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Nitrogen Flushing Efficiency in the ITk Outer Pixels of the Upgraded ATLAS Detector: A Steady-State Computational Fluid Dynamics Study

The ATLAS inner tracker (ITK) proposed for the upgrade is divided into the strips, outer pixels and inner pixels, each with its own complexities and inbuilt systems. The outer pixel is sandwiched between the strips and the inner pixel. It is flushed with N_2 from the inlet to the outlet to maintain the dryness of the outer pixels. However, specific temperature, humidity and dew point temperature distributions must be maintained to keep the outer pixels always dry. Computational Fluid Dynamics (CFD) has been used to provide engineering insights into upgrading the ITK. For the efficient performance of the ITK, specific positions where sensors must be placed should be carefully considered. These positions should remain dry, maintaining an average dew point distribution of -60 ℃. Therefore, to provide insight into the environmental conditions of the outer pixels, a CFD model has been developed. The CFD method was employed alongside the equations for the conservation of mass, momentum, energy and species. Due to the high flow rates, turbulent flow was assumed for all simulations. The Reynolds-averaged Navier-Stokes (RANS) equations were utilized and discretized using the finite volume method. For turbulence modelling in the enclosed domain, the standard ⊠-ϵ model with standard wall functions was applied. The temperature distribution, humidity and dew point temperature distribution of N_2 flushing in the outer pixels were predicted. The results showed that the temperature distribution ranges from 25 ℃ in regions with temperature boundary conditions to -20 ℃ in the inner structure of the outer pixel. The humidity in the outer pixels was 2.3 %, while the dew point had a maximum of -60 ℃ and a minimum of -80℃, except in areas with room temperature (25 ℃) boundary conditions. The results indicate that at the obtained dew point value, condensation in the outer pixel will not occur. Hence, the outer pixel will remain dry, validating the experimentally required specifications

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