PKL (*Bryophyllum Pinnatum*) electricity for practical utilization

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Abstract

A study of 1 kw PKL power plant set-up for practical utilization in Bangladesh has been conducted at the marsh power technology limited in Dhaka, Bangladesh. It has been designed and fabricated for 1 kw PKL mini power plant for feasibility study. The electrical and chemical characteristics have been studied. The dynamic method was applied during 1kw electricity generation period. A small PKL converter was used as an indicator. The pH meter was also used for the measurement of pH of PKL filtered juice during electricity production. The calibrated multi meters were used to measure the other electrical characteristics like internal resistance, voltage regulation, energy efficiency, pulse performance, capacity, self discharge characteristics, and discharge characteristics with load, energy density, power density and temperature effect. To measure the different performances of the device SEM has been used to study the morphological change of the electrodes. GC-MS has been used to identify the Hydrogen and Methane gas. AAS has been used to detect the metal ions in the electrolytes. Different parameters like conversion efficiency, voltage regulation, internal resistance, capacity, pulse performance, temperature effect, self discharge characteristics, dis-charge characteristics with load, energy density and power density have studied with the variation of time duration, pH, product and reactant ion concentrations. Finally, the longevity of the PKL filtered juice and Electrodes have been studied. Most of the results have been tabulated and graphically discussed.

Keywords: *Mini Power plant, PKL Electricity, Performance, Practical utilization*

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1. Introduction

People are using solar energy in our country with so much interest. But it has some difficulties to use for battery in the night. The longevity of the battery is not so good which is available in the market. People are facing problem for storage battery. To keep it in mind PKL power can be used instead of Solar Photovoltaic Electricity. For feasibility study it has been designed and fabricated 1 kw PKL (Pathor Kuchi Leaf) power plant. Solar PV system is very popular in the off grid region of Bangladesh. PKL electric system can be used side by side of Solar PV system at the off grid region of Bangladesh[1]. A new method of electricity generation system has been designed, fabricated and generated from *Bryophyllum* Leaf for 1 kw power extraction in Bangladesh. The electrodes were Zn and Cu where as *Bryophyllum* Leaf juice was as an electrolyte. The insulated container was battery box which was used as a voltameter. The battery box had 6 chambers and each chamber needs 1.5 liter *Bryophyllum* Leaf Juice. The *Bryophyllum* Leaf is called Pathor Kuchi Leaf (PKL) in our Local area. For generation of 1 kw PKL power, it was sat-up 6 battery boxes. Each box was connected with each other. It was extracted 1 kw power to run the different types of loads. There were two street lights, one ceiling fan, one table fan and five energy bulbs etc as Loads. By a self running PKL motor it was maintained a flow among the battery boxes so that the generated voltage and current were almost constant. The Al and Cu plates were also used as electrodes instead of Zn and Cu electrodes. Comparative studies of different electrical and chemical parameters have been studied for both Zn/Cu and Al/Cu based electrodes[2]. A morphological studies have been done for both Zn/Cu and Al/Cu electrodes by SEM (Silicon Electron Microscopy) and also for PKL juice as an electrolyte before and after the electricity generation. The metal contents and the concentration of reactant and product ions have been measured using AAS machine and UV-visible spectroscopy. The gas chromatography (GC) was used to identify the extracted gas as a bi-product.
Kew words: Electricity, PKL, Power, Fabrication, Performance, Off-grid region[3]

2.Materials and Method

Fig.1: 1 kw PKL power plant designed and set-up

Electrode Selection

Generally Zn and Cu are used as a electrode materials. Here Zn is the sacrificial element and acts as an anode. It losses electrons to the Copper materials. Copper is used as a cathode materials and gains electrons. A simple Bryophyllum pinnatum Leaf (BPL) unit cell can be made by putting a copper and a zinc plate into the BPL juice as electrode showed in Fig.1. In the process of the oxidation and reduction reactions, electrons can be transferred from the Zinc to the Copper through an electrically conducting path as a useful electric current. We have used Zinc as anode and Copper as cathode. Besides these two electrodes we will use Pathar kuchi leaf sap as electrolyte, which is our main concern. Pathar kuchi filtered sap is acidic in nature containing citric acid, iso - citric acid, Malic[4] Acid and cyanic acid etc. Acid has two parts positive ion and negative ion. Positive ion is attracted by negative cathode (Cu) and there positive ion of acid takes electron from cathode. Similarly negative ion goes toward anode and releases electrons there and thus creates a deposition layer on anode. Thus a continuous flow of electron through an externally connected wire is obtained & this is unidirectional flow of current, i.e., always from anode to cathode[5]. That's why DC current is generated. Then inverter will be used to convert DC current into AC current.

