Indigenous Development Of Ball Milling Machine To Study Its Effect On The Capacitance Of Ultra-Capacitors

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Abstract: To execute a work we require energy. Various sources of energy like renewable sources of energy like solar energy, tidal energy, geothermal energy, wind energy, conventional sources of energy like fossil fuels, wood etc. are available at our disposable to meet our energy demands. All the sources of energy available have some or the other limitations for its use. As a result we convert these available sources into our usable form called as electrical energy. Energy can be converted from one form to other but it cannot be created or destroyed. By employing this concept we humans have created the concept of energy storage devices to use the generated energy as and when required. To develop our energy storage devices is the need of the hour to bridge the gap between the ever increasing energy demands and the sources of energy available. There are various energy storage devices available but Electrolytic double layered capacitors or Ultra-capacitors are the future of energy storage devices. In this research, we have developed an indigenous ball mill machine and studied the impact of milling on the capacitance value of Ultracapacitors. This research paper explains the various experimental procedures carried out and successful accomplishment to increase the capacitance of ultracapacitors

IndexTerms **- Activated carbon, Ball mill machine, Energy Storage Device. Ultracapacitors.**

I. INTRODUCTION

As per the Law of Energy conservation," *Energy can neither be created nor it can be destroyed, it can just be transformed from one form to another form of energy"*. We require energy for all our day to day activities that gives us comfort and also liberty to increase our productivity in order to achieve our goals in life. We have various forms of energy like gravitational, chemical, nuclear, motion, thermal energy that could be exploited to meet our energy demands. As contradiction to the available sources of energy we use only electrical energy to meet our energy demands. As per the law stated above energy transformation from one form to the other is achievable and we use exactly the same concept of energy transformation. As we know that electrical energy cannot be stored and it is the most convenient form of energy to use with ease,we have devised a way to convert it to different form of energy and use it according to our energy requirements. The energy storage devices acts as a buffer to counteract the effect of power imbalance between supply and demand sides. Various forms of energy storage systems like Chemical energy storage systems which comprises of hydrogen, bio- mass, bio-fuels, oxy-hydrogen, liquid nitrogen, Electro-chemical storage devices like battery and fuel cell, Electrical energy storage devices like ultracapacitors, capacitors, superconducting magnetic energy storage, mechanical energy storage devices like flywheel energy storage devices and hydraulic devices. Thus, we convert the electrical energy to various forms as mentioned above and use it whenever needed. This leads to a major requirement to improve our energy storage devices capacity by reducing the losses in the process of storage and increasing the storage capacity. Ultracapacitors are the future of next generation energy storage devices and are on the prima facie of the research filed experts due to their advantages like short charging time, high power density. The working principle is same as that of capacitors but it offers a very high value of capacitance that can be used to meet our future energy requirements. This research work aims at developing an indigenous ball milling machine as the process of ball milling plays an important tool for optimizing the size of materials used to construct the electrodes of capacitors. The milling effect increases the capacitance and this is what we have proved in our research. In this experiment we have indigenously developed a ball mill machine and studied its effect on the capacitance value of ultracapacitors and successfully increased the capacitance value by a considerable amount.

In this paper, we have discussed in section II the complete design and construction of ball milling machine in section III we have discussed observation and analysis. The next section, that is section IV the results achieved from experimentation whereas section V describes the conclusion for the project.

II. DESIGN AND CONSTRUCTION OF BALL MILLING MACHINE

2.1 Working principle of ball milling machine

As we have studied the importance of increasing the efficiency of our energy storage devices in the previous section let us study the design and construction of ball mill machine and its working principle. A ball mill machine is a type of grinder where the material subjected to crush is impacted by rolling balls and crushed to finer particles. It
works on the principle of impact and reducing the strength of the material by continuous pressure created by motion of the balls in the vessel. This philosophy is used to crush the electrode material required for the construction of the ultracapacitors. The impact of collision of the balls crushes the material into superfine powder having thickness in nanometres. The scientific process of ball milling machine was invented in the 1960's at International Nickel Company by Benjamin Franklin and his co-workers. Their experimentation led to a great discovery that this method of crushing materials successfully produced uniform, fine dispersions of oxide particles in nickel base super alloys which could not be powdered into superfine particles by using any other conventional metallurgy methods. This innovative discovery changed the traditional methods of production of material which earlier was carried out by using high temperature synthesis. Since then ball milling machine was also used to change the conditions under which chemical reactions takes place either by inducing chemical reactions during milling mechano-chemistry or for increasing reaction rates, lowering reaction temperature of the ground powders. Ball mill machine is used in various fields and applications.

