Modeling of Recycler TSP port conductance

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In what follows we will briefly summarize the results of Monte-Carlo simulations performed by Jean-Francois Ostiguy in Dec. 2003 using a C port of the computer code MOLFLOW[1] by Roberto Kersevan, obtained from Cornell. Among other things, the code computes the transmission probability e.g. the probability for molecules emitted on one surface to be adsorbed on a different surface. This probability (which under ideal conditions, depends exclusively on the geometry) can then be used to compute the conductance for a particular type of molecule.

The code was first successfully validated by calculating the transmission probability and the conductance of a round pipe of finite length. The results were shown to be in excellent agreement with analytical predictions.

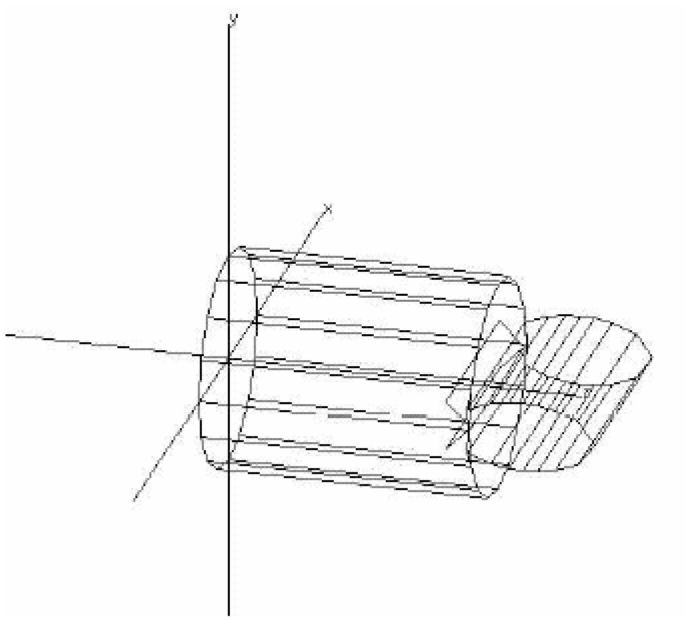


Figure 1. The TSP port geometry.

The 3-d geometry of the Recycler TSP port, used in these simulations (Figure 1), was entered from the mechanical drawings and approximated by polygons. There were two runs for the TSP geometry in Fig. 1. In all cases desorbtion was assumed to follow the Knudsen cosine law for angular distributions.

Run 1

Below are the conditions for the first run:

- the "entrance" port was first arbitrarily selected as the circular aperture on the left (see Fig. 1);

[1] MOLFLOW User's Guide, Sincrotrone Trieste internal note ST/M-91/17

- the “exit” ports are the apertures in the elliptical beam pipe;
- the sticking coefficient was set to 1 on all ports, 0 on all other surfaces;
- the ports were then reversed and the calculation repeated (to check the consistency).

The results were:
Total number of absorbed particles: 500091+499911=1000002

Particles adsorbed at the entrance ports (previously exit ports): 381008+381454=762462

Particles absorbed at the (circular) exit port: 237538

Transmission probability: $W_1 = 0.238$

The total surface of the two entrance ports is $A_1 = 72.88\ cm^2$ (3% lower than for the elliptical pipe because of the polygonal approximation).

$W \times A_1 = 0.238 \times 72.88 = 17.3\ cm^2$.

