Fabrication of Cu cooling systems for CMS –RPCs

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Introduction :

The RPC upgrade project for the CMS experiment, CERN, Geneva is foreseen in the proposed LHC shutdown in 2013-2014. India along with Belgium and CERN are mandated to build the fourth end-cap with RPCs in order to increase the trigger efficiency. 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. With the experience gained with the installed RPCs in the end-cap, it was observed that the rise in temperature of RPCs, significantly altered its efficiency. In order to tackle this problem, the Cu cooling circuit for the FEBs mounted on the RPCs was redesigned and this improvement in the cooling system had to be introduced for RE4. 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 to be integrated with the prototype RPC to be built for the upgrade and its performance evaluation. Another 10 sets each for RE4/2 & RE4/3 have been fabricated and ready for dispatch. Further fabrications of 90 sets for each will are in progress and will be completed in due course within a year. The Cu cooling circuit is fabricated with (8 mm OD and 6 mm ID) and OF Cu sheets with 1 mm thickness. A schematic of a typical Cu cooling circuit for a RE4/2 type chamber is shown in Fig. 1, mounted with FEBs and clamped to aluminum panels and Sagana connectors at the two ends.

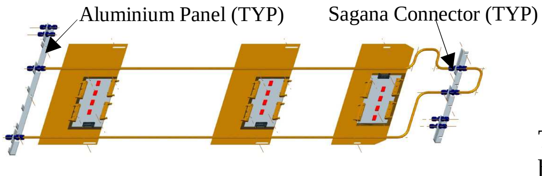

Fig. 1, Cu cooling circuit for a typical CMS-RPC

This paper explains the details and challenges faced in fabrication of this Cu cooling circuit for both the type of chambers (RE4/2 and RE4/3) for the upgrade project.

Methodology :

The copper cooling system consists of copper tubes, copper plates and aluminium brackets as well as connectors as shown in Fig. 1. The tubes have bends at required positions in horizontal as well as vertical planes. The tubes are joined with the plates, which in turn are in touch with RPC body. The heat generated in the body will dissipate through plates to chilled water flowing through pipes. The pipes are bent in horizontal plane to give space to various parts fixed on the RPC body as well as to provide certain flexibility to accommodate little variation in dimensions along the length during fabrication. At the ends the pipes are bent to provide 6mm lift in the vertical direction to match with the connectors. The pipes are made of half hard copper, hence the bent radius and bending procedure was qualified to achieve crack free bending. It was observed that smaller bending radii and / or fast operation of bending leads to cracks as shown in Fig. 2.

Fig. 2, DP Test showing cracked line on tube

To achieve maximum thermal conductivity between plates and pipes, maximum possible area and thermal conductivity of the joining material is required. A typical joint is shown in Fig 3.

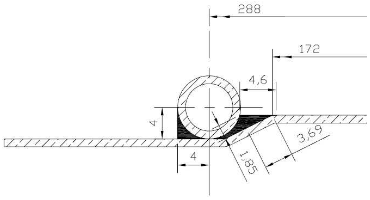

Fig. 3, A typical soldering joint detail

On account of high thermal conductivity of copper plate brazing or soldering were two preferred options of joining plates with pipes. Small thicknesses of plates were another bottleneck to avoid distortion of plates during joining. After detail study of various soldering and brazing materials it was observed that copper based brazing materials and silver based soldering materials are two commercially available probable options of joining the plates and tubes. At first the copper-silver brazing alloy was used to join the pipe with plates with proper clamping and preheating. The joints so obtained were reasonable good but the plated were found to be severely distorted. Few more trials were also observed but distortion could not be reduced to the acceptable range.

Hence the option of brazing was discarded and option of low temperature soldering was tried. Lead free silver based solders (Sn97) as well as silver based lead tin solder (Sn62) were used and various trials were done. Both the trials were successful and the joint so achieved were found acceptable as shown in Fig. 4.

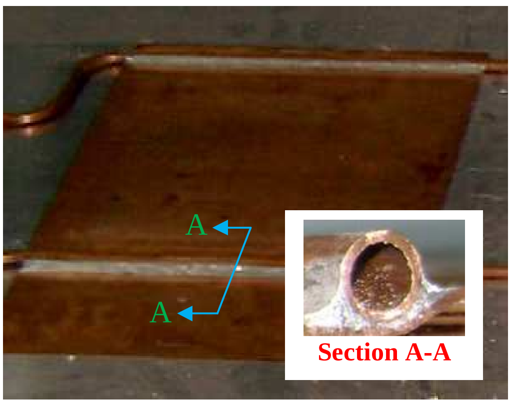

Fig. 4, Cooling ring after successful soldering

The distortions in the plates were very little and were within acceptable range. The options of lead free solder was not considered at present due to availability of sufficient long term data of this material and relatively high liquidus and solidus temperatures.

Fig. 5 shows a typical Cu cooling system after being fabricated under leak test with 20 bar pressure of Argon gas. Fig. 6 shows the leak rate of Cu cooling circuit at 20 bar of Argon gas pressure, measured for half an hour. The red dots show the room temperature, while the leak was being measured. The leak rate as shown in Fig. 7 is fairly acceptable. Each of the fabricated Cu cooling systems have to be leak tested in a similar way and uploaded into the data base, before dispatch to CERN.

Fig. 5, Cu cooling circuit after fabrication under leak test with 20 bar pressure of Argon gas

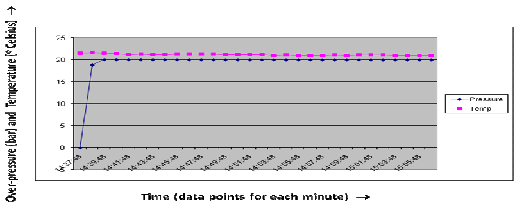

Fig. 6, Leak rate of Cu cooling circuit at 20 bar of Argon gas pressure

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