Electrolytes of the PKL electricity

Primary Electrolytes: The Primary Electrolytes are given by the following: Citric Acid, Iso-Citric Acid and Malic Acid / Fumaric Acid. These above weak organic acids have been protonated slowly/ ionized slowly and converted H^+ in the solution/sap: R-COOH (aq) + Cu2+ (aq) = H+(aq) + (R-COO)2Cu(aq)

Buffering Agent

The mixture of Organic acid and Cu-Salt (Cu-citrate) of that organic acid in solution act as a buffer solution. Because weak acid and its salt is Buffer Solution[6].

Catalytic Effect

Copper(Cu)electrode may act as electro catalyst surface to enhance the rate of deprotonation / dissociation of organic acids. Catalytic activities of metal: Pb-Sn-Zn-Cu-Ag-Fe-Ni-Pd-Pt. The electrochemical series is given by the following: Li-K-Ca-Na-Mg-Al-Zn-Fe-Sn-Pb-H_2–Cu-Hg-Ag-Au

Reason of Electricity Generation from PKL Cell

Let,M_1=Molar Concentration of the Zn^{++} , M_2= Molar Concentration of the Cu^{++} , M_3= Molar Concentration of the H^+ Again, $M_2+M_3=M$, Therefore, the PKL cell potential is +ve, if $M>M_1$, The cell voltage remains same ,when M_1/M remains same. If the M_1/M_2 is changed, the cell voltage also changes. The net cell reactions is spontaneous as written. The cell potential is +ve,if $M>M_1$.When the cell operates, the concentration of M decreases that was originally more concentrated and the concentration of M increases in the solution that was originally more dilute.At equilibrium M_1=M. At equilibrium, the cell voltage is zero and no current flows.The measured cell potential depends on the ratio of the two concentrations M_1 and M, because both M_1 and M are changed but the ratio M_1/M remains the same,the cell voltage remains the same.Since the substances in solution are same, the standard cell voltage, E^0_{cell} = 0, Hence, Nernst equation becomes, $E_{cell} = -(RT/nF)\ln(M_1/M)$, where, n = number of moles of electrons.F=Faraday constant(9.6485309 x 10^4 J/V • mol). *If $M_1/M = 1$, then* E_{cell} = o. Therefore, M_1=M,the system is at equilibrium and no net change can occur. When,$(M_1/M) <1$,then $\ln(M_1/M)$=-ve, and E_{cell} = +ve. The direction of spontaneous is from more concentrated solution to the less concentrated solution. Finally, it is concluded that if Ecel =+ve, then it will produce electricity and if E_{cell} =-ve, then it will not produce electricity. The - E_{cell} implies non spontaneous, + E_{cell} implies spontaneous (would be a good Source/battery!)[7]

Electrode Potential

Electrode Potential depends on two factors: (1)Solution Pressure/Solution Tension: which is const. at a given temperature and (2)Osmotic Pressure. The Electrode Potential, $E= (RT/nF) \ln(P_2/P_1)$, Where,P_1= Solution Pressure and P_2= Osmotic Pressure. When cell is not at standard conditions, we use Nernst Equation: $E = E^o – (RT/nF) \ln Q$

,R = Gas constant 8.315 J/K• mol, F = Faraday constant, Q = reaction quotient = [products coefficient]/[reactants coefficient], where, E = Energy produced by reaction, T = Temperature in Kelvins, n = No. of electrons exchanged in balanced redox equation. The useful nernst equation: E = E° - (0.0592/n) log Q @ 25°C(298K).