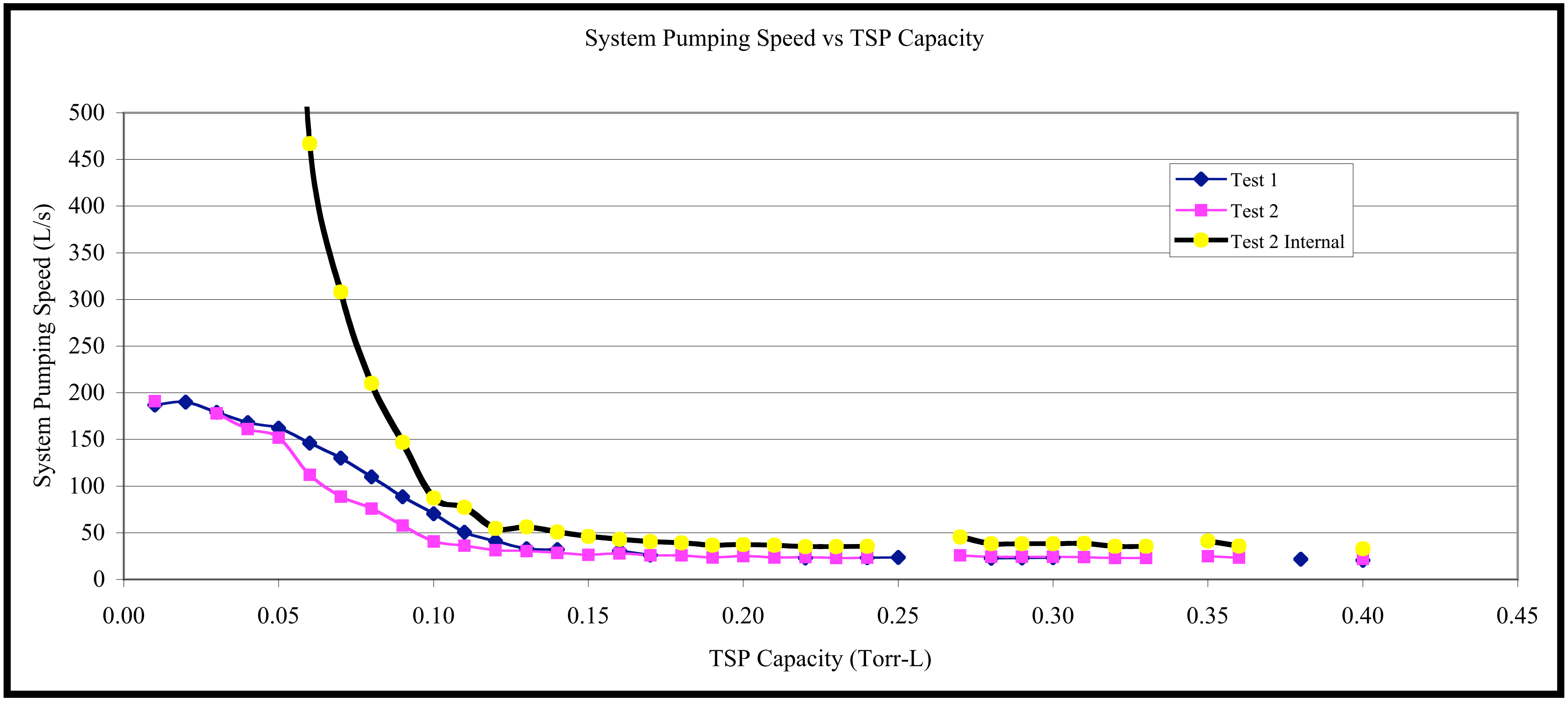
The conductance is then calculated as: $C_1 = sqrt(kT/(2\times\pi\times M)) \times W_1 \times A_1$

For N_2 at T=300K: C_1 = 119.2 [m/s] × 17.3 cm^2 = 206 L/s.

Run 2
To compare the simulation with measurements, one of the elliptical beampipe ports was blanked off with a flat surface (the sticking coefficient set 0). The circular (TSP can) port was used as an entrance port. Its area is $A_2 = 177.76\ cm^2$. With one output port blanked off, the calculated transmission probability, W_2, is 0.073. The resulting conductance is:

For N_2 at T=300K: C_2 = 119.2 [m/s] × 13.0 cm^2 = 155 L/s

Measured conductance
The measured conductance, with one port being blanked off, is **180 L/s** (see attached slide from Terry Anderson’s presentation) – an excellent agreement with calculations.



This plot shows the results of some tests that were done to determine the N_2 capacity of the Recycler TSP's. Nitrogen was introduced to the system with a freshly fired TSP and a 20 L/s ion pump. The nitrogen flow rate varied form a few E-6 to a few E-5 Torr-L/s. The black line is the internal pumping speed of the TSP and IP; the other lines are the system pumping speed of the test setup.