Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2, Issue 11, November -2015

Analysis of Surface resistivity and Volume resistivity of Laminates made from Conductive knitted fabrics

H. N. Amin[1], D. V. Bihola[2]

[1]*Textile Technology Department, Sarvajanik College of Engineering & Technology, Surat-395001,Gujarat.*
[2]*Textile Manufacturing Technology, R.C. Technical Institute, Ahmedabad-380060, Gujarat.*

Abstract – *A conductive textile is a material mostly in form of fabric or laminates or composites which can conduct electricity for High Tech products in Electrostatic discharge control, Electromagnetic shielding protection applications. Conductive textiles can be made with metal strands woven or knitted into the construction of the textile. There is also an interest in semiconducting textiles, made by impregnating normal textiles with carbon- or metal-based powders. As per selection of metal strand like – Copper, Silver, Aluminium, Steel, Carbon etc. material can explore its performance. Here in this study with use of copper wires of different gauge, knitted fabrics are developed and laminates are prepared for which surface resistivity and volume resistivity are measured and analyzed for ESD control applications.*

Key words *– Surface resistivity, Volume resistivity, Knitted Fabric, Laminates, Conductive textile*

I. INTRODUCTION

Whether we call it "soft tech" or "wearables," we can all agree that there has been great advancements in recent years with merging of textiles and electronics [1]. The interest in conductive textiles was renewed when the concept smart textiles emerged some fifteen years ago [2]. In the electronic industry, today ESD control/protective products need to meet various requirements [3]. Electronic components that are electrostatic discharge sensitive (ESDS) must be protected throughout the entire manufacturing cycle [4]. Development of products through woven or knitted process for Electrostatic discharge control is greatest need of present market to avoid hazardous malfunctions in working area. (The terms conductive and static dissipative typically refer to resistance or resistivity ranges used in the evaluation of ESD control materials and products[5].)

II. DEVELOPMENT OF LAMINATES

2.1 Raw Material

Glass filaments - 156T - E Glass Filaments

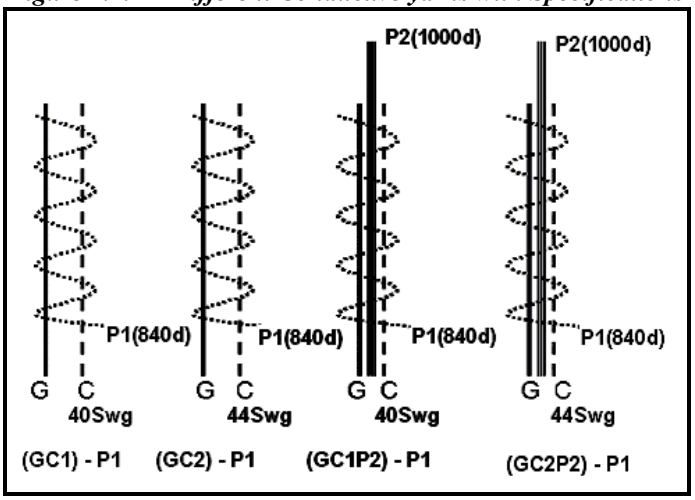
Polypropylene Filaments - 840d & 1000d
Copper Wire - 40Swg & 44Swg

2.2 Sample Preparation

Samples are mainly prepared in three stages – Yarn stage, Fabric stage and Laminate stage.

- Yarn Preparation : Conductive yarns are prepared on the Hollow spindle machine. In this work, four types of conductive yarns are produced which are shown below :

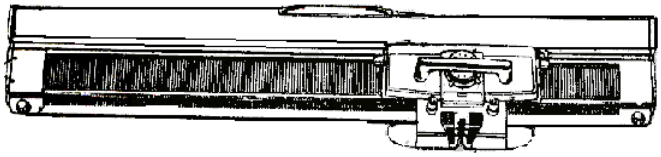
"Figure 2.2.1 – Different Conductive yarns with Specifications"



G - Glass Filaments (156T), C1, C2 - Copper wire & P1,P2 - Polypropylene Filaments

- Fabric Preparation : Conductive knitted fabrics are produced from above four types of conductive yarns on Simple Hand Knitting Machine.

