Temperature Measurement and Water Flow Calorimetry for the Neutral Beam Test Stand Operation at KAERI

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1. Introduction

Temperature measurements during the beam line operation of the neutral beam test stand(NB-TS) is very important for the estimation of the absorbed energy by the beam line components such calorimeter and also for the temperature monitoring of the various components, and have been accomplished by the utilization of many of the thermocouples(TCs) installed onto the NB-TS and the data acquisition system(DAQ) based on the National Instruments'(NI) SCXI system[1]. Preliminary estimations of the absorbed energy by the calorimeter during the beam extraction have been made. Greater efforts for the noise reduction in the TC signal acquisition has been made with partial success. We present the status of the temperature measurement and water flow calorimetry(WFC) related to the NB-TS operations.

2. Status of the Temperature measurement and calorimetry

Most of the temperature measurement needs for the NB-TS have been met through the utilization of TCs installed at various locations of the NB beam line. Many of the TCs(mostly K type) were installed onto the ion source, optical multichannel analyzer(OMA), neutralizer, bending magnet, ion dump, and the calorimeter[Figure 1]. Signal readings from TCs were achieved through the utilization of the National Instruments'(NI) SCXI-1102 on the DC potential region and then sent to the control room where PXI-8176 processed the signals. A LabView program under the settings of the MAX(measurement and automation explorer) program of NI processed the signals for the data treatment.

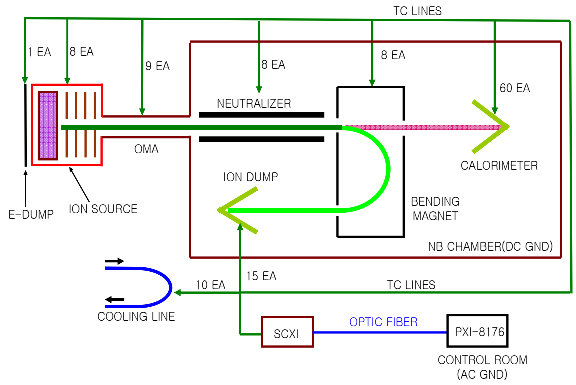

Figure 1. Thermocouples and the instrumentation installed onto the beam line components of the NB-TS.

The following relationship holds for water flow calorimetry(WFC) for the beam line components such as calorimeter:

$$Q = mc\int_{0}^{\infty}\Delta T(t)dt \quad (1)$$

where Q is the absorbed energy(cal), m is the mass flow rate(l/sec), c is the specific heat(1 cal/g℃), $\Delta T(t)$ is the temperature difference between the inlet and outlet of the coolant flow, and dt is the time increment. Presently, the estimation works of the absorbed energy during the beam extraction experiments are under way using the above relationship. A typical example of the WFC for beam power of 5.3 MJ (Shot# 7026; 97 kV/ 22.2 A, 3 sec) was:

-OMA Scraper: 0.55MJ(10.3%)
-Neutralizer: 0.44MJ(8.3%)
-Bending Magnet Scraper: 0.23MJ(4.3%)
-Calorimeter: 3.9 MJ(73.6 %)
-Other components: 0.18MJ(3.5%).

3. Noise reduction in the temperature measurements

Noise intrusion of the temperature measurement has been a great obstacle for the exact estimation in the WFC. Partial replacements of the TCs from the grounded types to the ungrounded ones have greatly reduced the noise intrusion to the final acquired data.

Cooing channels of the ion source are divided to two compartments for each of the four electrodes, e.g. plasma grid(G1), gradient grid(G2), deceleration grid(G3) and extraction grid(G4). Onto outlet of each of the compartment a TC was installed. Initially, enormous noise levels were detected when we attempted to measure the temperatures with the grounded type TCs and later on with the ungrounded ones. Final trial was the adoption of NI's USB-9211A Portable USB-Based DAQ, which can be field-operated with a portable computer powered by the batteries and include $250V_{rms}$ channel-to-earth ground isolation. Through the adoption of this instrument, TC signals from ion source electrodes during the beam extraction could have been satisfactorily measured with greater noise immunity[Figure 2]. Preliminary estimation of the grid heat load over the total extraction energy for Figure 2 has been found to be as follows:

- Grid 1 : 2.0 %
- Grid 2 : 0.43 %
- Grid 3 : 0.11 %
- Grid 4 : 0.47 %

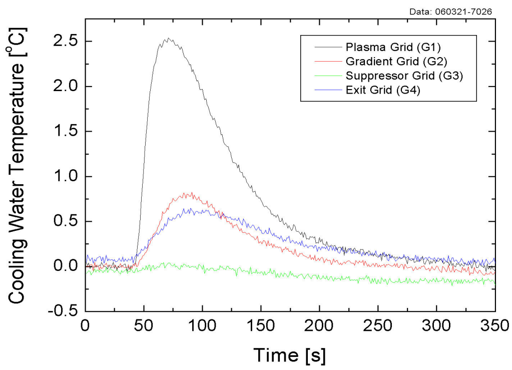

Figure 2. Cooling water temperature with time in accelerator grids for ion beam of 97kV/22.2A, 3 seconds(5.3 MJ; Shot # 7026).

4. Conclusion

Temperature measurement needs of the neutral beam test facility have been met through the adoption of many of the thermocouples and NI's SCXI system. Many of the TCs(mostly K type) were installed onto the ion source, OMA, neutralizer, bending magnet, ion dump, and the calorimeter. Major difficulties of the temperature measurements have been the noise introduction from the operation of the ion source. Some of the noise levels have been greatly reduced by adoption of the ungrounded type TCs. However, noise levels of the TC signal from the ion source electrodes were not reduced even with the ungrounded type TCs. Satisfactory noise immunity for the TC signal coming from the ion source electrodes were attained when we adopted NI's USB-9211A Portable USB-Based DAQ; further incorporation of this portable system to the main DAQ at the control room should have to be made in the near future.

REFERENCES

[1] Ki Sok Jung and Byung Hoon Oh, "Development of Optical Signal Transmission for the KSTAR Project Pertaining to Instrumentation and Control of the Neutral Beam Test Stand at KAERI", KIEE International Transactions on Electrical Machinery and Energy Conversion Systems, Vol. 5-B, No. 3, pp. 289-295, 2005.