



## **Development of Indigenous Ball Mill Machine and its Effect on Capacitance of Ultra capacitors**

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### **ABSTRACT:**

Energy is required to do work. There are various sources of energy like conventional fossil fuels, renewable energy sources like solar, wind energy, tidal energy, geothermal energy which can be utilised to meet our energy demands but there are some limitations to its use. So we convert these energies into Electrical energy and exploit to fulfil our energy requirements. Energy cannot be created it can be converted form one form to other. We use this concept and store Electrical energy in various forms. A lot of research is going on in the field of energy storage devices in order to bridge the ever increasing gap between the energy supply and demand. There are various storage devices but Ultracapacitors or Electrolytic double layered capacitors are the future of energy storage. In this experiment we have indigenously developed a Ball Milling Machine and studied its impact on the capacitance value of ultracapacitors. This paper explains the experimentation carried out and successful accomplishment in increasing the capacitance of active carbon used to make electrodes of ultracapacitors.

**Keywords:** Indigenous design, Ball milling Machine, Ultracapacitors, Energy Storage Devices, Increased Capacitance

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### **I. INTRODUCTION**

Energy cannot be created nor it can be destroyed, it can be transformed from one form to another” says the Law of Energy Conservation. Energy is required by us for all our activities and it gives us the comfort and gives us the liberty to increase our productivity and achieve what we want. There are various forms of energy available that can be exploited to achieve our energy demands but our entire energy demand and supply is met using electrical energy. As per the Law stated above we can only transform energy from one form to another we cannot store it. As electrical energy is the most convenient form of energy for our use with ease and convenience. Energy storage units function as buffer to counteract power imbalance between the demand and supply sides. Energy can be stored in various forms like chemical energy storage systems which comprises of hydrogen, bio-fuels, bio-mass, liquid nitrogen, oxy-hydrogen, Electrochemical storage devices like battery and fuel cells, Electrical energy storage devices capacitors and ultra-capacitors, Superconducting magnetic energy storage ,Mechanical energy storage devices like hydraulic devices, Flywheel energy storage. Thus we convert electrical energy to chemical energy, store it in batteries and use it whenever needed. The reduction of losses in the process of storage and increasing the storage capacity is the main issue that poses before us. Supercapacitors are the next generation of storage devices and are on the prima facie of the research field due to their advantages like high power density, short charging time, long cycling time. It is similar to operation of capacitors but it offers a very high value of capacitance which can be used in future to meet our power supply demands. Commercialization of manufacturing of the ultracapacitors is slow as the development This paper aims at developing a ball milling machine as ball milling is an important tool for optimizing the size of the material used to construct the electrodes of Supercapacitors in order to increase the capacitance. In this experiment we have indigenously developed a ball mill machine and have studied the effect of ball milling on the capacitance value of ultracapacitors and we have successfully increased the capacitance by a considerable amount.

In this paper, we have discussed in section II design of ball milling machine which describes about the entire fabrication and production procedure. In next section III a small description of the entire experimental setup is done. Further section IV explains the results obtained from the experimentation and explain the performance of the ball mill machine.

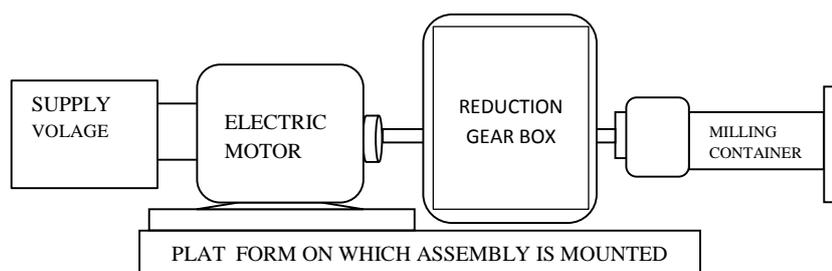
### **II. DESIGN OF BALL MILLING MACHINE**

After studying the introduction to ball milling system in section I let us now focus on the design of the ball mill machine .Ball milling machine works on the principle that powder of a material is subjected to the impact of balls, which are contained in the vessel. It works as a grinding machine that crushes the electrode material used in construction of ultracapacitors. The collision of these balls would crush the material into superfine powder having thickness in nanometres.

The process of ball milling is the brain child of Benjamin Franklin and his co-workers at the International Nickel Company in late 1960s. While performing the experiment, which led to great discovery, it was found that this method could successfully produce fine, uniform dispersions of oxide particles in nickel base super alloys that could not be powdered into superfine particles using any other conventional metallurgy methods. Their innovative discovery changed the traditional method in which production of material was carried out by using high temperature synthesis. Ball milling machine is also used to change the conditions under which chemical reactions usually take place either by inducing chemical reactions during milling mechano-chemistry or for increasing reaction rates, lowering reaction temperature of the ground powders.