Electrodes cleaning

The methods are generally employed for cleaning of metal surface: Acid bath/cleaning, Alkali cleaning, Mechanical cleaning, Flame cleaning and Sand blasting cleaning. The Rate of electrochemical reaction depends on the factors: Temperature of electrolyte[8]. The activity of reactants/Nature of reactants, The material of the catalyst (that is on the same factors that determine the rate of chemical reaction. It may be either electrolyte or electrode, The path traveled by the electrons is greater than the size of the atoms, Electrode Potential, Nature of Electrolytes, Nature of Electrodes, Size and number of Plates or the surface area of active materials in contact with the electrolyte, Quantity of Liquid/Electrolytes in the Cell and Rate of discharge[9].

Threat of the PKL Cell and its remedy

When the PKL Cell operates, then a spongy and reddish brown deposit of Cu is formed on the surface of zinc. As a result electron flow decreases[10]. By using acid bath or cleaning method we can remove spongy and reddish brown deposit of Cu.

Why much larger Current is generated in PKL Cell

In order to form PKL Cell, Enough $CuSO_4$/$ZnSO_4$/Fe2$SO_{4/}$Fe2SO_4 solution is added to the compartment in PKL solution. Since the internal resistance between the $CuSO_4$/$ZnSO_4$/Fe_2SO_4/Fe_2SO_4 solution and PKL Juice is much lower than that of salt bridge, much larger currents can be drawn from them[12].

Table-1 Difference between Electrolytic Cell and PKL Cell [11]

Electrolytic Cell	**PKL quasi Galvanic Cell / Voltaic Cell.**
It requires a source of external energy	It is a source of energy.
It converts electrical energy into chemical energy	Converts chemical energy into electrical energy
Has cathode as the negative electrode	Has cathode as positive electrode
Has anode as the positive electrode	Has anode as negative electrode
Involves oxidation at anode and reduction at cathode	It involves oxidation at anode and reduction at cathode

PKL Cell voltage varies with ion concentration and Temperature

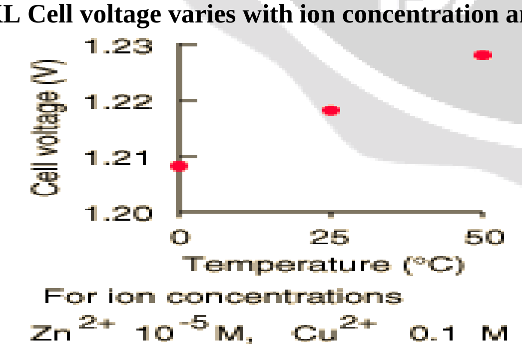


Fig.2 Cell Voltage - Temperature(^{0}C)Curve

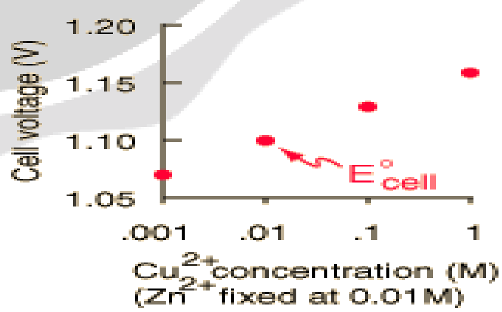


Fig. 3 Cell Voltage – [Cu^{2+}] ion

Why the PKL Cell is so called?

The cell potential (voltage of the cell) depends on the chemicals/Electrolytes used. For example, the chemicals in *dry-cells* (batteries) are such that the potential is always about 1.5 V. This has become a standard and is now a limiting factor in deciding which chemicals can be used to create battery[13].

Electrolyte selection

Fig.4 PKL juice preparation

Fig. 5 PKL juice with secondary salt

PKL has divided in to 4 types. These are (1) Early stage PKL (2) Middle stage PKL (3) Pre matured stage PKL & (4) Matured stage PKL. PKL juice was used as an electrolyte. Zn and Cu were put in to the PKL juice. The PKL juice gains the Zn^{2+} from the Zinc atom[14]. As a result Zn atom donates electron to the Cu atom and then Cu atom gains of electron. The Cu^{2+} ions available in the PKL juice attracts the free electron of the Cu atom comes from the Zn^{2+}. At first we toke Pathor Kuchi Leaf and blended with water by a blender Machine. As a result 50% solution of PKL Juice/Sap/Malt has been prepared[15]. This solution of PKL Juice/Sap/Malt has been used for electricity generation. Once a mixture is prepared for producing electricity, it serves the purpose for 6 months continuously. It is observed that to produce 15 kwh electricity 1 kg of leaves are required[16].

