Advanced Automatic Scanning System (AASS) for the surface resistivity measurement of RPC electrodes

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Introduction

The India based Neutrino Observatory (INO) is an approved mega science experiment, which will use ~30,000 resistive plate chamber (RPC) detectors of dimension 2m × 2m as active detector in the Iron Calorimeter (ICAL). The technical detail of the RPC detector is explained in Ref. [1]. Uniformity and the range of surface resistivity of graphite coating on the glass electrodes are very important. Therefore, it is an essential requirement for the quality control of the RPC detector that the surface resistivity value must be in the acceptable range with minimum variation so that uniformity should be maintained. We have already successfully used automatic Scanning System (ASS) [1] for the surface resistivity measurement. However, the ASS has some limitations regarding stability, accuracy, mode of operation etc. The main feature of the advanced ASS is that it can measure the surface resistance of RPC electrodes at nearly constant contact pressure of jig. It was observed with previous ASS measurement that surface resistivity readings changes as the contact pressure between the jig and the electrodes surfaces changes. In the AASS, jig is improved and it is equipped with Force Sensitive Resistor.

Experimental Setup

In the ASS, three double binding DC motors were operational in moving the jig and axis bars for scanning the electrodes. While in the AASS, all motors are fixed at certain position and jig is moving through the hard rubber belt, as shown in Fig. 1. A photograph of the 2m × 2m AASS, FSR sensor and jig equipped with FSR is shown in the Fig. 1. The Arduino Motor Shield has controlled the movements of all the DC motors along with the Arduino microcontroller [2]. Force-sensing resistors consist of a piezoresistivity conductive polymer, which changes resistance in a predictable manner following application of force to its surface. The sensing film consists of both electrically conducting and non-conducting particles suspended in matrix as shown in Fig. 1(b). The particles are submicron sizes, and are formulated to reduce the temperature dependence, improved mechanical properties and increase surface durability. Applying a force to the surface of the sensing film causes particles to touch the conducting electrodes, changing the resistance of the film. As with all resistive based sensors, force-sensing resistors require a relatively simple interface. Compared to other force sensors, the advantages of FSRs are their small size, low cost and good shock resistance.

Fig. 1: Photographs of **(a)** the 2m × 2m AASS, **(b)** Force Sensitive Resistor (FSR) sensor and **(c)** Jig equipped with FSR sensor.

Resistivity measurement

A Jig of size 5cm × 5cm has been used for the surface resistivity measurement. Copper strips of width 1cm are fixed at the end of jig. A FSR of sensing area 4cm^2 is fixed at jig having side, which touches the RPC electrode surface as shown in Fig. 1(c). A FSR sensor can sense the applied force in the range of 1–98 Newton. Activation of FSR sensor has been done using proper circuit with the help of Arduino (microcontroller). Consequently, in the output terminal of the Arduino IDE plate form analog FSR reading, this is further converted to the force in units of Newton. To make sure the operation and measurement of the FSR sensor, we measured the resistance of known resistors such as 285, 120 and 10kΩ ranges. We found satisfactory results as shown in the Fig. 2.

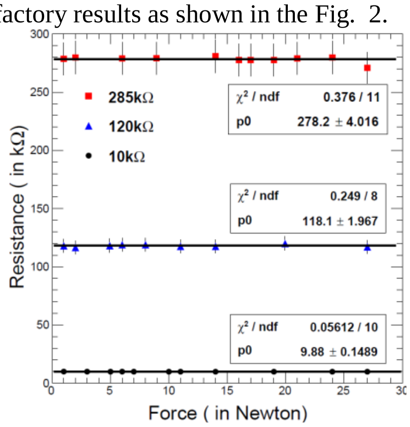

Fig. 2: Distribution of measured resistance values using different applied pressure on jig.

From Fig. 3, one can observe that the measured resistance value using FSR is independent of applied pressure on the jig. However, if no pressure is applied on the jig the observed values have large fluctuation and uncertainty. Therefore, a minimum pressure is required on the jig to get correct value of the resistance. The minimum pressure required for the measurement of correct resistance may be in the range of 3-5 Newton.

Advantage of FSR sensor

While measuring the surface resistivity per square of the electrodes surface of the RPC detector using ASS, a minimum constant current was, flowing through the jig even if jig is not touching the electrode surface and shows some resistance value. Another problem was when jig started touching the surface of electrode, current value changes rapidly. Which value is correct and has to be saved was completely unknown. These problems have been resolved using FSR sensor. Code has been developed in such a way so that only at the fixed force between jig and electrode surface, the resistance measuring circuit will activate and save the current value.

Results and discussion

The AASS is operational and successfully measuring the surface resistivity of the glass electrodes of the RPC detector of 1m × 1m and 50cm × 50 cm. Although the AASS is, design to perform the operation for 2m × 2m electrodes as shown in Fig. 1(a). We performed the surface resistivity of the same glass electrodes having surface area 50cm x 50 cm with the ASS and the AASS. The obtained results are shown in Fig. 3. One can observe from Fig. 3 that the results obtained using FSR is correct due to calibration and uniform.

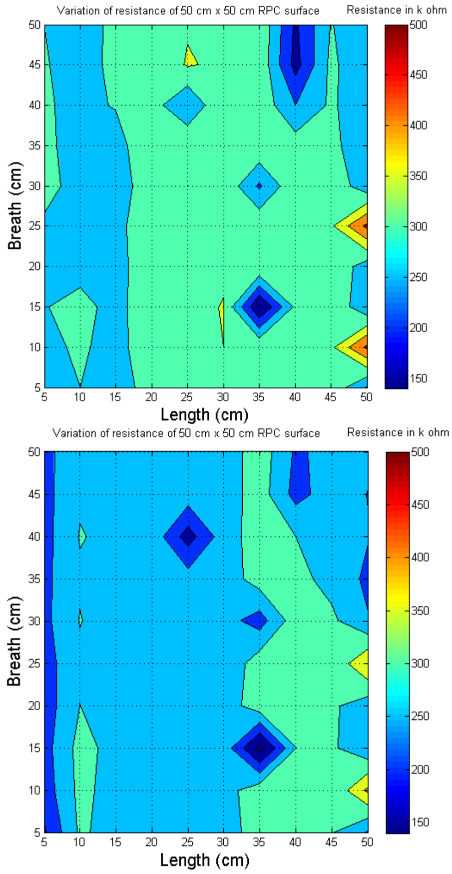

Fig. 3: (Top) contour plot of the surface resistivity per squire measured without and (Bottom) with FSR sensor.

Acknowledgement

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Reference

[1] M. K. Singh et al., JINST **12**, T01006 (2017); A. Pandey et al., Proc. DAE Nucl. Phys. **61**, 1060 (2016).

[2] A. Pandey et al., IJIRSET **6(6)**, 10856 (2017).