PUMPING SPEED OFFERED BY ACTIVATED CARBON AT LIQUID HELIUM TEMPERATURE BY SORBENTS ADHERED TO INDIGENOUSLY DEVELOPED HYDROFORMED CRYOPANEL

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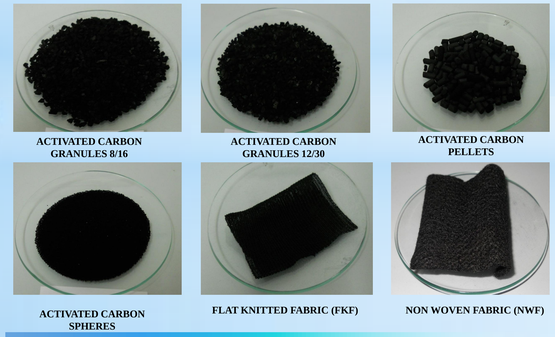
ABSTRACT

- Towards the aim of developing pump with large pumping speed of the order of 1 L/(s-cm2) or above for gases like hydrogen and helium through physical adsorption, development of activated carbon based sorbents like granules, flocked fibres, knitted and non-knitted cloth sphere was carried out.
- To investigate the pumping speed offered, a test facility SSCF (Small Scale Cryopump Facility) was set up. SSCF measures pumping speed as per international standards. Hydroformed cryopanel (an indigenous technology developed in India) of size ~500 mm x 100 mm were tested in SSCF.
- The system comprises a dome mounted with gauges, calibrated leak valve, gas analyser, sorbent adhered to cryopanel etc. The cryopanel was shielded by specially designed chevron baffles.
- Pumping speed measurements were carried out for gases like hydrogen, helium and argon at a constant panel temperature in the pressure range of 1E-7 to 1E- 4 mbar, and pumping speed was found to be in the range of 2000 L/s for a pressure range 1E-6 to 1E-4 mbar, and 4000 L/s for pressure range 1E-7 and below for a pumping surface area of ~1000 cm^2 thus giving an average pumping speed of about 2 L/(s-cm2).
- Using the Monte Carlo codes, SSCF was modelled and simulation studies performed. Parameters like sticking coefficient, capture coefficients affecting the pumping speed were studied.
- This presentation highlights the setup of SSCF, observed experimental results, simulation results from the code and briefly discuses the characterization of developed sorbents.

SELECTED ACTIVATED CARBON SAMPLES

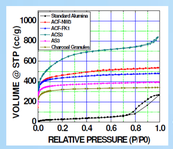


ACTIVATED CARBON GRANULES 8/16 | ACTIVATED CARBON GRANULES 12/30 | ACTIVATED CARBON PELLETS

ACTIVATED CARBON SPHERES | FLAT KNITTED FABRIC (FKF) | NON WOVEN FABRIC (NWF)

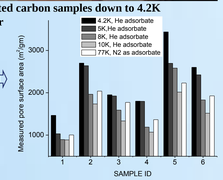
ADSORPTION STUDIES ON FADS

Experimental Facility for ADsorption Studies (FADS) of activated carbon samples down to 4.2K integrated with GM Cryocooler

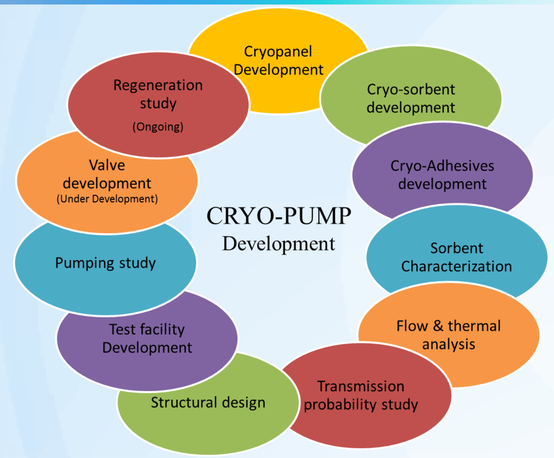


Studies carried out at FADS for the samples ID
1. Carbon Pellets,
2. Activated Carbon Spheres (ACS Type-3),
3. Activated Carbon Fiber-Non Woven (ACF-NW),
4. Srilankan Charcoal,
5. Activated Carbon Fiber Flat-Knitted (ACF-FK type-3)
6. ACS with adhesive coated on SS plate.

