Development of a CO_2 cooling prototype for the CBM Silicon Tracking System*

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Nowadays the high energy physics detectors require ever more powerful cooling plants as well as a non-invasive piping. This means that the mass budget has to be as small as possible in order to not decrease the efficiency of the detector effective surface. We report on the development of a bi-phase CO_2 test cooling system, called TRACI-XL, that is based on the "2 phase accumulator controlled loop (2PACL)" concept and is carried out at GSI within the EU-FP7 project CRISP in cooperation with experts of the DT group at CERN, and the CBM group at Eberhard Karls University, Tübingen. TRACI-XL is the 1 kW prototype that will be used as a pre-plant design for the cooling of electronics in the CBM Silicon Tracking System STS. A design study of the system is depicted in Fig. 1.

Figure 1: A CATIA model of TRACI-XL.

Concept definition stage

Several fields of engineering have been addressed for the realization of this phase of the prototype design. Different areas as thermodynamics and its study of nucleate boiling, had to be carefully considered. Due to the complexity of this type of evaporative process only the experimental findings can provide more information for the design of the final plant to be installed in the CBM experiment.

Technical documentation like PID diagrams have been developed to be as clear as possible and being similar to some of the screens that were subsequently used in the HMI (Human Machine Interface) thus making TRACI-XL a user-friendly prototype in which a malfunction can quickly be detected. Considering it as one of the most important parts of the system, the secondary CO_2 line has been designed as rigorously as possible, taking into account the possibility of future upgrades to the plant, providing extra flexibility to implement in the future other functionality such as electrical valves to be fully controlled by PLCs. All this is achieved through the choice of high performance Swagelok VCR fittings with high life cycle where subsequently modules may include new parts.

Development of control electronics

The STS cooling system has to provide necessary cooling power for the front-end electronics at a given thermal load. For this reason, process variables have to be monitored and maintained at their desired values by communicating to the devices in the cooling plant, e.g., heaters, pumps, indicators, etc. The task is automated using Siemens modular programmable logic controllers (PLC). The PLC functionality includes sensor monitoring, device control, data logging and archiving. The system is controlled via a touch panel Human-Machine Interface (HMI). The software framework STEP 7 v11 (TIA Portal) communicates to the PLCs via PROFINET protocol, thus providing a compact automated solution for the TRACI-XL project. Figure 2 shows a test system including the PLC controller with sensor-specific modules (resistance temperature detector, thermocouple, analog input for pressure transmitter readout, etc.) Analog values and digital indicators are displayed on the touch panel.

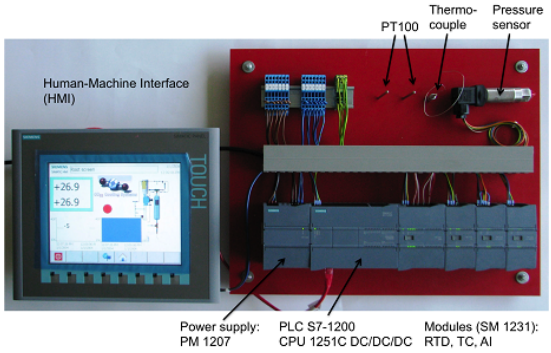

Figure 2: PLC-based test system with analog sensors and touch panel control.

References

[1] Verlaat, B., International Conference of Refrigeration 2007, Beijing, China, ICR07-B2-1565

[2] Proposed correlation data for isothermal two-phase two-component flow in pipes. R. W. Lockhart, R. C. Martinelli, Chem. Eng. Progr., Vol. 45 (1949), pg 39-45.

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