© 2016 IJSRSET | Volume 2 | Issue 2 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

# Effect of Separator Thickness Variation for Supercapacitor with Polyethylene Separator Material

**Pradip Mandake[1], Dr. P. B.Karandikar[2]**
[1]Department of Electrical Engineering, Bharati Vidyapeeth Deemed University College of Engineering, Pune, Maharashtra, India
[2]Department of Applied Science, Army Institute of Technology, Pune, Maharashtra, India

## ABSTRACT

An electrochemical double layer capacitor often called a supercapacitor. Supercapacitor stores electrical charges in the electric double layer at an electrode-electrolyte interact with separator between two electrodes. Supercapacitor is new technology of storage devices of electrical energy. Due to its long cycle life and high power density, it is advantageous than conventional capacitor and batteries. Separator materials have important role for improving capacitance and energy density of supercapacitor. It is also effect on ESR and power density. In leading research and development organisations in the world, research works is going on in search of porous separator materials for improving performance of capacitance of the supercapacitors.

**Keywords:** Supercapacitor, Separator, Energy Storage Devices.

## I. INTRODUCTION

Recent years growth of energy consumption is increased, and storage of electrical energy is most important problem arises, hence there is essential of energy storage devices. Battery, fuel cells and capacitor are the conventional energy storage devices. The supercapacitor is recent trend of the energy storage devices. Which is stores energy in the form of charge. Supercapacitor are the high power and energy density than the conventional energy storage devices like fuel cells, capacitor and battery. Electrochemical capacitors with high electric capacity. supercapacitors is a essential components in modern power engineering. Supercapacitors have less charging and discharging time, Due to this advantages, there is a wide range of applications of these energy storage devices, for example, as sources of strong current pulses, for quickly charging useful amounts of energy, e.g. for electric engine braking.

Supercapacitors consist of two electrodes of highly porous materials separated by an synthetic polymeric material that allows ions through it by diffusion which is known as separator, and both electrodes are connected with this ion-permeable process. When voltage is applied between both electrodes, an ion in the electrolyte form electric double layers of opposite polarity to the electrodes polarity.The electrolyte provides the conducting medium. Separators are used to physically separate the both electrodes to avoid a short circuit by direct contact. For minimize ESR, separators have required to thin and must be porous to the conducting ions between them. Separators are chemically inert to protect the electrolyte's stability and conductivity. Supercapacitor consists of electrodes, current collectors, separator, and electrolyte. Many researchers had done research to achieve a high performance supercapacitor for various experimental studies such as on the electrode, current collectors, and electrolytes to have their high energy and power densities. On the other hand, only a few research papers reported about the study of separator for the energy storage devices. Large number of research is carried out on supercapacitor, for its properties like, high power density, high durability and fast charging and discharging mechanism. Scientist have done experimentations on various types of porous membrane to obtaining high power, high capacitance, low ESR, high energy density of supercapacitor. More recently for separator material, they are focusing on natural porous materials. Some of the researcher is

experimentation on egg shell membrane type of separator for supercapacitors and other applications.

In this Research work, the Polyethylene types of separator with different thickness and which effects on supercapacitor parameters are studied. The polyethylene separator are used, but there are nonwoven polypropylene (PP) mat, AGM, porous PP membrane, HI-SEP, PVC and nonwoven cellulose paper used in energy storage devices.

## II. METHODS AND MATERIAL

### Experimentation

There have Polyethylene type of separator used for experiment. There have three types of PE thickness, 0.35mm,0.25mm,.20mm. In market there are standard thickness of separators are available mostly. The manufacturers are produced same standard of thickness of separator. For variation of separator thickness beyond standard thickness the increased separator layers between the two electrodes one by one.