"Figure 2.2.2 – Hand Knitting Machine"

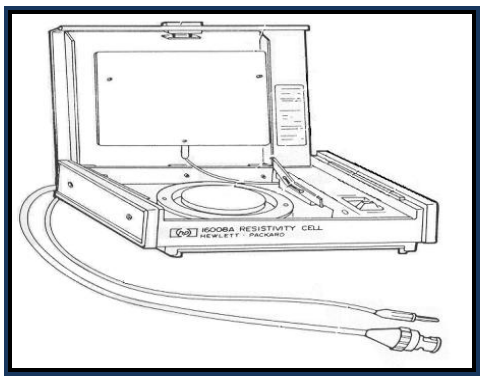


- Laminate Preparation : Laminates are developed from these Conductive knitted fabrics using Hydraulic Press with Special Thickness Sample Plates.

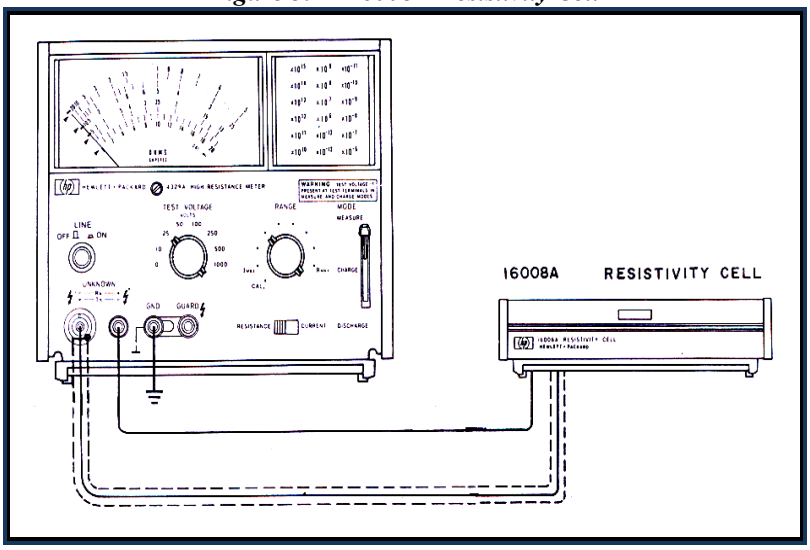
III. TESTING OF SURFACE RESISTIVITY AND VOLUME RESISTIVITY

Resistivity of the various laminates is measured in terms of Surface Resistivity and Volume Resistivity. Five readings are taken to measure resistivity of each sample. Both the resistivity are measured according to the ASTM standard D 257 method using High Resistance Meter (Model: 4329 A) and 16008A Resistivity Cell as shown in Figure 3.1 and 3.2.

"Figure 3.1 - High Resistance Meter (Model : 4329 A)"



"Figure 3.2 - 16008A Resistivity Cell"



IV. ANALYSIS OF SURFACE AND VOLUME RESISTIVITY

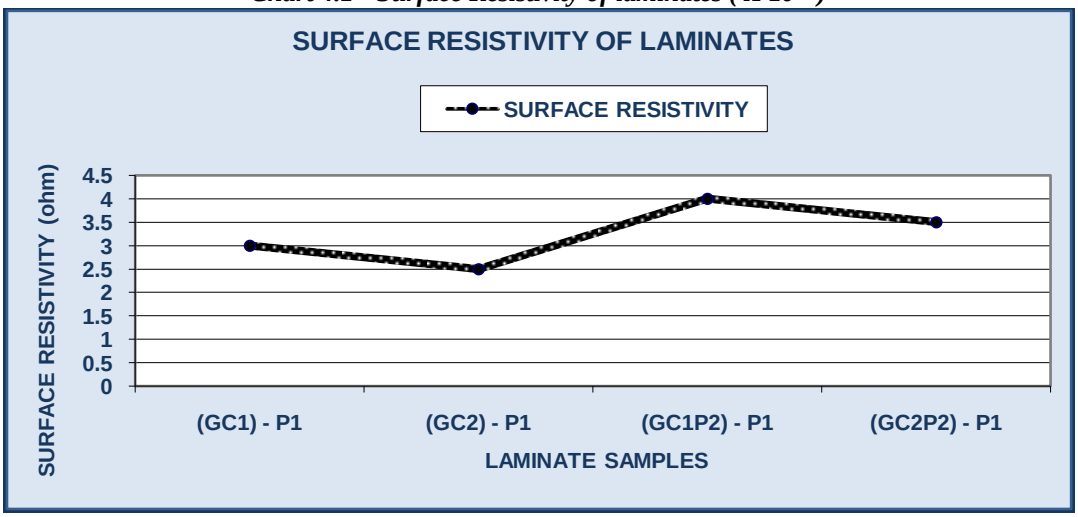
4.1 Surface Resistivity

The Surface resistance is the resistance in ohms as determined by using specified electrodes placed on the surface of the material and Surface resistivity is the resistance in ohms between opposite edges of a square of a material. The Surface resistivity is independent of electrode dimensions and is calculated by multiplying the measured surface resistance by appropriate factors.

