Building of a Bakelite Resistive Plate Chamber Detector

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Abstract. A Bakelite Resistive Plate Chamber (RPC) has been fabricated using the facility available at NISER high energy physics laboratory using locally available materials. The semi-conductive graphite coatings on the outer surfaces of the electrodes are made and the surface resistivity of the graphite coatings are measured using a jig. The detector is leak tested using water manometer. The detail fabrication procedures and the results of surface resistivity measurement and leak test are presented in this article. Such detectors are used in high energy physics experiments, like for example the one proposed to detector neutrinos in Indian Neutrino Observatory.

Keywords. Resistive Plate Chamber, Particle detector.

1. INTRODUCTION

In recent times Resistive Plate Chambers (RPCs) are one of the most widely used detectors in high-energy physics (HEP) experiments. They are used mainly as triggering detectors to know that an event has occurred or as Time of Flight (TOF) detector [1]. The RPC is a gas filled detector utilizing a constant and uniform electric field produced between two parallel electrode plates made of a material with high bulk resistivity e.g. glass or Bakelite. RPC has good time resolution ($\sim 1 - 2ns$) and spatial resolution ($\sim$ cm). The high resistance of RPC plate limits the spark size produced after the ionization of gas due to the passing charged particles. I have carried out my first fabrication of such detectors at NISER using the facility available for imparting training at the undergraduate level to students. We have made a $30cm \times 30cm$ Bakelite resistive plate chamber module using locally available materials. Such detectors have been considered for the possibility of use in the high-energy physics experiments such as in India-based Neutrino Observatory program [2].

This paper discusses building of a RPC using Bakelite and other components from the local sources and the measurement of the surface resistivity of the detector. The detector is tested for gas leak. The method of leak test and the results are also presented.

2. CONSTRUCTION OF RPC

Two $30cm \times 30cm$ Bakelite sheets with $3mm$ thickness are used as electrodes. After proper cleaning with isopropyl alcohol, a graphite coating (surface resistivity $\sim$ a few hundreds of $k\Omega/\Box$) is made on the outer surfaces of the RPC to distribute the applied voltage uniformly over the entire detector. A gap of $1cm$ from the edges to the graphite layer is maintained to avoid external sparking. The inner surfaces of the two sheets are separated by a $2mm$ gap. Uniform separation of the electrodes are ensured by using five button spacers of 1cm diameter and $2mm$ thickness, and edge spacers of $30cm \times 1cm \times 0.2 \sim cm$ dimension, both being made in the laboratory itself using a polycarbonate sheet. Two polycarbonate nozzles (1mm hole diameter in 2mm thickness) for gas inlet and outlet, are placed diagonally as part of the edge spacers. All the components of the RPC are shown in Fig. 1.

Figure 1. Various components for RPC fabrication. Two graphite coated bakelite sheets (A), edge spacers (B), gas nozzles (C) and pick-up strips (D).

All the spacers and nozzles are glued to the Bakelite sheets using Araldite epoxy adhesive. Finally the gas gap between two Bakelite sheets is made using the edge spacers and button spacers. Applying a layer of the epoxy adhesive to prevent permeation of moisture seals the edges of the Bakelite sheets. Two small copper tapes $\sim 20\mu m$ thick and $1cm \times 1cm$ are pasted by the kapton tape on both the outer surfaces (on the graphite coating side) for the application of high voltage. The high voltage connectors are soldered on these copper tapes. $100\mu m$ thick Mylar sheets are used on the two sides of the RPC to cover the graphite coatings and to isolate the graphite coated surface and the pick-up strips. The complete RPC module is shown in Fig.2.

In order to collect the accumulated induced charges, pick-up strips are placed above the graphite coated surfaces. The pick-up strips are made of aluminum, which are pasted on one side of 8 mm thick locally available foam. The area of each strip is 3cmx30cm with a separation of 2mm between two adjacent strips. The ground plane made of aluminum, is pasted on the other side of the foam.

Figure 2. Complete RPC module.

3. SURFACE RESISTIVITY MEASUREMENT

The surface resistivity of graphite coating that is one of the most important parameters for RPC is calculated by measuring the leakage current. This measurement is done with the help of a jig (developed locally) and a multimeter available in the laboratory. The jig is made of two 10cm long brass rods (conductor) separated by a 10cm long Teflon rod (insulator) and, connected in a square shape.