Container Selection

The container was used with insulated material. There were 6 boxes and each box was made by 6 chambers. The chamber was fulfilled by PKL juice and the Cu and Zn plates as electrodes were immersed in to the PKL juice. The Cu and Zn Plates were set-up parallely in the Chamber and the each chambers were connected in series combination with each other[15].

Connecting wire

The connecting wires were made by copper. To make a series or parallel connection copper wires were used.

Container selection

The containers were made by plastic box which was available in the local market. There were 6 boxes for getting 1kw PKL power[16]. The size of the each box was 0.5m x 0.3m. The containers were put inside the iron made stand (Shown in Fig.1).

Juice mixing with secondary salt

The juice was made with different concentration. To get better performance $CuSo_4$ was mixed with prepared juice which acts as an electrolyte[17].

Fabrication of PKL Module

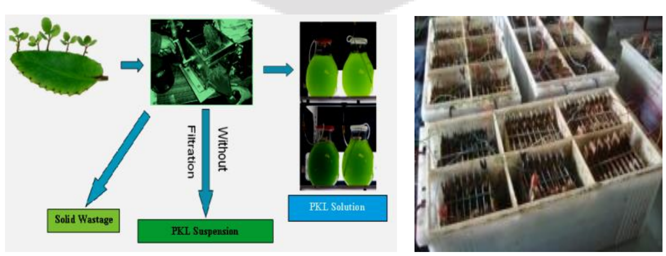


Fig.6 Preparation of a PKL module with PKL juice

For electrolytic studies the analyzed PKL Malt/Juice/Sap put in between Zn and Cu flat parallel electrodes with various surface areas separated say a 0.5 ±0.1 cm gaps and discharged using an external load. Using this process we get a PKL unit cell, module, Panel & arrays.

Production of electricity

When the connections of electrodes are ready we are at the final stage of producing electricity from PKL. At this stage the final task is to pouring the juice of PKL to the container or pot where the electrodes are placed. A chemical reaction is than taken place, which in turn, creates positive and negative potentiality around the plates. Now if we connect the zinc and copper plate through a proper load the current will flow from the cell to the external circuit. Oxidation will occur at anode (zinc) and reduction at the cathode (Cu^{2+} and H^{+}). This will create a movement of electrons from zinc to copper and will produce current in the circuit[18]. The net cell reaction will be as

$Zn + Cu^{2+} + H^{+} \rightarrow Zn^{2+} + Cu + H_2\uparrow$, Where the reactant ions are Cu^{2+} and H^{+} and the product ion is Zn^{2+}. Thus metal at anode loses electrons and dissolved and metal at cathode gains electrons and grows[19].

Energy source

The energy for the PKL battery comes from the chemical change in the zinc (or other metal) when it dissolves in PKL juice. The zinc is oxidized inside the cell, exchanging some of its electrons with the organic weak acid which exists in the juice in order to reach a lower energy state, and the energy released provides the power.

In 1971, Wilson and Marriage analyzed the major and minor acids present in leaves of *Bryophyllum calycinum* (which is another species of *Bryophyllum*) through ion exchange (Marriage and Wilson. 1971). This BPL solution has following Acid and Minerals (Alabi et al., 2005)[20]:

Table-2. Analysis of amino acid (mg/100g) of *B. pinnatum*.