First, the all types of separators are cutting there ribs and make smooth and proper size of thickness. Then each types of separators are cutted in proper dimension for required to prototype developing supercapacitor. The size of separator is 3 cm X 4 cm. For experimentation developing of one prototype, taken two wire mesh SS316 of dimension 1cm X 3cm. A $MnO_2$ (50%) and Vulcun XC–72(50%) with isopropyl are activated material paste is formed, a loading of 20 mg/cm is applied on the wire mesh. After loading, wire mesh is kept dried for 15 minutes by naturally, also it is dry by the use of dryer. After drying, wire mesh is sandwiched between the one type that is first 0.35mm thickness of three separators with the help of feviquick solution which is used as a adhesive. Another prototype was developed by using a same activated materials and electrode size with different thickness like 0.25mm and 0.20mm. For all prototypes, electrolyte used is potassium sulphate ($K_2SO_4$) because it got higher potential voltage. After this, above process is repeated by increasing the layers of Polyethylene separator between two electrodes of supercapacitor of three different types of thickness of separator. The variation of thickness of PE separators increased and the effect of capacitance and internal resistance are observed.

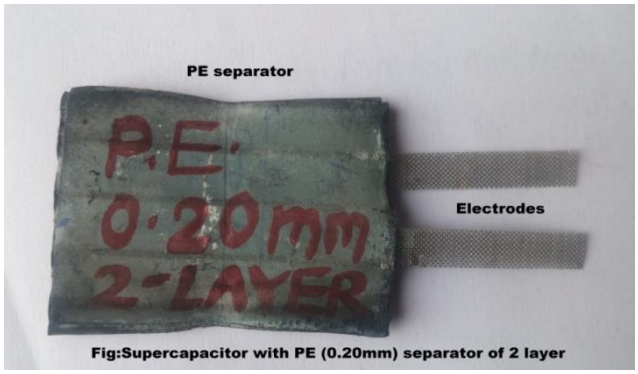


**Figure 1:** PE (0.20mm) separator two layers of super capacitor

## III. RESULTS AND DISCUSSION

The capacitance and ESR are the significant factors for design of the supercapacitor. There are analyzed the capacitance and ESR factors influenced by the multiple layers of supercapacitor with PE types of separators having various thickness. Electrochemical capacitors are able to achieve high levels of capacitance and store large amounts of charge due to the ample availability of surface area. The porous separator membrane that separates the two electrodes of an electrochemical capacitor allows ions to diffuse across to the opposite electrode, without recombination, when voltage is applied. Separators are manufactured with fiberglass cloth, thin plastic films made from nylon, polyethylene . It must be porous and very thin to allow the charged ions to pass without obstruction. The separators of supercapacitor must be able to withstand penetration crystalline minerals in order to prevent the electrodes from contamination. The ions move through the Separator via an Electrolyte solution. If the separator breaks down, this will weaken high power cells end results.

**Table 1 :** Capacitance of three different size of polyethylene supercapacitor with variation in separator layers

| **Thickness** | **Capacitance (f)** | | |
|---|---|---|---|
| | **0.35mm** | **0.25mm** | **0.20mm** |
| 1 layer | 0.2308 | 0.2815 | 0.26933 |
| 2 layer | 0.2179 | 0.3083 | 0.2736 |
| 3 layer | 0.3125 | 0.2944 | 0.34049 |
| 4 layer | 0.2711 | 0.2549 | 0.40381 |

**Table 2 :** Esr of Three Different Size of Polyethylene Supercapacitor With Variation In Separator Layers

| Thickness | ESR (Ohm) | | |
|---|---|---|---|
| | **0.35mm** | **0.25mm** | **0.20mm** |
| 1 layer | 17.33 | 23.7737 | 50.12 |
| 2 layer | 48.19 | 30.8191 | 40.20 |
| 3 layer | 51.20 | 49.7255 | 33.43 |
| 4 layer | 60.85 | 62.7619 | 23.50 |