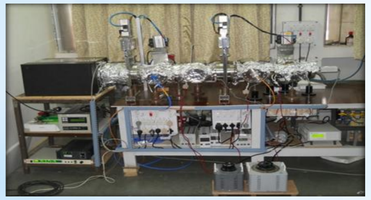
Adsorption isotherms of some activated carbon spheres, granules and cloths in comparison with standard alumina



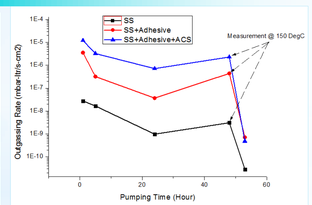
DIVERSE FIELDS INVOLVED



CHARACTERIZATION IN OGMS



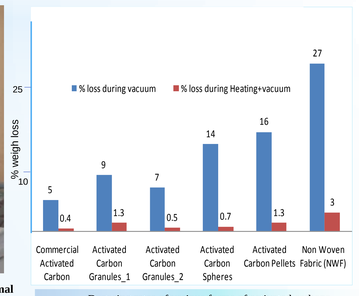
OutGassing Measurement System (OGMS) to measure thermal outgassing of different forms of activated carbons



Experimentally measured outgassing rate for Activated carbon spheres adhered to SS substrate

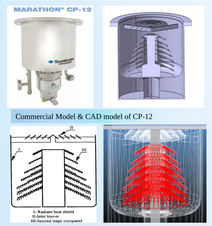
CHARACTERIZATION IN DGMS

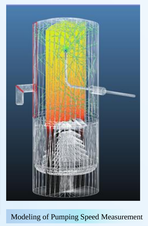
DeGassing Measurement System (DGMS) to measure thermal degassing of different forms of activated carbons



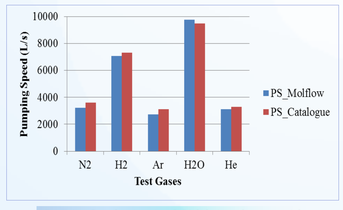
Degasing rates of various forms of activated carbons