Ball milling machines are used in every field for various purposes. There are various types of ball milling machine like vertical ball milling machine, horizontal ball milling machine, Industrial ball milling machine, cement mill, vertical roller mill etc [5]. The basic principle of operation and design of all ball mills is same but have different applications in varied areas. For example, Horizontal ball mill machine has a detachable drum which has a door for material to be loaded and can be used for paint mixers whereas Vertical ball mill machine are about a size of blender and can be used for laboratory purposes to crush down sample to superfine thickness for experimentation purposes. 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]. The chambers in the machine are differentiated by progressively small mesh that differentiates the materials at various stages.

The size of the ball machine is decided according to the application for which it is being used. For our experimental analysis we developed a horizontal ball mill machine with a detachable container made of specific Stainless steel the material which is used to make containers in food industries. An Induction motor having a reduction gear box is fixed at the shaft of the induction motor which reduces the speed of the induction motor by any suitable gear ratio. Thus the speed of the induction motor was reduced .The aim of development of our ball mill machine was to develop a ball mill machine that could be used in laboratories for crushing the carbon that is used in construction of electrodes of ultra-capacitors.



**Figure.1 Block Diagram of Ball Mill Machine**

The machine is robust and can run for hours together for ball milling. Belt pulley transmission system is used from shaft of the motor to the shaft of reduction gear box. Many industrial fabricating processes like boring, buffing, welding were used to construct the milling container and the entire platform on which the assembly is mounted.

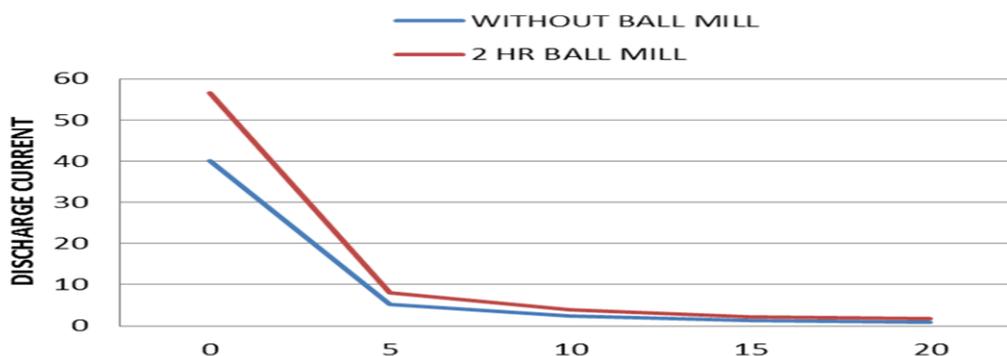
### III.EXPERIMENTATION

As described in section II the design of ball mill machine, this section provides information about the experimentation. There are various types of Supercapacitors available. The commercially available ones are non-aqueous type. Rolled type construction of Supercapacitors is usually suggested as it provides higher capacitance. It is difficult to construct rolled type capacitor for laboratory purposes as it requires winding machine and other high end equipment for manufacturing[2]. For our Experimentation we constructed separator type of ultracapacitors.

After the successful fabrication of the Ball Mill Machine it was put to rigorous testing. The aim was to study the effect of ball milling on crushing the activated carbon various time intervals. With various permutations and combinations like the quantity of carbon taken in container , changing the size of the balls that are used for crushing and varying the ball milling time interval. First the quantity of activated carbon activated carbon was measured with the help of weighing machine and the material was filled to 100%,70%, 50%,30% and 20% of the height of the container and was ball milled for 30 min, 60 min, 90 min and 120 min. activated carbon is more appropriate as it offers low internal resistance and good value of capacitance. After each an interval of 30min of ball milled sample of activated carbon the was withdrawn out from the container and was used to make Electrolytic Double Layered Capacitor or Super capacitors. The Supercapacitors so made was allowed to set for an overnight and then tested the following day. The Ultra capacitors were dipped in a solution of electrolyte for nearly 20 min and current was supplied to the electrodes using DC source. The capacitor was charged and discharged alternatively for a time interval of 15 seconds in order to stabilize the charging and discharging current of the ultracapacitors. The values of discharging currents were noted down. Nearly 20 capacitors were tested and discharging currents for all were recorded. Following observations were made for a sample which was ball milled fo120 mins filling the container upto 58% of height of the container. The capacitance was calculated using formula  $C=Q/V$  where  $Q$  =charge of the capacitor and  $V$  is the voltage supplied to the capacitor while testing.