The working principle of the jig is that the resistance measured for a uniform thickness, t of graphite layer will give the surface resistivity of the graphite layer. The voltage is applied in the brass (conductor) through multimeter. If ρ is the bulk resistivity of the surface of length l and cross-sectional area A then the resistance is given by,

$$R = \rho l/A = \rho l/lt = \rho/t$$

So the surface resistivity depends only on the graphite material and the thickness of the graphite layer. Since the length of the metal rods and their separation is kept same the unit of the surface resistivity is given by $k\Omega/\Box$ and it reads $k\Omega$ per square. The uniformity of the surface resistivity of graphite coating for the two bakelite electrode plates is scanned moving the jig in horizontal and vertical direction on the graphite surface. For each direction 100 readings are taken. For each plate the uniformity is checked both in vertical and horizontal direction. The uniformity of the surface resistivity of a plate during horizontal measurement is shown in Fig. 3. For the plate 1 the average surface resistivity is found to be $\sim 500k\Omega/\Box$ and that for the plate 2 is found to be $\sim 800k\Omega/\Box$.

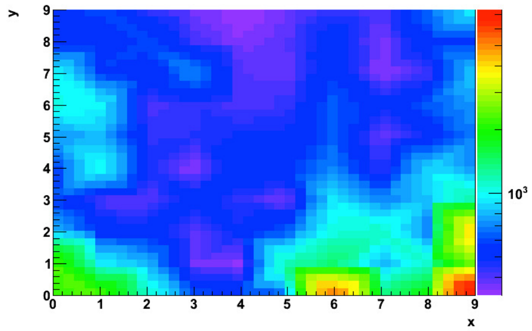

Figure 3. The surface resistivity in $k\Omega$ of graphite coated surface. x and y both dimensions are $30 \sim cm$ divided into $0 - 9$ zones.

4. LEAK TESTING

As a first step of building the detector it was subjected to a leak test by using a water manometry. The set-up for the leak testing is shown in Fig. 4. A U-tube filled with water is connected to the output of the RPC module and from the input argon gas is flown to the detector in such a way that there is a difference in the water level of the two arm of the U-tube. Once a difference is made the input of the detector is closed with a stop cork. The difference of the water level is measured with time. The measurement is continued for half an hour. The differential pressure in mbar is measured from the height difference of the water column. Initially the pressure decreases little bit but it remains constant at a differential pressure of 2 mbar during the measurement. The differential pressure as a function of the time is shown in Fig. 5.

Figure 4. Set-up for leak testing.

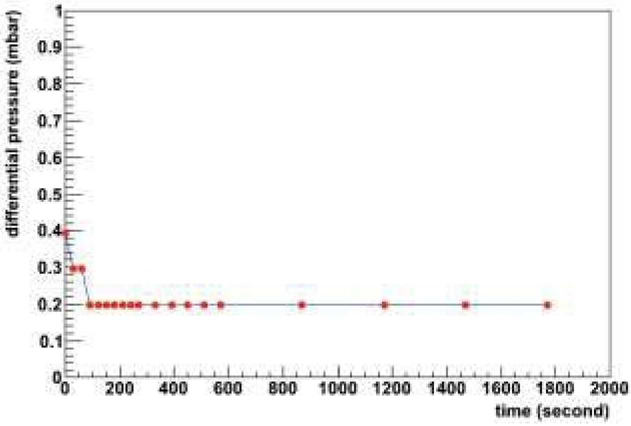

Figure 5. Pressure difference as a function of time.

5. CONCLUSION AND OUTLOOK

One RPC module is fabricated using Bakelite electrode. All the materials like Bakelite sheets, polycarbonate sheets, aluminum foils, foam, mylar sheets, copper tape etc. are obtained from the local market in Odisha. The uniformity of surface resistivity is measured. For the plate 1 the average surface resistivity has been found to be $\sim 500k\Omega/\Box$ and that for the plate 2 has been found to be $\sim 800k\Omega/\Box$. The fabricated detector is found to be almost leak-free (it can still be improved). The testing of the module in the streamer mode for efficiency, counting rate etc. are planned for future.

6. ACKNOWLEGEMENTS

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