2.2 Design and construction of ball mill machine

The various types of structures of ball machine are horizontal ball milling machine, vertical ball milling machine, vertical roller mill, cement mill, industrial ball milling machine etc.[5]. The basic working principle of operation and design of all ball mills remains same even when used for various applications. The size of the ball mill machine is decided on the basis of application for which it is being used. For example, Vertical ball mill machine are as small as size of blender that can be used to crush down sample to superfine thickness for experimentation procedure in laboratories whereas Horizontal ball mill machine is constructed using the detachable drum and has a door access to load and unload the material. The industrial ball mill machine is used for mass production and varies in size like from size of refrigerator to approximately to a size of bus and has various multiple chambers and forced air system that constantly moves the material in the mill [5]. After deciding our aim of study, we developed a design of horizontal ball mill machine. The detachable container was made of stainless steel the material which is used to make containers in the food and dairy industry. Stainless steel was invented by keeping in mind the problem of corrosion which was a major concern for the food and other industries where maintaining the purity of the material was important. An induction motor was used as driving machine of the system. The shaft of the induction motor was fitted with a reduction gear box which helped to reduce the speed of induction motors any suitable gear ratio. The main purpose of designing the ball mill machine was for laboratory purposes especially for crushing carbon that can be used for construction of electrode of ultracapacitors. The machine was designed keeping in mind the necessity of robust operation of machine that could be run for hours together for the process of ball milling. We have employed belt pulley transmission system from shaft of the motor to the shaft of reduction gear box. Boring, Buffing welding are some of the industrial fabrication processes used for construction of our ball mill machine container and the entire platform on which the assembly is mounted. Fig.1 shows a typical block diagram for the design of our ball mill machine with various components marked in the system.

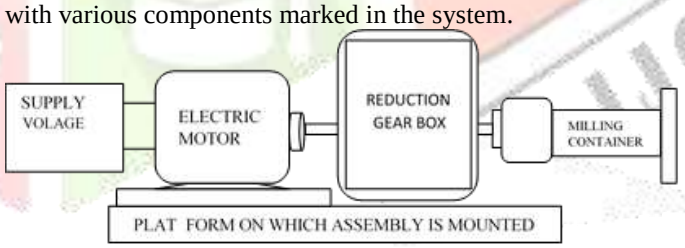

Fig.1 Block Diagram of Ball milling machine

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2.3 Experimental Procedure

In section II, we have studied design and working of the ball mill machine. In this section, we will study the experimental procedure followed to carry out the experimentation.

A variety of Supercapacitors are available. The two main Supercapacitors available are Rolled type and separator type. Rolled type construction of Supercapacitors is usually preferred as it provides higher capacitance, but its construction for laboratory purposes is difficult as it requires a winding machine and other higher equipment for its manufacturing. We have used separator type ultracapacitors. After the successful construction of ball mill machine, it underwent rigorous testing. Our main aim was to study the effect of ball milling action on crushing the activated carbon with various time intervals. There were various permutations and combinations of various parameters that were used to get different results. The variations were like changing the quantity of activated carbon, varying the ball mill time interval. After weighing the quantity of activated carbon was measured with the help of weighing machine, the activated carbon was filled in varying proportions like 20% ,30% ,50% , 70%, and 100% of the height of the container and was ball milled for 30min, 60min, 90min, and 120min. Activated carbon offers a very low internal resistance and good value of capacitance. After ball milling for an interval of 30 min the testing sample was withdrawn out of the container and was used to construct the Electrolytic Double

layered capacitor or Supercapacitors. The so constructed Supercapacitors were kept overnight to allow it to set and were tested the following day. After dipping the ultracapacitors in a solution of electrolyte for nearly 20 min, current was passed through the electrodes by using a DC source. In order to stabilize the charging and discharging current of ultracapacitors. The values of discharging currents were recorded and 20 ultracapacitors were put to test. The parameters required for calculation of the capacitance of the ultracapacitors The capacitance of the ultracapacitors under testing was calculated using formula C=Q/V where Q =charge of the capacitor and V is the voltage supplied to the capacitor while testing.

III. OBSERVATION & ANALYSIS

In section II, we have learnt the design and experimental procedure used to carry out the experimentation. In this section we will study the observed values and the analysis we can infer from the process. The observations stated here are for a sample of activated carbon that was ball milled for 120 minutes and was filled up to 58% of the total height. The discharged current for the ultracapacitors for 120 minutes is stated below. Activated carbon used for construction of electrode was evaluated on various parameters like energy density, capacitance, pulse current, power density[1]. The following Table no. I shows the recorded data of discharging current of sample of ultracapacitors, one whose electrode is ball milled for 120 minutes and the other electrode made of activated carbon which is not ball milled.

Table no. I Readings for capacitor discharge current vs. time

Sr No.	Time	Discharge current of electrode without Ball Mill	Discharge current of electrode with 2 hour ball mill
	(in seconds)	I_1(mA)	I_2(mA)
1	0	36.081	61.92
2	5	4.608	9.567
3	10	2.07	3.951
4	15	1.233	2.403
5	20	0.864	1.611
6	25	0.657	1.224
7	30	0.531	0.999
8	35	0.45	0.837
9	40	0.378	0.729
10	50	0.27	0.576
11	60	0.243	0.468
12	90	0.153	0.315
13	120	0.108	0.225
14	150	0.09	0.18
15	180	0.072	0.153

The above Table no. I shows the recorded data of discharging current of sample of ultracapacitors, one whose electrode is ball milled for 120 minutes and the other electrode made of activated carbon which is not ball milled. The following Fig.2 plots the discharge current of the ultra-capacitors against time.