Thiamine	Pyrdoxine	Ascorbic Acid	Glycine	Cyteine	Casein Hydrolysate	Nicotinamide
0.30b	0.74b	13.28c	2.71c	0.64d	53.68d	1.60a

Table -3. Analysis of mineral ash and fiber content (mg/100g) of *B. pinnatum.*

Na	Ca	K	P	Mg	Mn	Fe	Cu	Zn	Ash	Fiber
7.65b	65.40b	90.25a	60.46a	87.62b	5.50a	14.13a	5.94a	7.92a	10.22a	10.25b

Table -4. Major and minor acids in *B. calycinum*

Acid	%	Acid	%	Acid	%
Cis-Aconitic	1.60	Lactic	0.20	Iso-citric	46.50
Citric	10.10	Malic	32.50	Pyurvic	1.00
Fumaric	0.90	Oxalacetic	0.40	B-Ketoglutaric	0.50
Glyoxylic	0.10	Oxalic	0.20	Succinic	1.00

Single Unit Cell Reaction and Analysis of Different Parameters[21]

When electrodes are immersed in the electrolyte (BPL sap), the negative electrode contains the substance that is oxidized, while the positive electrode contains the oxidizing substance that is reduced. Thus at negative electrode oxidation of S(N)red occurs according to: S(N)red $\Rightarrow$ S(N) ox + n.e ,While S(p)ox is reduced at the positive electrode : S(P)ox + n.e $\Rightarrow$ S(P)red ,Both together from the cell reaction : S(N)red + S(P)ox $\Rightarrow$ S(N)ox + S(P)red + energy[21]. The main constituent of elements of Bryophyllum pinnatum Leaf is Fe++ and Cl- (Saha, 2008). These ions can move freely in the BPL solution. Besides, the half reaction of a galvanic cell is-

On Zn : $\rightarrow Zn^{++} + 2e^{-}$ $E_0 = 0.76$ V

On Cu : $2H^{+} + 2e- \rightarrow H_2$ $E_0 = 0$ V ……..… (1). Therefore, $Zn + 2H^{+} \rightarrow Zn^{++} + H_2$ $\triangle E = 0.76$ V

Thermodynamic Parameters

The thermodynamic parameters are the most important Fundamental Law for any galvanic cell [14]. Three thermodynamic parameters play an important role in the galvanic cell- Enthalpy of reaction$\triangle$H, Free enthalpy of reaction △G and Entropy of reaction △S. Relations between these parameters are: △H - △G = T.△S … (2). The equilibrium cell voltage, U_0 (V) is: U_0 = △G /n.F …. ….(3), Where, n = number of exchanged electronic charges; F = Faraday constant. n.F.Uo represents the generated electrical energy (kJ), △H and △G depend on the concentrations of the reacting components of the BPL (/PKL) juice. So, the corresponding relation is-

$$\triangle G = \triangle Gs + R.T. \left(\sum \ln[(a_j)^{j_i}]_{prod} - \sum \ln[(a_j)^{j_i}]_{react} \right) \quad (4)$$

Here, a_i = activity of the reacting component (mole.cm3); ji = number of equivalents of this component that take part in the reaction. Combining Eqns. (3) and (4), the result is Nernst Equation-

$$U_o = U_{o,s} - \frac{R.T}{n.F} .\ln \frac{\prod (a_i)^{j}{}_{react}}{\prod (a_i)^{j}{}_{prod}} \quad (5)$$

This equation gives the dependence of the equilibrium voltage (actually open circuit voltage) on the concentration of dissolved components [22].

Electron Transfer

The electron transfer reaction denotes the central reaction step where the electrical changes is exchanged. Current flow affords additional forces because of an energy barrier that has to be surmounted by electrons. The required additional energy is called " activation energy " and the dependence of reactions rates is expressed by the Arrhenius eqn., $k=k_o.\exp\left(-\frac{E_A}{R.T}\right)$ (6), With k = reaction constant; E_A=activation energy which is temperature depended. In electrode reactions, n.U.F is the driving force. So the relation, $k = k'.cj.\exp\left(\frac{n.F}{R.T}U\right)$ (7), Where k' includes In our study, electrode polarization plays an important role for BPL cell performance, which is obtained from the relation-, $\eta_+ = U_+ - U_+^o$, or, $\eta = U - U_0$ (8, Here, η_+ and η = polarization of positive and negative electrodes respectively; U+ and U = actual potential; U_+^o = equilibrium potential of positive and negative electrodes, respectively the 'equivalence factor' n.F between mass transport and current i[23].

