Study of Silicon Fiber Sheet based readout strips panel impedance

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From the birth of Resistive Plate Chamber (RPC) detector, charge is picked up by plastic honeycomb based readout strip panel. Since then, search of new dielectric material for readout strip panel is going on due to some major drawbacks. This article is focused on the study of silicon fiber sheet based readout strip panel impedance.

1. Introduction

For any large underground laboratory such as the **I**ndia **b**ased **N**eutrino **O**bservatory (INO), it is very important that every R & D work should confirm that each component will work according to our requirement. Importance and level of seriousness enhance multifold in case of deep underground laboratory or nuclear power plants, since INO will use ~30,000 RPC detectors. Each RPC will consist of two readout panels one above and other below the RPC detector. We have discovered a suitable dielectric material named Silicon Fiber Sheet (SFS) for fabrication of readout strip panel. From our initial R&D works on SFS, we answered the following questions: Does the thickness of SFS change significantly with the weight of RPC detector? How its impedance will vary with the weight of gas chamber?

2. SFS thickness variation with the load

To study the variation in thickness of readout strip panel with load of glass RPC detector, we placed different loads from 10 gram to 5 kg (heavy load, i.e., more than the normal weight of RPC gas chamber) on the 2 cm × 2 cm piece of SFS for 72 hours. The thickness of SFS before and after the load placement have been measured with help of a binocular microscope having least count of 1μm. Relative thickness measurements procedure has been adopted for this purpose. First, we focused the surface of the unloaded area of SFS and then focused on the pressed area due to loading and recorded the difference.

FIG. 1: Photograph of Olympus BH-2 binocular microscope having 100X objective and 15X eyepieces.

The observed change in the thickness of SFS is of the order of few microns. To observe the variation in the thickness we have converted the weights in pressure unit dyne/cm^2. The observed result is shown in Figure 2. From Figure 2, one can easily understand that initially there is small rate of change in the thickness that saturates soon. The saturation region starts as heavier loads are applied.

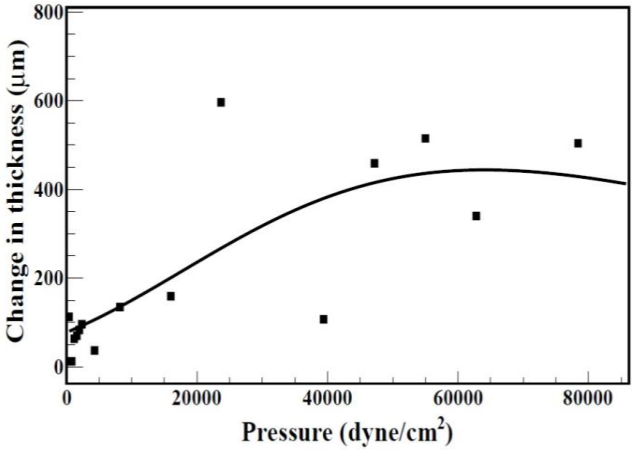

FIG. 2: Variation in thickness of SFS with pressure

During the loading on the SFS, lead bricks were placed, each of weight 5 kg, and the SFS material crossed its elastic limit. Therefore, after unloading, SFS material did not regain its original shape, i.e., there is no change in its thickness again. Therefore, from this study, we concluded that though there is a change in the thickness of SFS initially, but after pressing it with heavy weights during prefabrication of readout panel, there is almost no change in its thickness due to the weight of glass RPC detector. It means that the material of SFS is behaving like plastic after prefabrication loading. Further, we have studied this behavior for a long period of 90 days. We confirmed our earlier findings.

3. Variation of impedance with load

From our earlier study we understand that there will be almost no change in the thickness of readout strip panel with the weight of glass RPC detector. Further we studied the change in the impedance with load. For this purpose we used a 9302 LCR meter as shown in Figure 3. LCR meter was set at 1 kHz frequency and impedance of the order of M-ohm scale. We gradually increased load on to the readout strip panel. Variation of impedance as a function of load is plotted in Figure 4. From figure 4, one can see that the variation in impedance occurs in very light load region

and becomes almost constant in the heavier load region. It may also be noted that the change in the impedance is not significant due to load equivalent to the RPC detector.

FIG. 3: 9302 LCR meter for measurement of capacitance (C), inductance (L) and impedance (Z).