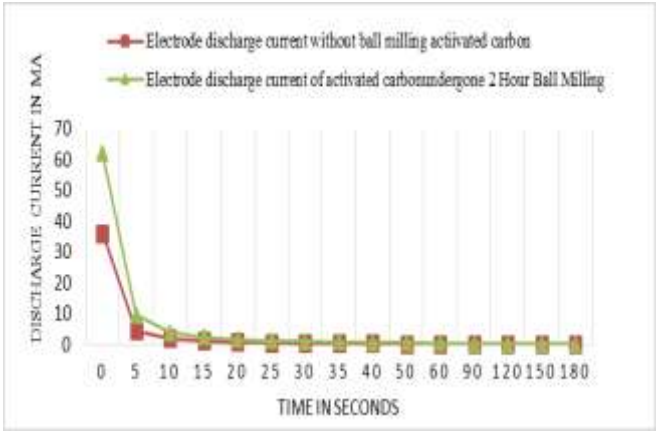

Fig.2 Electrode discharge current vs. Time

IV. RESULTS

We have seen the values of observations of discharge current plotted against time in section III. In this section, we will evaluate the observations and infer conclusions that were obtained from the experimentation. The capacitance of the ultracapacitors was calculated using formula C=Q/V where Q =charge of the capacitor and V is the voltage supplied to the capacitor while testing. As observed in Table. I we can see that the value of discharge current was increased from 36.08 mA to 61.92 mA. The peak pulse current of sample of activated carbon ball milled for 30min, 60min, 90 min was also observed. The values of peak current from 30 min and 60min were almost constant but the visible change could be observed in the sample that was ball milled for 120 mins. It could be seen that as the crushing time increases the value of peak current increases.

Table no. II Various parameters that influence the capacitance of the ultracapacitors

Sr. No	Ball Milled Time	Pulse Current	Energy Density	Specific capacitance	Area Base.C	Faraday
No.	Min	(mA)	J/gm	F/gm	F/cm2	F
1	0 MIN	36.081	0.754	0.312	0.025	0.075
2	30 MIN	37.08	0.773	0.319	0.026	0.077
3	60 MIN	39.15	0.832	0.344	0.028	0.083
4	90 MIN	41.94	1.003	0.415	0.033	0.100
5	120 MIN	61.92	1.385	0.572	0.046	0.137

Table no. II clearly displays the effect of ball milling on the capacitance of the ultracapacitors. As observed the values of various parameters like energy density, specific capacitance, the specific area base of carbon increases with increase in the time for which the material is subjected to ball mill.

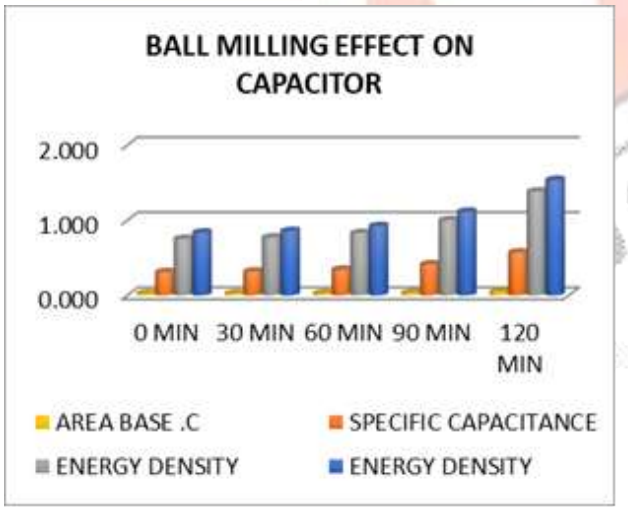

Fig.3 Effect of ball milling on various capacitor parameters

The effect of ball milling on different parameters of capacitors is shown in fig.3.which clearly shows that capacitance is increased with increase in time of ball milling.

V. CONCLUSION

As we have seen in section IV. As the ball milling time has increased the value of peak current is increased. The impact of balls on the activated carbon reduces the particle size to such an extent that the size of the particle of electrolyte and the crushed carbon become comparable. The electrolyte solution enters the pores and cracks of activated carbon and makes it more conductive. Equivalent series resistance (ESR) is the sum of in-phase AC resistance which includes resistance of dielectric plate material, terminal leads at particular frequency and electrolytic solution. Due to ball milling process the value of ESR is decreased. Hence we get a higher value of

capacitance and reduced value of ESR by using a ball milling machine for crushing the activated carbon that is used as electrode material. Thus, we have successfully constructed the ball mill machine and tested its performance and proved that the capacitance of the capacitor can be increased by effect of ball milling machine.

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