Influence of Temperature[24]

The Arrhenius equation (6) in connection with the term 'activation energy' can explain the kinetic parameters of BPL (/PKL) unit cell, which are depended on temperature. The logarithmic form of equation (6) is-

$$\ln (k) = -\frac{E_A}{R.T} + \text{In} (k_0) \quad (9)$$

Internal Resistance

The capability of the PKL battery to handle a certain load is determined by the following relation: R_i = △i /△v , where, R_i = Internal Resistance, △i = Current changes and △v = Voltage changes.

Capacity

Capacity means how much current you will get for how long time. The Capacity of single BPL cell is obtained by the following relation, C^{Ah} = I. △t Ah , where, C^{Ah} = Capacity in AH, I= current in amp and △t = time in hour.

Age of the PKL

In the research work it is shown that the efficiency for electricity generation from the PKL varies with the age of the PKL.

Concentration of the PKL malt / juice/sap/Extract

The voltage is generated from the PKL varies with the concentration of the PKL malt / juice/sap. That is voltage, V α ρ, where ρ the concentration of the juice and v is is the voltage of the cell.

Area of the electrodes

The voltage generation from the PKL is directly proportional to area of the electrodes. That is V α A, where, A is the area of the electrodes and and v is is the voltage of the cell.

Distance between two electrodes

The voltage generation varies with the distance between two electrodes. It is shown that voltage decreases with the increase of the distance between two electrodes.

Temperature effect of the malt / juice/sap

It is shown that the voltage variation can be expressed by the relation: $\Delta V = K \times \Delta T \times N_{cs}$, where , ΔV = Change of voltage, K = coefficient factor, ΔT = Change in temperature, N_{cs} = No. of PKL Unit cell connected in series.

Performance Study of PKL Electricity

A brief description of the tests conducted to study the electricity generation from different stages of PKL is given by the following :

Energy Efficiency of the PKL Electricity

The efficiency of the different types of PKL have been studied. The conversion efficiency of different stages PKL electric panel have been given by the following:

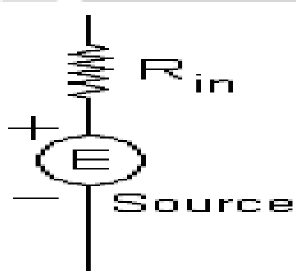
The, Energy Efficiency = E_D/E_c , Where, E_D = Total energy during charging, E_C = Total energy during discharging

Now if V_C = Charging Voltage (Volt), I_C = Charging Current (Ampere), T_C = Charging time (Hour), Then $E_C = V_C I_C T_C$

Again if V_D = Discharging Voltage (Volt), I_D = Discharging Current (Ampere), T_D = Discharging time (Hour). Then $E_D = V_D I_D T_D$. Therefore, we can write, the energy efficiency= $(V_DI_DT_D)/(V_cI_cT_c) = (V_D/V_c)(I_DT_D/I_cT_c)$. where, Voltage efficiency = (V_D/V_c) and Coulomb efficiency = (I_DT_D/I_cT_c). At the beginning of charge cycle of a lead acid battery Coulomb Efficiency is near about 100%. But near end of charge cycle Coulomb Efficiency reduces due to electrolysis of water. If we consider the, Voltage Efficiency = 88% and Coulomb Efficiency = 90% . Then overall Energy Efficiency = (88%) × (90%) = 79%

Determination of the Energy Efficiency of PKL System

PKL system is a renewable source of electricity. This system need not to charge. So the conventional method of calculating energy efficiency is not applicable for the system. But we can easily measure the energy efficiency of a PKL system calculating the output energy and internal loss[25]. Let us consider the equivalent circuit of a PKL cell as shown in fig. 5 below.



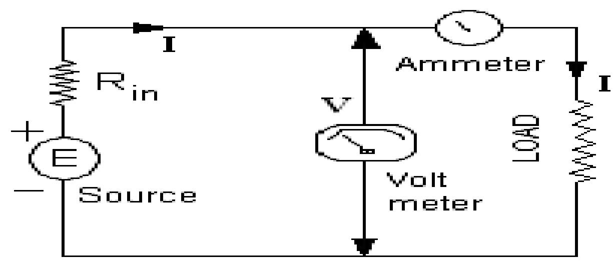


Fig. 7 Equivalent circuit of a PKL cell. **Fig.8 Circuit arrangement for measuring power**

According to this circuit there is only means of loss of energy is in the internal resistance. Therefore if we can calculate the energy loss in internal resistance R_{in} we can calculate the energy efficiency easily.

