Study of Performance of Bakelite Resistive Plate Chamber (RPC)

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Abstract Resistive Plate Chamber (RPC) is a type of gaseous detector having excellent time and position resolutions. VECC is involved in the R&D of indigenously developed bakelite RPCs. The largest size of bakelite RPC developed in India is 100cm X 100cm. We present here the test results of a bakelite sample along with the cosmic ray test results of a bakelite RPC (30cm X 30cm X 0.2cm) fabricated at VECC. The steps taken towards the development of a large size (240cm X 120cm X 0.2cm) bakelite RPC have also been discussed.

1 Introduction

Resistive Plate Chamber (RPC) is a gas filled detector which utilises a constant and uniform electric field produced between two high resistive parallel electrode plates e.g. glass, bakelite. Several high energy experiments like ALICE, CMS, ATLAS, BELLE use RPCs. RPCs can be used both for timing and trigerring purposes. RPCs will be used as active detectors in the proposed Iron CALorimeter (ICAL) experiment in India based Neutrino Observatory (INO) project [1],[2] and in the Near Detector (ND) of Deep Underground Neutrino Experiment (DUNE). ICAL will be a mammoth 50kTonnes of magnetised iron plates of dimension 48m X 16m X 0.05m stacked one over another. RPCs of dimension ~ (2m X 2m X 0.002m) will be inserted in between two iron plates. There will be ~150 such layers of iron plates.
2 Fabrication of 30cm X 30cm X 0.2cm bakelite RPC

We have fabricated a single gap 30cm X 30cm X 0.2cm bakelite RPC from 0.3cm thick bakelite electrode. The bakelite sheets were procured from local market. A gap of 0.2 cm was maintained between these electrodes with the help of 4 button spacers, each of diameter 1 cm and height 0.2 cm and 4 side spacers of length 28 cm and height 0.2 cm along with two gas nozzles. The outer surfaces of both the electrodes were painted with conducting black graphite paint mixed with special thinner in 1:1 ratio in order to apply uniform electric field across the plates. Figure. 1 shows the different components of the fabricated RPC.

![RPC Figure]

Fig. 1 Components and different stages of fabrication of small size (30 cm X 30 cm X 0.2 cm) RPC

3 Results

3.1 Electrical properties of bakelite sample

The electrical properties like bulk resistivity and surface resistivity of the bakelite sample were measured and shown in figure 2. The bulk resistivity of the bakelite sample was measured to be \(\sim 9 \times 10^{11} \Omega \text{cm} \) whereas the surface resistivity was measured to be \(\sim 3 \times 10^{12} \Omega/\square\).
3.2 I-V characteristics and current stability of RPC

The I-V characteristics of the fabricated bakelite RPC has been studied in streamer mode of operation with a gas composition of Argon:Freon(R134a):Iso-butane::55:40:5 as shown in figure 3(a). Two distinct slopes in the I-V characteristics have been obtained with a breakdown voltage $\sim 7000V$. The RPC has been tested for current stability for $\sim 50$hrs at $\pm 6000V$ as shown in figure-3(b).

Fig. 3 Fig. 3(a) shows the I-V characteristics of the bakelite RPC and Fig. 3(b) shows the current stability of the bakelite RPC at $\pm 6kV$. 
3.3 Efficiency and noise rate

The efficiency and noise rate of the RPC with cosmic rays have been measured. An efficiency plateau was obtained for the RPC beyond 8000V. The efficiency, as shown in figure 4(a), was found to be \( \sim 98\% \). During this test, noise rate of the RPC was also calculated and was found to be \( \sim 1.7 \text{ Hz/cm}^2 \) at 9000V. A linearly varying behaviour of the noise rate with the applied voltage is shown in figure 4(b).

![Efficiency and noise rate plots](image)

Fig. 4(a) shows the efficiency and Fig. 4(b) shows the noise rate of fabricated bakelite RPC and.

4 Fabrication of large bakelite RPC

With the successful results of the small (30cm X 30cm X 0.2cm) bakelite RPC and acceptable values of bulk and surface resistivity of the bakelite sample, we have started to develop large size (240cm X 120cm X 0.2cm) bakelite RPC. Figure 5(a) shows the various steps towards the fabrication of such a large size RPC and figure 5(b) shows the large RPC under test.

5 Conclusion

To conclude, the electrical properties of the indigenously produced bakelite sheets have been found promising for RPC fabrication. A single gap bakelite RPC of dimension 30 cm X 30 cm X 0.2 cm has been fabricated and tested with cosmic rays for current stability, efficiency and noise rate. The results satisfy the use of this
bakelite to fabricate RPCs for both ICAL and DUNE-ND. We are in the process of measuring the time resolution of the detectors. We have also developed large size (240cm X 120cm X 0.2cm) RPC from the same sample. The test of this RPC is under process.

References

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