Prototype RPC for the upgrade of CMS end-cap

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The RPC upgrade project for the CMS experiment is foreseen in the proposed LHC shutdown in 2012. India along with Belgium and CERN are mandated to build the fourth end-cap with RPCs in order to increase the trigger efficiency, especially in the forward region ($\eta <$ 1.6), when after the shut down, the LHC will also shift to higher luminosities. The existing CMS set up has three end-caps (±) consisting of 432 trapezoidal, double layered, bakelite RPCs [1]. The proposed RPC upgrade project for CMS envisages another 200 RPCs to be built, tested, characterized, installed and commissioned jointly by India, Belgium and CERN. The process started with fabrication of 2 mm thick bakelite gas-gaps, for which the bakelite sheets (also known as High Pressure Laminates - HPL) were tailor made and cut to required sizes in Italy. The typical bakelite resistivity for the fresh production was measured as lying between 8 – 10 x 10^{10} Ω cm, as expected. These HPLs were then transported to KODEL, Korea for fabrication into gas-gaps coated with graphite, fitted with gas nozzles, line and button spacers and internal treatment of the bakelite surface of the gas-gap with linseed oil. The QA/QCs are strictly followed in all these processes, as any deviation in any of the process parameters could significantly alter the performance characteristics of the RPCs to be configured from these gas-gaps.

A pre-production run, prior to the actual mass production of gas-gaps for the RPC upgrade was planned in March/April 2011 and about 18 gas-gaps for the two types (RE4/2 and RE4/3) were sent to CERN for their evaluation and also for validation of the mechanics coming from China and other accessories from India, thereby looking into all the aspects of integrating the first prototype for the upgrade. This apart, with the experience gained with the installed RPCs in the existing end-caps, it was observed that the rise in temperature of RPCs, significantly altered its efficiency. In order to resolve this problem, the Cu cooling circuit for the FEBs mounted on the RPCs was redesigned. Improvement in the cooling system had to be introduced for RE4, due to its particular position facing the CSC electronics. As some of the installed RPCs would need to be replaced during the shut down, it was decided to incorporate all the proposed alterations in the design, such that they are also backward compatible. During the pre-production run all the necessary mechanical components were revalidated and the technical specifications and QA protocols were formalized. A prototype of the Cu cooling circuit for the RE4/2 type chamber was fabricated in MDPDD-BARC, meeting the required specifications and was dispatched to CERN. The Cu cooling circuit was fabricated with ETP/DHP semi hard Cu pipes (8 mm OD and 6 mm ID) and ETP / OF Cu sheets with 1 mm thickness. Deoxidized High Phosphorus (DHP) Copper is commercially available pure copper, which has been deoxidized with phosphorus, leaving relatively high residual phosphorus content. This copper is having a lower electrical conductivity and is used where weightage is more for heat transfer/conductance electrical properties are not that important. Electrolytic-Tough-Pitch (ETP) is the most common copper required to be 99.9% pure. It has 0.02% to 0.04% oxygen content (typical). The Cu circuit will have chilled water at 19^{o}C running at a pressure of 2 bar, in order to cool the electronics and the body of RPCs through the aluminum honey comb panels on to which it is mounted. A typical Cu cooling circuit is shown in Fig. 1, mounted with FEBs and clamped to aluminum panels at the two ends, the distance between which is 1504 mm. The two Cu pipes are separated by a distance of 288 mm.

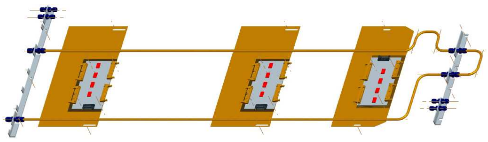

Fig. 1 Cu cooling circuit for a typical CMS-RPC

The first RPC of type RE4/2 for the upgrade was assembled with some of the components such as twisted pair flat cables, gas pipes, aluminum patch panels, L brackets and Cu cooling system sent from BARC and was further characterized for its performance, at ISR lab., in CERN, as shown in Fig. 2.

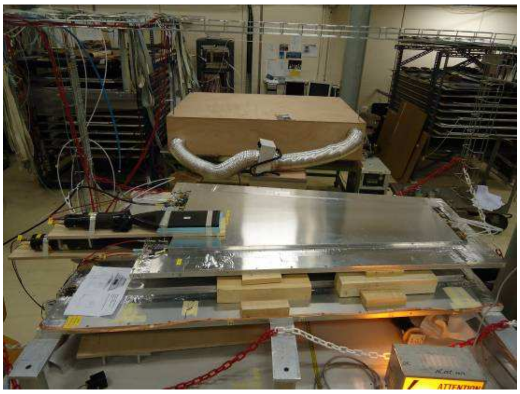

Fig. 2 First RPC for the upgrade project for CMS under evaluation at ISR Lab., at CERN

The gas-gaps inside the RPC were purged with RPC gas mixture (R134a : Iso-butane : SF_6 :: 95.2 : 4.5 : 0.3) for two days and then the efficiency of the RPC was measured with cosmics for different η regions in a localized way with plastic scintillators at different thresholds. Fig. 3, shows the efficiency plots for the prototype for the η region = A1, at threshold settings of 190, 215 and 250 mV for 1000 cosmic triggers. As seen from the plots, the efficiency is greater than 90% at an operating voltage of 9.4 kV even for the highest threshold setting. The above exercise was therefore successful in demonstrating that the gas-gaps which were freshly built after a lapse of about a year followed all the QA/QCs and that the gas-gaps did qualify as RPCs meeting the required specifications. This exercise also gave a green signal for the mass production of bakelite and gas-gaps for dispatch to the three assembly sites at BARC, Ghent and CERN. The first lot of gas-gaps from KODEL, Korea is expected to arrive in BARC during Nov 2011.

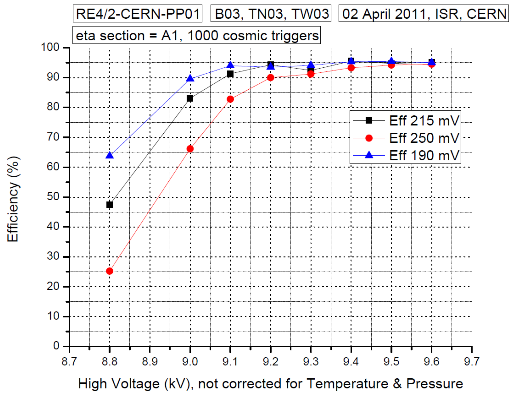

Fig. 3 Efficiency of the prototype RPC

In the Indian context, NPD-BARC along with Panjab University, Chandigarh are mandated to built and test the first 50 RPCs of type RE4/2, the production for which would soon start in NPD-BARC, as soon as the first set of gas-gaps arrive from Korea in November 2011. The test facility for entire assembly line for the RPCs already exists at NPD-BARC. Another assembly site at Panjab University, Chandigarh is also coming up and shall be soon functional in next couple of months. This apart, MDPDD-BARC has also to fabricate about 200 Cu cooling circuit for both the type of chambers (RE4/2 and RE4/3) for the upgrade project for which the first 10 sets are under assembly. These 10 sets are to be delivered by the end of this year at the respective assembly sites for configuring the RPCs. We would like to acknowledge the help provided by S. T. Sehgal, A. T. Chaudhari and T. P. Sabharwal in configuring the Cu cooling circuit before its dispatch to CERN and students from Panjab University and the entire RPC team at CERN for helping in validation of the prototype.

References

[1] Assembly, testing….
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