**Table no.1 Observation of capacitor discharge current vs time**

TIME (IN SECONDS)	WITHOUT BALL MILL	2 HR BALL MILL
	I <sub>1</sub> (mA)	I <sub>1</sub> (mA)
0	40.09	68.8
5	5.12	10.63
10	2.3	4.39
15	1.37	2.67
20	0.96	1.79
25	0.73	1.36
30	0.59	1.11
35	0.5	0.93
40	0.42	0.81
50	0.3	0.64
60	0.27	0.52
90	0.17	0.35
120	0.12	0.25
150	0.1	0.2
180	0.08	0.17



**Figure.2 Capacitor discharge current vs. Time**

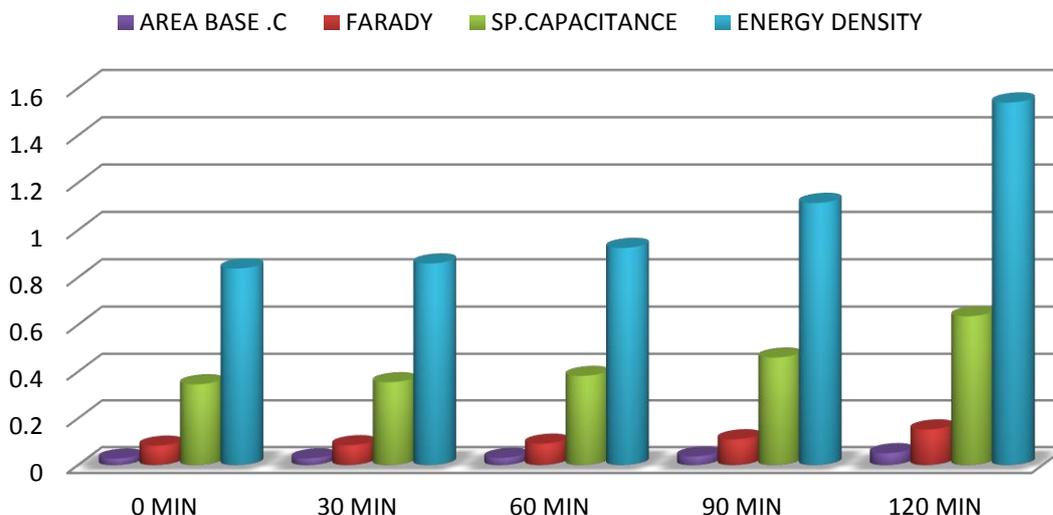
#### IV. RESULTS

As we have seen the experimentation in section III this section provides information about the various results that were obtained from the experimentation. Activated carbon was taken for constructing the electrode as it gives better performance in comparison with other carbon material [2]. To observe the effect of ball milling on the activated carbon it was evaluated on various parameters like Capacitance, Pulse current, Energy density, Power Density[1]. Following graph shows the comparison between the capacitor discharge current of activated carbon without ball milling the material and after it was Ball milled for two hours in Ball machine developed by us. Figure.2 shows the increase in the peak pulse current. It was observed that as shown in Table no.1 that the peak pulse current was increased to 68.8mA from 40.09 mA. It was observed that capacitance of the ultra capacitor was increased by 70 per cent. Thus, the increase in capacitance and peak pulse current proved successful design and operation of the developed ball mill Machine

**Table2. Super capacitors parameters**

SR NO.	BALL MILLED TIME MIN	PEAK PULSE CURRENT (mA)	FARADY F	SP.CAPACITANC E F/gm	AREA BASE .C F/cm <sup>2</sup>	ENERGY DENSITY J/gm
1	0 MIN	40.09	0.08310227	0.346259471	0.027700758	0.837947919
2	30 MIN	41.5	0.08518182	0.35492425	0.02839394	0.858916685
3	60 MIN	44.5	0.09170825	0.382117708	0.030569417	0.924724854

4	90 MIN	46.6	0.11055682	0.460653417	0.036852273	1.114781268
5	120 MIN	68.8	0.15264773	0.636032208	0.050882577	1.539197944



**Figure.3. Effect of ball milling on super capacitor parameters**

### V. CONCLUSION

All characteristics like peak pulse current, energy density, area base capacitance, discharging currents etc. were studied as shown in Figure3 and Figure4. There was increase in the pulse peak current of the activated carbon which was ball milled for Two hours. It was found that after ball milling the material for a certain period of time the capacitance of the material can be increased thus making the storage device more efficient. The design of ball milling machine was successfully designed and the machine was fabricated. As local production and fabrication processes were used it leads to conclude that indigenously developed low cost ball mill machine can be manufactured on a commercial level for laboratory purposes. Finally we can conclude that active carbon contained to 58% of the container height and ball milled for two hours continuously can increase the capacitance of activated carbon by 70 %.

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