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Design and manufacturing of complex shaped service interface panel with sheet moulding compound -process

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Tracker barrel with 2S-modules (TB2S) is one of the sub-detectors of the upcoming CMS Phase-2 Tracker. It is composed of 368 ladder frames arranged in a cylindrical pattern, which each house 12 silicon sensor modules. The ladder frames are assembled in a precision gluing jig, where aluminium inserts eventually supporting the modules are glued into a surrounding frame cut and glued from carbon fiber profile. The services for the modules –electrical wires, optical fibers and the cooling piping –are routed longitudinally along the ladder frame reaching to each module. These services need to be grouped and routed towards their exits in a neat arrangement towards the outer end of each ladder, which requires a designated service interface panel in the front of the ladder. This front panel needs to provide mounting positions for the adapter of the optical naked-fanout, soldering sleeves of the cooling pipes, pre-heater connectors, and to provide a strain relief for the electrical octopus going through the front panel towards the periphery of the detector.

The physical size of the naked-fanout -adapter alone forces the front panel design to deviate from the standard C-profile basis used elsewhere in the ladder frame. Instead, a fully custom geometry had to be designed to satisfy the specific support requirements and tight space envelopes while maintaining its structural rigidity contribution to the ladder frame. To realize the resulting complex geometry from carbon fiber with feasible serial production capabilities, sheet moulding compound (SMC) -process was identified as a potential manufacturing method to be utilized. In SMC, a sheet-formed raw material blank of resin and chopped fibers is simultaneously compressed and heated in a mould, resulting the material flowing and filling up the mould cavity.

To make a prototype series utilizing this method, a mould was designed, and some temporary support features were added to the design of the moulded part. The complex shape of the mould was machined from aluminium with combination of milling and EDM-wire cutting. The mould was made from individually separatable sections to ease the demoulding of the finished part. A designated afterworks jig was built for the removal of temporary features and finishing of the moulded part.

The functionality of the front panel design was proven with mock-up studies and finally in a full-scale service fitting with a real ladder prototype. The basic structure was found to be practical, only some minor improvements were proposed to the strain relief of the electrical octopus and fixing of the pre-heater connectors. The SMC-process was successfully utilized in prototyping, and it was proven to be suitable for the front panel's use-case. During the prototyping the process parameters and procedures were tweaked, and some improvements to the mould design were identified.

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