"Table 4.1 - Surface resistivity of laminates"

1) Samples	**Surface Resistivity (ohm)**
(GC1) - P1	3 .0 X 10^{12}
(GC2) - P1	2.5 X 10^{12}
(GC1P2) - P1	4.0 X 10^{12}
(GC2P2) - P1	3.5 X 10^{12}

"Chart 4.1 - Surface Resistivity of laminates (X 10^{12})"



The typical value of Surface Resistivity of sample material lies between 2.5 x 10^{12} to 4 x 10^{12} ohm/sq. With 40Swg (copper content – 29%), the surface resistivity values are higher than that with the 44Swg (copper content – 17%). Whereas with addition of polypropylene in the core, the Surface resistivity values increases for both 40Swg ((GC1P2) - P1 – 23%) and 44Swg ((GC2P2) - P1 – 12%). This indicates that the Surface resistivity is affected not only by proportion of conductive material but also by the composite structure of the material.

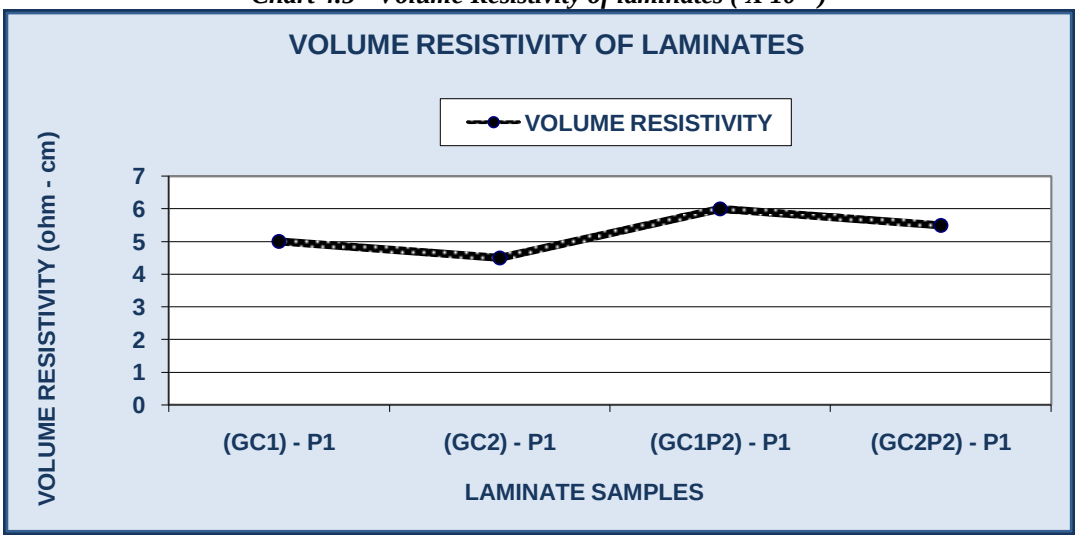
4.2 Volume Resistivity

Volume resistivity is a measurement of the resistance to the conduction of electricity provided by a unit cube of material. It is also described as the ratio of the voltage applied to one face of the material to the voltage existing on the opposite face of the cube. Higher the value indicate greater the insulation.

"Table 4.2 - Volume resistivity of laminates"

2) ***Samples***	**Volume Resistivity (ohm – cm)**
(GC1) - P1	5.0 X 10^{12}
(GC2) - P1	4.5 X 10^{12}
(GC1P2) - P1	6.0 X 10^{12}
(GC2P2) - P1	5.5 X 10^{12}

"Chart 4.5 - Volume Resistivity of laminates (X 10^{12})"



The value of Volume resistivity in range of 10^{12}, which show the better insulating effectiveness.Increase in Polypropylene content increases value of insulating effectiveness.

V. CONCLUSION

The typical values of Surface resistivity and Volume resistivity of the samples have been obtained in the range of 2.5 X 10^{12} to 4 X 10^{12} ohm and 4.5 X 10^{12} to 6 X 10^{12} ohm - cm respectively, which indicates that the materials having better insulating effectiveness on the surface. Increase in polypropylene content increases the value of insulting effectiveness.

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