§19. Operation of N-NBI System during the LHD Experimental Cycle

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In order to achieve a high injection power (up to 5.2MW) and long pulse duration (up to 80s) of NBI system in the 4th experimental cycle, an elaboration in diagnosis and monitor has been needed through the NBI-operation, concerning ion sources, beam line components, armor plates in LHD, and utilities (i.e., power supplies, cryopump system, water cooling system etc) [1]. Although limiting device for the performance is considered to be high current negative ion source, beam blocking caused by re-ionized ions (such as observed on PLT) had been a concern. The life time of the ion source filament and a leak detection of small water vapor in negative ion source was studied, as those facts meant/caused to poison Cs by air or by an even small amount of water vapor sensitively.

The temperature rise of thermo-couple of the protection plates of the injection port in Beam-Line-2 increased with increasing gas pressure at the port. On the other hand, thermo-couple at the opposite side horizontally did not change with the pressure. Those result to direct observation of the heat load caused by re-ionized ions [1]. The corresponding power loss was estimated to be approximately 2-10% with the typical gas line density. This was considered to be an acceptably small loss of power. However, it led to a temperature rise of the Mo plate of about 300 ℃ at the end of the 80s injection pulse. The temporal gas pressure increment for long-pulse injection corresponded to out-gassing from the heated plates by re-ionized ions. This was effective in conditioning the duct.

Filament had to be renewed during even one LHD-experimental cycle. It is observed that filament weight loss is distributed within the filament location of the ion source (Fig.1). Filament located in the central space of the plasma source shows a high weight loss, i.e., shorter filament life time. Filament life time differed between the ion sources.

As high pumping speed cryopumps are applied in NBI system, the detection of water vapor with Q-mass analyzer was not sensitive. When QMA was equipped only in the ion source vacuum vessel, we could observe small amount of leak of water vapor (Fig.2) in trouble of ion source. Production efficiency of hydrogen negative ions was almost lost by this small amount of water vapor [2]. One QMA had been attached in the ion source vacuum vessel for sensing ion source and second QMA in the beam dump vacuum vessel for sensing major beam line components and the injection port.

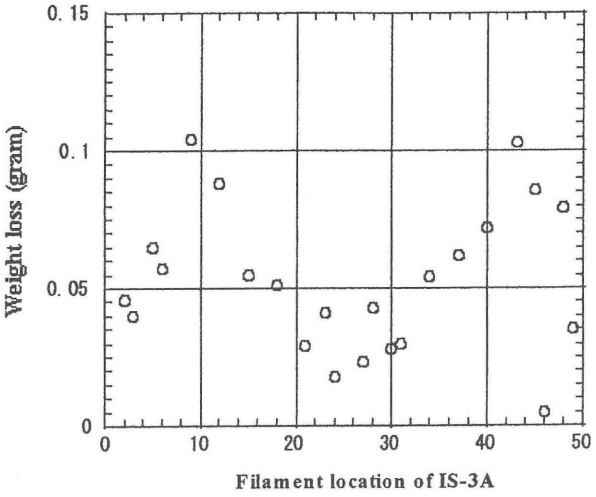

Fig.1 Weight loss distribution of tungsten filamenst in LHD-NBI negative ion source of IS-3A used in one cycle.

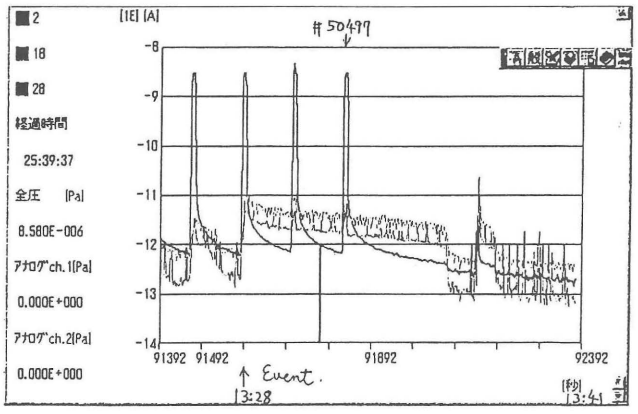

Fig.2 Time trend of Q-mass analyzer in the ion source vacuum vessel of LHD-Neutral Beam Line. Partial pressure (in log-linear scale) of water vapor in trouble of the ion source is detected under beam operation

References:
(1) Y.Oka et al., to be published in Proc. of 21st SOFT, Madrid.
(2) Y.I. Belchenko et al, Rev. Sci.Instrum. vol.71,p.741(2000).