ANALYSIS OF TRANSMISSION PROBABILITY



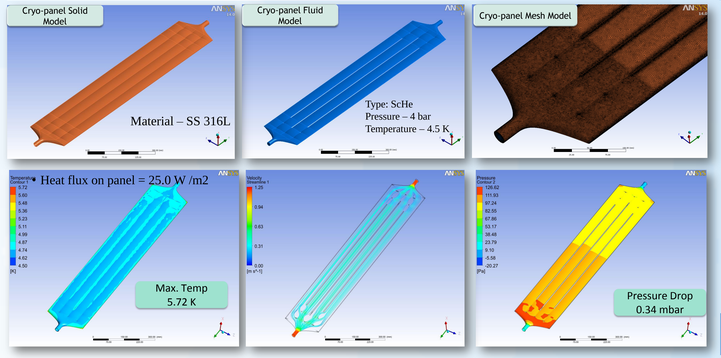


Modeling of Pumping Speed Measurement

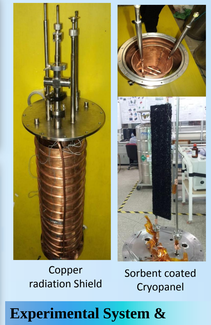


Pumping Speed estimation & Validation of commercial cryopump

CFD ANALYSIS FOR CRYO-PANELS

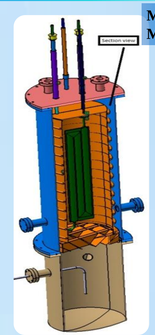


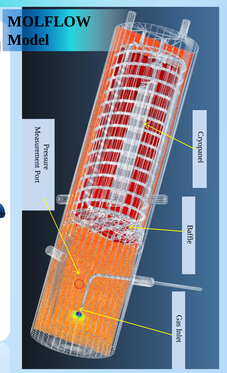
GEOMETRICAL DETAILS OF SSCF



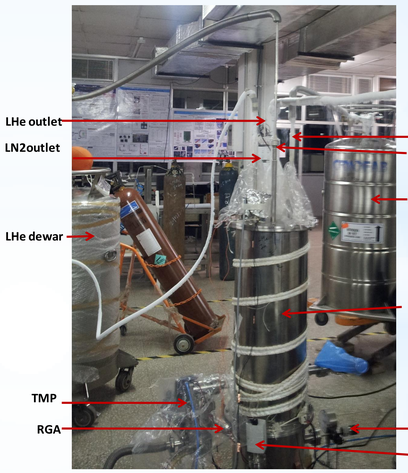
Copper radiation Shield | Sorbent coated Cryopanel

Experimental System & Components

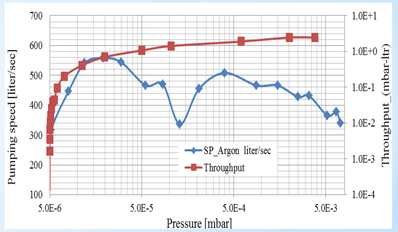




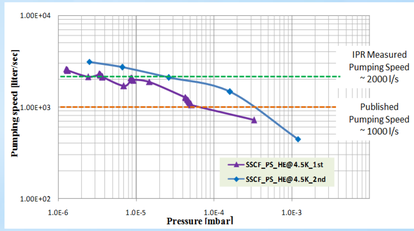
SMALL SCALE CRYO-PUMPING FACILITY (SSCF) & EXPERIMENTAL RESULTS



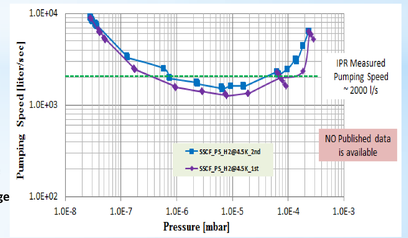
SSCF Experimental System



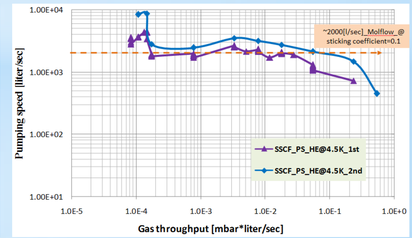
Argon Pumping speed over throughput and pressure@77K



Pumping speed Vs pressure for helium @ 4.5K

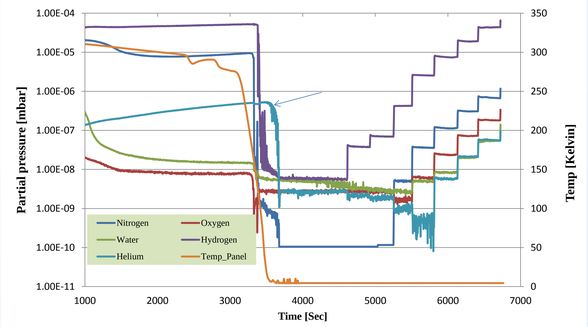


Pumping speed Vs pressure for hydrogen @ 4.5K



Estimation of helium and hydrogen sticking co-efficient

Partial pressure and temperature variation during experiments



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CONCLUSION: The development of SSCF involved characterizing the selected materials for operational requirements and drastic environmental conditions. The QA and QC of the materials was tested at the facilities FADS, OGMS, DGMS to qualify for vacuum and cryogenic environment. Simulation methodology for transmission probability analysis was established and tested on an experimental system with various geometrical configurations. The motive behind Small Scale Cryo-Pump (Pumping Speed 2000 l/s) was to check the pumping speed offered as per AVS standard, as a step towards quantifying with respect to standards. Finally, aimed to cover the physics and engineering validation arena to go ahead for Multi-panel Cryopump (MPCP-08) development.