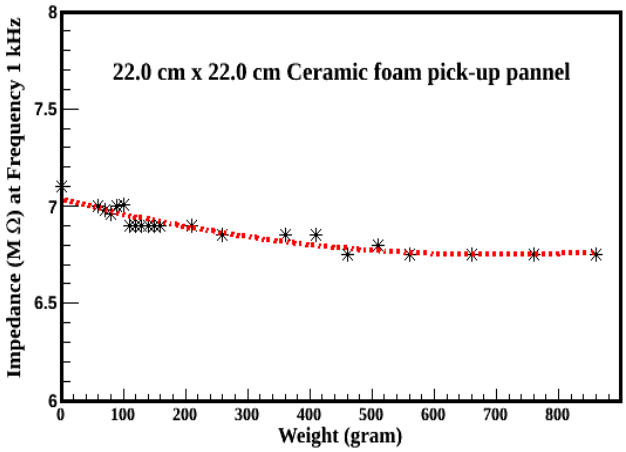

FIG. 4: Variation in impedance with the load.

Therefore, the variation in impedance occurs as we expect from our earlier experiment of measuring change in the thickness with loads, i.e., the obtained results from both experiments are complimenting each other. Thus, on the basis of this study we may conclude that there will be no variation in the impedance with the load of RPC detector.

4. Strip vise impedance variation study

Constant widths i.e. 2.8 mm, readout strip panels were fabricated. Therefore, it is important to study the variation of impedance strip by strip. For this purpose, we prepared a SFS based readout strips panel having dimension 50 cm × 50 cm × ~0.5 cm and with the help of LCR meter model (9302), we measure the impedance of each strip at 1 kHz frequency. Similarly, procedure was adopted for the plastic honeycomb (PH) based readout strips panel, which is being used by worldwide experiments for the impedance measurement of the each strip. Results are plotted in Figure 5 and compared with the results of PH based readout strips panel. From figure 5, we may conclude that the impedance variation is observed in both types of readout strips panels but the SFS based readout panel has least fluctuation in the impedance. The best linear fit value of impedance i.e., the average impedance is found to be 2.95 MΩ and 2.81 MΩ at 1 kHz frequency for PH and SFS based readout strips panels, respectively. It also shows that these values are not significantly different.

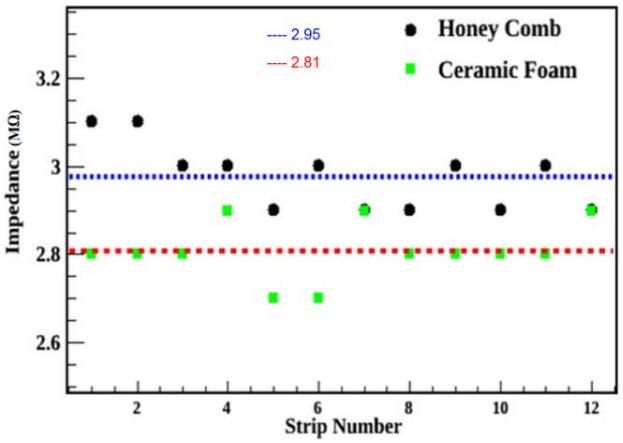

FIG. 5: Variation of impedance for PH and SFS based readout strips panels at frequency 1 kHz.

5. Conclusions

From this study we observed that the thickness of SFS based readout strips panel will not change due to the weight of the RPC detector. Also, we observed the same results even in the long term study of 90 days. Therefore, one should not worry on this issue while using the SFS based readout strips panel for any underground laboratory. We observed slight variation in the impedance in the light load region, in separate measurement. We may conclude that the impedance of SFS based readout panel doesn't change with the load of the RPC detector. We observed that the impedance value of each strips of the readout panel doesn't change significantly and comparatively less fluctuation is seen in the impedance for SFS based read out panel. Therefore, from earlier studies on SFS based readout panel and from this present study we are strongly suggesting the use of SFS based readout strips panels for any underground laboratory such as INO considering the safety and environmental issues.

Acknowledgment

The authors are thankful to the Department of Science and Technology (DST), New Delhi for financial support, and the India-based Neutrino Observatory (INO) collaboration.

Reference

[1] M. K. Singh et. al., IJIRSET **4** (10), 10035 (2015).
[2] M. K. Singh et al., JINST (2016) in press.