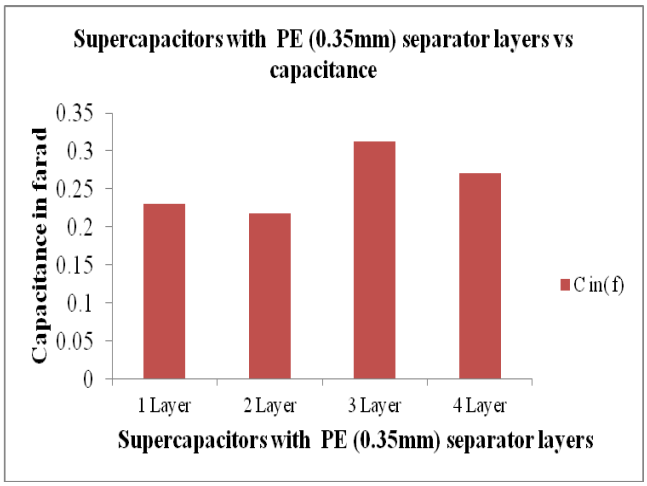


**Figure 2:** Capacitance of PE (0.35mm) separator layers of supercapacitor

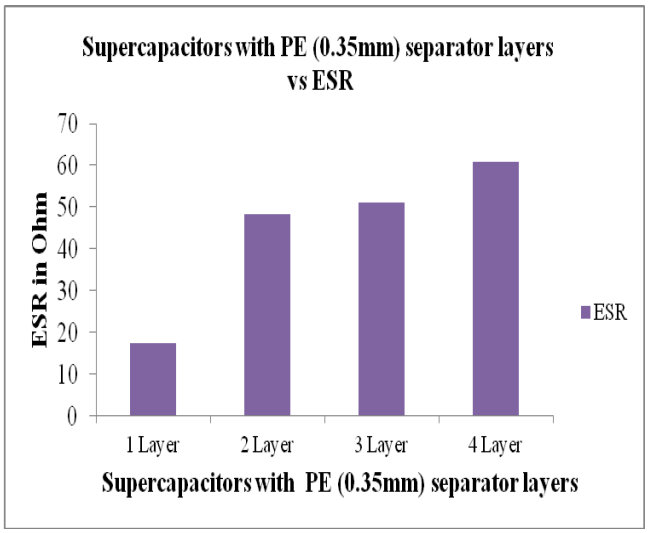


**Figure 3:** ESR of PE (0.35mm) separator layers of supercapacitor

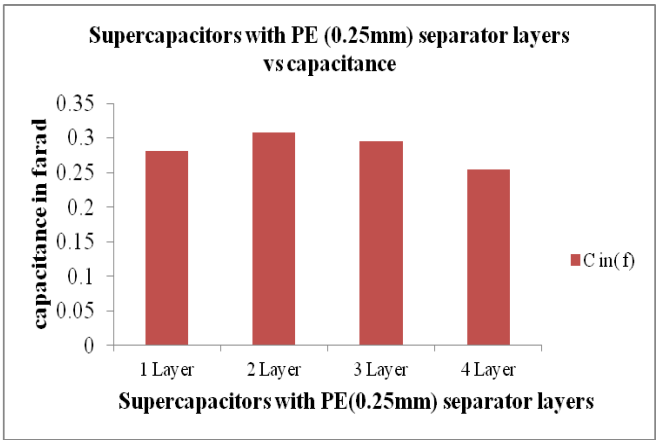


**Figure 4 :** Capacitance of PE (0.25mm) separator layers of supercapacitor

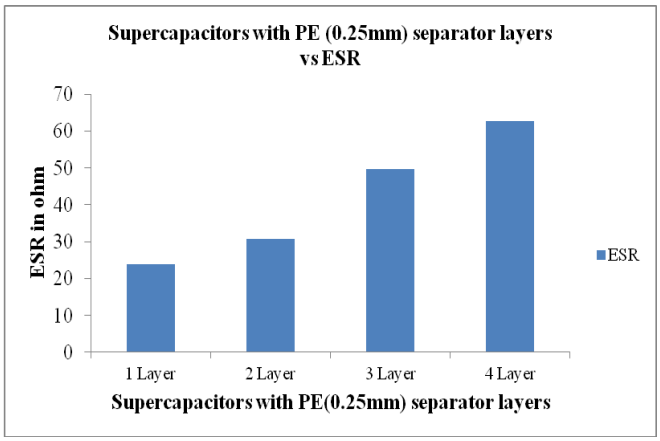


**Figure 5:** ESR of PE (0.25mm) separator layers of supercapacitor

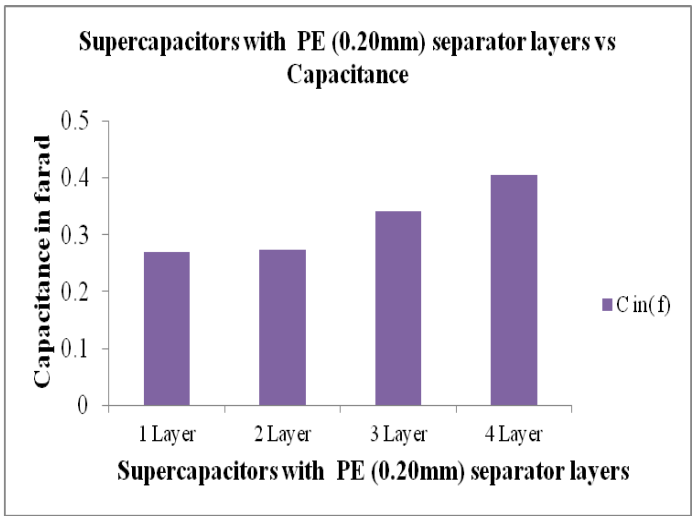


**Figure 6 :** Capacitance of PE (0.20mm) separator layers of supercapacitor

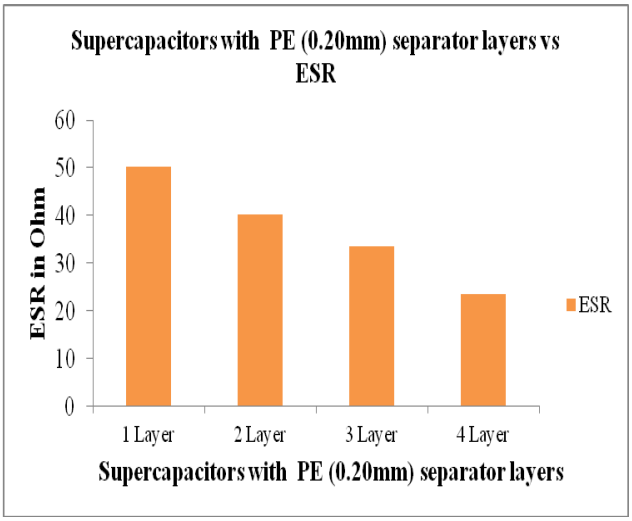


**Figure 7:** ESR of PE (0.20mm) separator layers of supercapacitor

**Table 3.** Effect of pe separator thickness on esr and capacitance

| Sr. No. | Thickness(mm) | Capacitance | ESR |
|---|---|---|---|
| 1. | 1.4 | 0.2711 | 60.85 |
| 2. | 1 | 0.2549 | 62.76 |
| 3. | 0.8 | 0.4038 | 23.50 |
| 4. | 0.4 | 0.2736 | 40.20 |

## IV. CONCLUSION

There two characteristics of supercapacitor derived from various thickness of PE separator are studied which are capacitance and ESR. After studying it is observed that, Polyethylene separator thickness increased as capacitance values decreased, and also increasing internal resistance value of supercapacitors. It is concluded that thickness is only not sufficient to determine the ESR and capacitance, but porosity, wetability, strength of separator material are depend also The separator series resistance is proportional to the separator thickness and inversely proportional to its area. The conductivity of the separator is proportional to its porosity.

## V. ACKNOWLEDGMENT

The authors sincerely acknowledge the Management and Principal of Bharati Vidyapeeth Deemed University College of Engineering, Pune and Army Institute of Technology, Pune. Authors would also like to thanks to Mr. D.M.Tagare former MD of M/S. Madhav capacitors Pvt. Ltd. Bhosari Pune, Mr. Nikhil Kulkarni CEO PMK Energy Pvt. Ltd Jaysingpur, and Prof.Dr.D.S.Bankar, Head of Electrical Engineering Department, Prof. R.M. Holmukhe M.Tech Co-Ordinator, Bharati Vidyapeeth Deemed University College of Engineering, Pune, for his kind support during the course of this research work. Authors wish to thank all teaching and non- teaching staff for their timely help and support.