We know, Energy efficiency = Output/Input = Output/(Output + Losses)

Let us consider the circuit shown in fig. 6. If I Ampere current flows through the output load, this current will also flow through the internal resistance R_{in} of the circuit. Now if V be the load voltage then the Output Power = V × I and the Power Loss in internal resistance = I^2 R. Therefore, we can calculate the power efficiency as, Energy efficiency = [Output/(Output + Losses)]=[VI/(VI+ I^2R)]. The Energy efficiency generally represented as percentage value. The Energy efficiency = [VI/(VI+ I^2R)]x100% .

Calculation of Energy Efficiency of PKL System

To calculate the efficiency we can use the data from Article 7.6.1 above. Let us consider Load voltage = 1.1 Volt, Load current = 1 Ampere, Internal Resistance = 0.6 Ohm. Therefore we can find, the output Power = Load Voltage × Load Current = 1.1 Volt × 1 Ampere = 1.1 Watt, Power loss in internal resistance of the cell = $(1 \text{ Ampere})^2 \times 0.6$ = 0.6 Watt. Therefore, the Energy Efficiency = (1.1)/(1.1+0.6) = 65%

3.Results and discussion

It is found that the Energy Efficiency of the PKL cell = 65%. It may be noted here that this value of the efficiency is for a particular time. Because, both voltage and current will change with time. Therefore efficiency will also change. If we want to measure the efficiency for a period of time it is better to measure the power in Ampere- Hour (AH). The Energy efficiency = [Output/(Output + Losses)] = [VIH/(VIH+ I^2RH)]. We have, Energy efficiency = [Output/(Output + Losses)] = [VIH/(VIH+ I^2RH)]= [VAH/(VAH+ I^2RH)], Where, H = Hour of use, AH = total Ampere Hour used. If we use the system for 2 hour (H = 2 Hour) as the above example with the same value as - Load average voltage = 0.8 Volt, Load average current = 0.9 Ampere, Internal Resistance = 0.6 Ohm. The Energy efficiency = [(0.8)(0.9)(2)/ (0.8)(0.9)(2)+ (0.9^2)(0.6)(2)] 100% = 60% or, The Energy Efficiency = 60%. Since the internal resistance of a cell or battery represents the health of the battery or cell. So that internal resistance value indicates the battery health. From the table 11.2, it is shown that the excellent ranking of the internal resistance range of the battery is (0.075 to 0.150)ohm, for good ranking it is (0.15 to 0.250)ohm for marginal ranking it is (0.25 to 0.350)ohm and for poor ranking it is (0.350 to 0.500)ohm. If the internal resistance shows above 0.500 ohm, then that battery or cell becomes fail. According to these results, It is possible to manufacture a good and excellent ranking PKL cell or module. In case of PKL cell it is also found that if we discharge the cell with a light load (50% of the source) it runs for a longer period. But for higher rate (100% of the source and above) of discharge its capacity falls dramatically.In case of PKL cell it is also found that the cell can supply substantially higher current pulse. PKL cell is a very simple cell. Here there is no complex construction. Just a zinc plate and a copper plate are sunk in PKL juice. It is zinc-copper based cell and completely a renewable source. It is not subjected to charge. So there is nothing to think the charging of this cell. The PKL cell is based on Voltaic or Galvanic Cell. That is why it can be called so called Voltaic or Galvanic Cell or Quasi Voltaic or Galvanic Cell. We can regain the capacity of the cell by the following ways: (1) By adding the PKL juice after some regular time interval (2) By changing the PKL juice after some regular time interval. (3) By cleaning the plates after some regular time interval. When we do these activities the cell gets back its full life again. Every time we can get the PKL juice from our field and the plates are usable unless it is completely dissolved (only Zinc plate) or become unusable. So this is a very important characteristic of the PKL cell which will make it useable for the poor people. It is found that the from the above calculation the Voltage Regulation (%) = 8.69%. In this case, the concentration of the juice was: 70% water + 20% PKL + 10% Copper sulphate. Voltage regulation measures the stability and quality of the power system. Voltage regulation, $V_R \sim 0$ is the desirable/ideal/best value, which is practically impossible. To get it better result, the concentration of the juice was: 50% water + 40% PKL + 10% Copper sulphate. Then We have, No load Voltage (i.e. Open Circuit Voltage), VNL = 6.16 Volts and the Full load Voltage, VFL = 5.85 Volts. Then the Voltage Regulation becomes, VR ~ 5.3%. Similarly, We can get the lower value of the VR (Voltage Regulation) to improve the stability and quality of the PKL power system Capacity of a PKL Cell means how much current (A) you will get for how long time (hours). In this thesis, we have calculated the capacity of the PKL Cell by using the voltage regulation is found that the Energy Efficiency of the PKL cell = 65%. It may be noted here that this value of the efficiency is for a particular time. Because, both voltage and current will change with time. Therefore efficiency will also change. If we want to measure the efficiency for a period of time it is better to measure the power in Ampere-Hour (AH). So that it is very useful to design and fabricate of the PKL power system.

