Contribution ID: **56** Type: **not specified**

NEUTRAL BEAM INJECTOR –A POPULAR HEATING AND CURRENT DRIVE SYSTEM FOR FUSION

The neutral beam injector (NBI) is one of the most successful and popular auxiliary heating and current drive systems for fusion devices. The popularity increases after the discovery of H-mode or high-confinement mode of plasma in ASDEX tokamak due to intense heating of the tokamak plasma by its NBIs [F. Wagner et.al., PRL49, pp. 1409 - 1412 (1982)]. This H-mode breakthrough gave a big boost to the usefulness of NBI to heat the fusion plasma in a fusion reactor to achieve the desired Lawson criteria, and gave great hope to the possibility of energy extraction in a laboratory through fusion reaction. The NBI delivers high-energy neutral particles (like hydrogen atoms) into the fusion reactor (e.g. tokamak) that can penetrate the strong (˜ a few T) magnetic field, become ionized inside the plasma, and then transfer their vast kinetic energy through collisions with plasma ions and electrons. As a result, raises the core temperature to fusion-relevant levels (Lawson Criteria). Tangentially injected NBI also provides current drive and helps plasma rotation in the torus of a tokamak for steady-state operation through momentum transfer. The majority of NBIs are based on positive ion source technology with the gas-based neutralizer (PNBI). Their beam energies are restricted to ˜ 100keV per nucleon. For larger fusion machines (like ITER, LHD, JT60U), NBIs with beam energy > 100 keV per nucleon are required to provide sufficient penetration depth in the fusion plasma to heat the core. Because the neutralization efficiency of positive hydrogen ions in the conventional gas-based neutralizer is significantly low at energies above 100 keV per nucleon, these NBIs are based on negative ion source technology (NNBI). However, NNBI has some critical technical issues, and those need to be addressed for efficient long-pulse operation. The challenges are mainly from power efficiency, negative ion yield, Caesium (Cs) catalyst dynamics, neutralization efficiency, thermal and neutron-induced damage perspectives. The talk will give an overview of the NBI system and some of its technical issues, highlighting contributions of IPR in this field.

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