Neutral particle control during the KSTAR 1st experimental campaign

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1. Introduction

The control of the neutral particle including the impurity is one of the important factors in obtaining the reliable tokamak startup operation. It is closely related with in-vessel wall condition as well as the external gas puff. Two different discharge conditioning methods were used in KSTAR(Korea Superconducting Tokamak Advanced Research). The GDC(Glow Discharge Cleaning) was routinely conducted and ICRF-DC(Ion Cyclotron Range of Frequency-Discharge Cleaning) was conducted between the tokamak shots. KSTAR is also equipped with the baking system which heats the vessel by supplying hot water between the double wall and the maximum temperature is limited by 100 ℃. In this paper, the experimental data of gas puff and the impurities during the KSTAR 1st experimental campaign are reviewed in terms of neutral particle control.

2. Discharge cleaning

The wall conditioning is conducted over night with RF assisted GDC and number of GDC electrode is two. The nominal current and voltage is 300 V and 5 A respectively. Firstly, the hydrogen gas is used and then the helium is used for removing hydrogen gas adsorbed in the vessel. During hydrogen discharge, partial pressure of oxygen(m/e=16), water(m/e=18), CO(m/e=28) is slightly increased. The base pressure of the vessel reached about $4.8*10^{-7}$ mbar after strong GDC for 3 weeks. GDC is also conducted for the tokamak shot during over-night[1].

ICRF-DC was conducted between the tokamak shot because it can be used in permanent toroidal magnetic field. We could control the neutral particle density. After shot went on over 1000 shots, it seemed that the tokamak startup was very reliable without ICRF-DC.

2. Gas puff and the behaviour of adsorbed hydrogen on the vessel

During the 1st campaign, the fuel gas was controlled by the gas puff valve and the response time was about 50 msec. During several days after KSTAR first plasma, the tokamak shot was not reliable. It was very difficult to get over the plasma current of 10 kA around 40 msec from the blip and also very hard to get more than three successive shots. The successful shot means achievements of 100 kA. However, the recipe suggested by Dr. Muller from PPPL stabilized the discharge with injection of small gas puff around 40 msec and we could increase the success probability of the shot afterward. This recipe of the gas puff was applied only for dipole mode.

During the 1st experimental campaign of KSTAR, TF(Toroidal Field) field was limited to 1.5 T so that 2nd harmonic ECH was used for the startup rather than fundamental ECH[2]. Gyrotron was being conditioned and the maximum rf power was limited by 400 kW. So the ECH power is very marginal for the reliable startup by using 2nd harmonic ECH(Electron Cyclotron Heating) and the operating windows of the timing and pressure are also very narrow. The breakdown (we define the breakdown time as the rising of H-alpha signal) started within 20 msec after injection of ECH power and it started earlier as the filling pressure was increased. But it depended on gas puff condition. The pressure dependence on the breakdown time was only obeyed with the same gas puff condition.

In addition, the operating window of the pressure was very narrow and the nominal operational range was 3.5-3.8 mbar with fixed gas puff condition, A few successful shot were obtained around 5 mbar range but we used different pre-filling conditions. The shot is successful only if the breakdown time is located between -20 and 0 msec before the ohmic startup. So the shot is controlled by analyzing the previous shot and adjusting the gas puff quantity. Though many cases were successfully controlled, it is necessary to analyze the unsuccessful controlling cases for the successful startup of the next campaign.

Another interesting point is that the operating pressure is moved to the higher pressure range as the shots going on as shown in Figure 1. The reference is about shot number of 940. It is around the boundary between the conventional and dipole mode of tokamak start-up configuration.

The hydrogen was adsorbed in the vessel during the shot and it desorbed after the shot. This was also observed by the gas pressure gauge and RGA(Residual Gas Analyzer). The success shot shows highly rising of the partial pressure of hydrogen than the failed shot.

3. Deposited impurity on the ICRF antenna and poloidal limiters

After experimental campaign, it was observed that there were many deposited areas around the antenna and the poloidal limiter. It was found that it was likely tokamakium rather than the sputtered deposited layer from the antenna via EPMA(Electron Probe Micro Analysis) analysis on the deposited layer. The composition of deposited layer on the poloidal limiter was nearly the same as that on the inboard limier.

GDC anode and ECH mirror were also coated with unknown materials, however, the quantity is too low to analyze.

4. Summary

During the 1st experimental campaign, the control of the neutral particle was performed by using GDC and ICRF-DC to get the reliable start-up. It seems that the discharge-cleaning may contribute to the success of start-up. The further studied on the random start-up and narrow pressure window of pre-filing gas condition should be conducted in the next campaign.

References

1. Y.S. Bae et al., Nuclear Fusion, 49(2009)022001

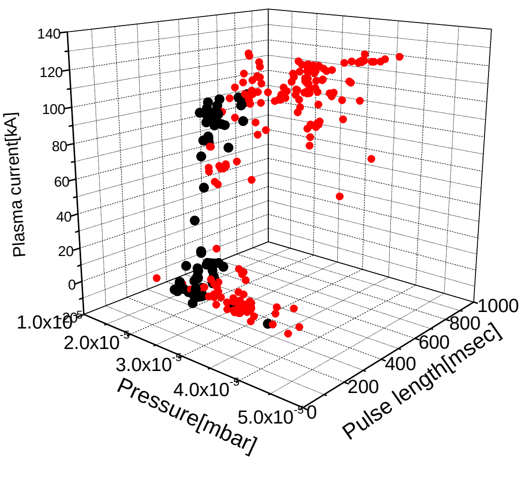

Fig.1. Pre-filling pressure change during the KSTAR 1st experimental campaign (black: before #940, red : after #940)