## VI. REFERENCES

[1] Gaurav Shekhar,P.B. Karandikar and Mukesh Rai "Investigation of Carbon Material Derived From Leaves of Tree for the Electrodes of Supercapacitor" International Journal of Emerging Engineering Research and Technology Volume 2, Issue 6, September 2014, PP 127-131.

[2] SUN Xian-Zhong,ZHANG,Xiong HUANG, Bo MA Yan-Wei."Effects of Separator on the Electrochemical Performance of Electrical Double-Layer Capacitor and Hybrid Battery-Supercapacitor" Acta physics.-chim.2014,30(3),485-491.

[3] P. Simon and Y. Gogotsi, "Materials for electrochemical capacitors," vol. 7, pp. 845-854, November 2008, 2008.

[4] Practical aspects & hurdles in the development of low-cost high performance supercapacitors A.G. Pandolfo, A.M.Vassallo, CSIRO Division of Coal & Energy Technology.

[5] R. P. Deshpande, Capacitor Technology and trends, Paperback 2013.

[6] Zhi Jun Jia ,Jun Wang , Yi Wang ,Tao Qi , and Chang Ming Li DOI: 10.1002/aelm.201500123

[7] X. Li, W. Xing, S. Zhuo, J. Zhou, F. Li, S. Qiao and G. Lu, Bioresour.Technol.,2011, 102,1118.

[8] C. X. Guoab and C. M. Li, Energy Environ. Sci., 2011, 4, 4504.

[9] S. Bose, T. Kuila, A. K. Mishra, R. Rajasekar, N. H. Kim andJ. H. Lee, J. Mater. Chem.,2012,22,767.

[10] Karandikar, P.B.,Pandey, A.K.,Negi, A.,Ku mar, S.“Comparative study of rolled and stacked type aqueous supercapacitor”,Global Humanitarian Technology Conference: South Asia Satellite (GHTC-SAS), IEEE, Year:2013, pp:260-263.

[11] Separator Membranes Produced from Polymers by Electrospinning for Applications in Electrical Double Layer Capacitors. Matt Biggers (Biomedical Engineering) – University of North Carolina at Chapel Hill.

[12] Alexis Laforgue,Lucie Robitaille”Electrochemical Testing of Ultraporous Membranes as Separators in Mild Aqueous Supercapacitors” DOI: 10.1149/2.020207jesJ. Electrochem. Soc. 2012volume 159, issue 7, A929-A936.

[13] P. B. Karandikar, D. B. Telange, Uday Mhaskar, Ramesh Bansal, “Validation of Capacitance and ESR Model of Manganese Oxide Based Aqueous Supercapacitor,” Electric Power Componants and Systems, Taylor and Francis, July 2012, Vol 40, pp. 1105-1118.

[14] Kumagai S.; Mukaiyachi ,K. ;Sato, M.;Kamikuri,N.; TashimaD.”Roles of pore structure and type of electrolyte on the capacitive performance of activated carbons used in electrical double- layercapacitors”, Electrical Insulating Materials(ISEIM), Proceedings of 2014 International Symposium on year: 2014, pp; 511-514.

[15] Mahulkar N., Karandikar P.B.,;” Comparison of different types of carbon materials as electrodes of supercapacitor”, International journal of innovative research in engineering and technology, Vol 01, Issue no 1, Febuary 2014, pp 12-18.

[16] Taer, Erman, Sugianto, M.A. Sumantre, Rika Taslim, Iwantono, D. Dahlan, and M. Deraman. "Eggs Shell Membrane as Natural Separator for Supercapacitor Applications", Advanced Materials Research, 2014.

[17] Mathew, Seema, Parashuram B. Karandikar, Gaurav Shekhar, and Datta S. Chavan. "A novel Neem based supercapacitor and its modeling using artificial neural network", 2015 International Conference on Power and Advanced Control Engineering (ICPACE), 2015.

[18] Battery separator industriesonlineAvailable http://www.targray.com