P.1: Development of programmable standalone controller for bakeout & activation of hybrid UHV pump

Non-evaporable getter (NEG) coating technology for vacuum chambers was developed in UHV Technology Section for its application in vacuum systems of particle accelerator and storage ring. Ti-Zr-V NEG coating is a novel room temperature capture pump for achieving very low pressure down to extreme high vacuum (< 10^{-11} mbar). The primary advantage of Ti–Zr–V NEG thin-film coating is its passive pumping action, requiring no electrical power during operation once activated. NEG coating on Aluminium chamber can be fully activated by heating up to 180°C for around 24 hours. It pumps active gases (H_2O, CO, CO_2) by chemisorption and H_2 by diffusion. However, it is ineffective for pumping methane (CH_4) and inert gases. Combination of NEG and SIP, henceforth called hybrid pump overcomes this & deliver high pumping performance in an extremely compact design. Triode type SIP effectively pumps CH_4 and inert gases. Thus, the hybrid NEG+SIP configuration provides comprehensive gas species coverage required for accelerator-grade UHV systems. These hybrid pumps are highly reliable, long lasting and state of art UHV pumping solution for next generation synchrotron radiation sources and LIGO projects.

A prototype standalone compact single-channel heating controller, operable without the need for a PC, has been designed and developed for bakeout and activation of this hybrid pump (shown in Fig. P.1.1).

Fig. P.1.1: Photograph of the controller

The controller features an LCD & keyboard interface. Temperature monitoring is carried out using a K-type thermocouple sensor. Up to 1 kW heater control is achieved using an SSR in ON/OFF mode. The typical baking and activation cycle consists of five stages: RAMP-UP-1 to 100 °C, DWELL-1 for 24 hours, RAMP-UP-2 to 180 °C, DWELL-2 for 24 hours (NEG activation), and finally RAMP-DOWN to room temperature with controlled cooling.

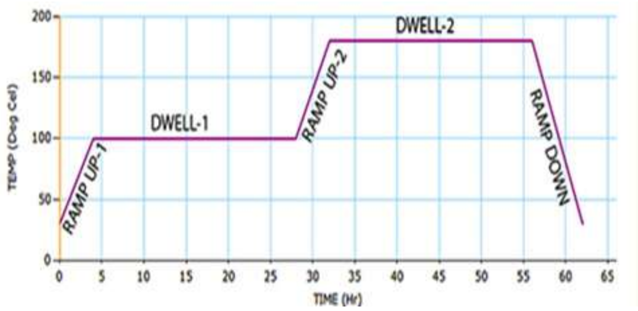

Fig. P.1.2: Typical cycle showing all states

The user can configure the controller for either single ramp or dual ramp and thus increasing its further scope of use.

The ATmega328 controller was used for overall control & supervision of the process. The thermocouple is interfaced with controller using MAX31855 ADC. This converter resolves temperatures to 0.25°C, and exhibits thermocouple accuracy of ±2°C, over the specified operating range of the K-type thermocouple.

The user can configure various settings like the dwell-temperatures, dwell times, slope, etc. Key features of the controller include:

1. Single button cycle start using pre-configured parameters stored in EEPROM.
2. Configurable hold state, allowing coordination with another connected system bakeout cycles to prevent premature NEG activation.
3. Automatic detection of open or reversed thermocouples, pausing the heating cycle until corrected.
4. Controlled set-point ramping that limits temperature to the user-defined slope, with dynamic cycle-time adjustment using the current temperature as the starting set-point to minimize total cycle time.
5. Power-failure recovery capability, wherein the cycle resumes from the last state upon restart, using the current temperature as the new initial set-point.

Various baking & activation cycles were conducted using this standalone controller. Further observation & upgradation are under process to enhance robustness and multi-channel capability.

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