

A CONTINUOUS CRYOGENIC DIFFUSION PUMP FOR FUSION REACTORS

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A pumping system designed to pump magnetic fusion reactors has been operated pumping deuterium, hydrogen and hydrogen- helium mixtures. A 500 mm bore liquid helium cooled “snail” cryocondensation pump was used to pump the hydrogen species. The snail pump is equipped with a unique regeneration head which continuously removes the hydrogen ice from the cryocondensation surfaces while the pump is in operation. The hydrogen ice is evaporated inside the snail head and pumped with a 500 m³/h roots blower. The snail cryopump is attached to a 500mm bore x 3m long liquid nitrogen cooled entrance duct. The “cold duct” provides several important functions of the pumping system, it: 1) provides the conduit between the diverter and the cryopump, 2) pre-cools the gases allowing the elimination of a restrictive entrance baffle, 3) reduces the molecular mean free path allowing the duct to operate in the fluid flow regime. The fluid flow regime increases conductance and allows compression of the helium stream by diffusive drag. With the large compression of the helium, it can be pumped with a conventional turbomolecular pump. The cryopump effectively strips the hydrogen species from the helium stream before it enters the turbomolecular pump. The pumping system thereby separates the hydrogen and helium streams.

Mass flow controllers were used to inject the hydrogen (deuterium) and helium into a standard AVS test dome fitted with a capacitance manometer. Pure hydrogen was pumped at flow rates from 1.7 to 67.4 Pam³/s (the limit of the flow system) with the test dome pressure varying from 0.1 to 0.52 Pa, the effective pumping speed varied from 17 to 129 m³/s which is in good agreement with Poiseuille flow. Deuterium was pumped at rates up to 33.6 Pam³/s, at 0.39 Pa, pumping speed 86 m³/s. Pure helium was pumped to 0.32 Pa m³/s at .49 Pa, pumping speed 0.67 m³/s. Hydrogen with 1% helium was pumped to 32.7 Pa m³/s at 0.52 Pa, effective pumping speed of both species was 63m³/s. The helium compression varied from 31 up to 93 at the maximum flow. The flow was limited by the pumping capacity of the turbomolecular pumps.

The design of the pumping systems, the test results and comparisons to fluid flow theory will be presented.