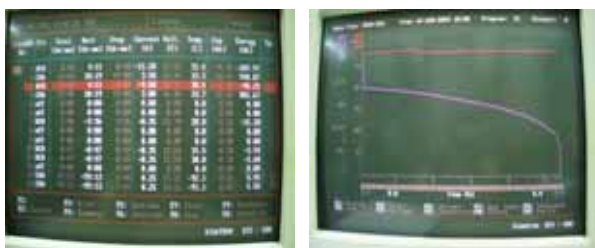**Picture 4** Diagram for battery Deep of Discharge Meter

From the diagram 4 the meter checks pressure of battery, the use electrical current to find used energy. The result is compared with the resistance in battery during the discharging and decreasing of acid degree. When the battery is discharging, the result will show in % of DOD. We can set the aunt of DOD for discharging battery. The meter will warn the system or reduce the load to prevent the battery from over discharging sooner than its normal usage.

4. EXPERIMENT AND RESULT

In experiment to find the relationship of electrical energy and battery life, we used deep cycle acid battery 125 Ah / 20HR   to discharge.

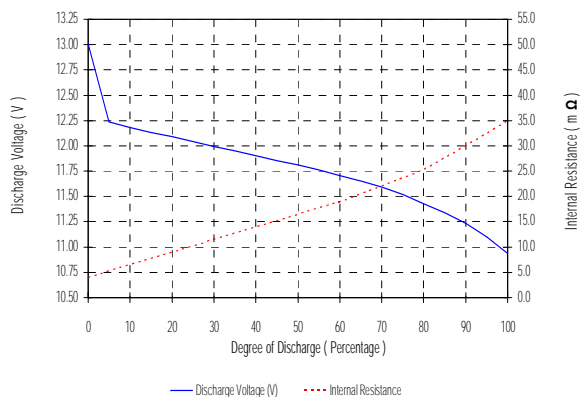From the table, we need to check the electrical pressure and specific gravity of acid during discharging of battery, First, we measure the discharged current, Second, we measure the resistance within battery. The result can be concluded as follows;

Picture 7 The relationship of electrical pressure and the resistance within battery
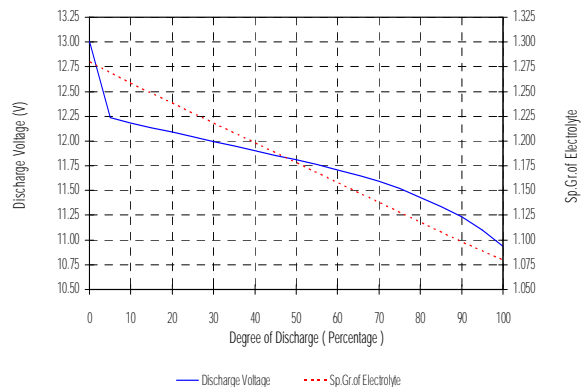
Picture 8 The relationship of electrical pressure and specific gravity
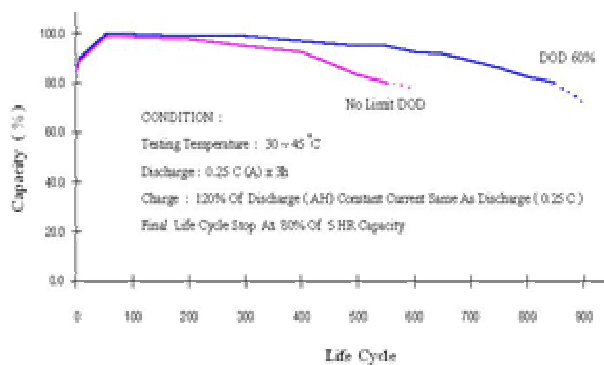
Picture 9 Showing the difference of battery life that has been controlled and not controlled.

5. CONCLUSION

From the experiment from picture 7 and 8, the internal resistance in the battery and the specific gravity of acid has effected the charge of DOD. As the result, it also effected the battery life. We can apply this information in battery Deep of Discharge Meter and warning system in solar cell system when DOD reaches the fix amount. The battery life in solar cell system will be longer and the energy is equally distributed according to picture 9. If we do not control DOD of battery,

Picture 5 Connecting wire with battery

Picture 6 Showing the result from computer for comparing the actual amount.

For 1 cycle, we discharged the battery at different DOD according to table 2. We recharged the battery with 120 % of the discharged current. We continuously discharged and recharged the battery until it is broken down. Every 25 cycle of charging and discharging, we tested battery capacity to determine battery life.

Table 2 Showing the electrical current that is discharged at different DOD

Battery Capacity (Ah)	DOD (%)	CH & DCH Current (A)	DCH Time (Hr)	Final Volt (V)	Charge Time (Hr)
125	10	4.17 (0.033C)	3	10.5	3.6
125	20	8.33 (0.067C)	3	10.5	3.6
125	30	12.50 (0.100C)	3	10.5	3.6
125	40	16.67 (0.133C)	3	10.5	3.6
125	50	20.83 (0.166C)	3	10.5	3.6
125	60	25.00 (0.200C)	3	10.5	3.6
125	70	29.17 (0.233C)	3	10.5	3.6
125	80	33.33 (0.266C)	3	10.5	3.6
125	90	37.50 (0.300C)	3	10.5	3.6
125	100	41.67 (0.333C)	3	10.5	3.6

the battery life is 550 cycle or 1.5 years. When we control battery usage by Battery Deep of Discharge Meter, the battery life increases to 820 cycles or 2.5 years. Nevertheless, We must use the correct type of batter. Users can see the difference between " Deep Cycle battery" and "Automotive Battery" according to table 1.

REFERENCES

[1] David Linder , Handbook of Batteries and Fuel Cells, McGraw- Hill , New York , 1992

[2] Nippon Denchi , Secondary Batteries for Actuaries Use ,Japan , Nippon Decchi   Co.ltd , 1999

[3] M.M.EI-Wakil , Powerplant Technology , Mc Graw Hill ,New York , 1984.

[4] H.B.Exell and Kaya Saricali , Solar Energy , Vol.18 ,1976.

[5] Solar Home System Project "Provincial Electricity Authority" Bangkok, Thailand. จค. 2 – ครส. -3 / 2547