4.Conclusions

The both electrical and chemical parameters have been studied for different concentration of the PKL juice. The effect of the secondary salt (Copper Sulphate) has been studied. It is shown that the efficiency varies with the variation of Concentration of Juice and the percentage of Copper Sulphate in the PKL juice. Furthermore, it is shown that the both electrical and chemical parameters depend on the following factors:

Thickness of the plate, Distance between two plates, Absoptance of the plate, Adsorptance of the Plate, Purity of the Plates, Area of the Plates, Temperature of the Juice. Furthermore, Some changes in the acidity of *Bryophyllum* (pathorkuchileaf) calycinum☹(1) It is shown that there is a diurnal change in the [H+] concentration in Bryophyllum calycinum corresponding approximately to the total acidity changes. The [H+] concentration increases at night and decreases during the day (2) The main factor is the light which causes the decrease in acidity, though it also occurs in the dark that means during night but it occurs much more slowly. (3) External oxygen tension does not seem to influence the acidity of the plant, nor does it influence the decomposition of the extracted juice (4)The performance of electricity generation is better at night than that the day time.The Usability of a new invention is very much important. If there is no usability of our new technology then it will go in vain. To determine the usability properly it is very much important to measure its performance. So the performance analysis is very much important. Under this study it is tried to identify the strengths, weaknesses, opportunities and threats of the Vegetative and fruits electricity system. Since the production of electricity from vegetative and fruits are relatively new invention, therefore the measurement of its performance was a vital thing. For the measurement of performance, the performance indicators are most important issue. As a new invention of the vegetative and fruits electricity system, the performance indicators are not yet determined properly. In this study it is tried to indicate the performance comparing the cell and battery performance. In this research work the performances are studied: Discharge characteristics, Temperature characteristics, Self discharge characteristics, Equivalent circuit and internal resistance, Effects of internal resistance, Discharge Rates and Peukert's law, Pulse Performance, Cycle Life and Depth of Deep Discharge(DOD), Voltage Regulation, Capacity determination of PKL system, Efficiency calculation of vegetative and fruits system, Willingness of the people to use the new technology and expected cost for the system. From the above mentioned parameters, except the internal resistance and voltage regulation, all other parameters are satisfactory compare to the performance indicators of the cell and battery. We get the typical value of internal resistance is 0.3 Ω which is very slightly higher than the acceptable range. Since the internal resistance is liable for internal voltage drop, therefore the voltage regulation was also found slightly poor. We found the typical voltage regulation around 5.3%. One of the important sides of this study is to determine the efficiency of vegetative and fruits electricity system. In case of conventional battery, the efficiency is determined with the ratio of discharging power to the charging power. Since in the vegetative and fruits electricity system need not any charging, therefore we can determine the efficiency with the help of the conventional efficiency formula (output to input) and also the total internal loss.

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