DESIGN OF THE MM GAS SYSTEM

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Outline

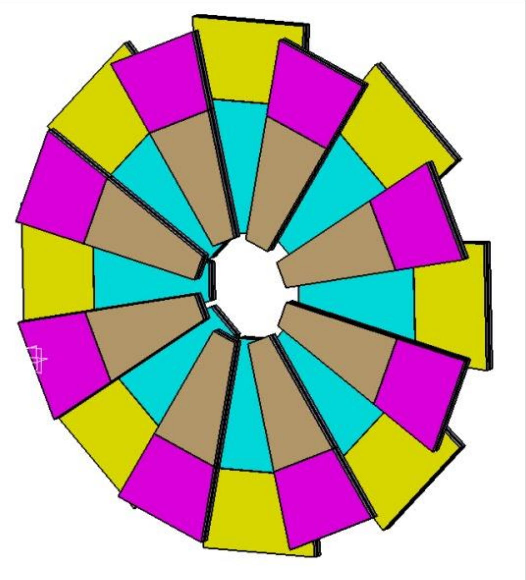
- The gas distribution and its desired specifications
- Relevant theoretical equations and definitions
- Simulation with “Pipe Flow”
- Simulation results and discussion
- Conclusions and Prospects

The main goal: is the required renewals

Calculation of the required gas flow

Flow rate of each MM MP with renewals r (which is our main goal): $Q_{MP} = \frac{rV_{MP}}{24}$ (in l/h)

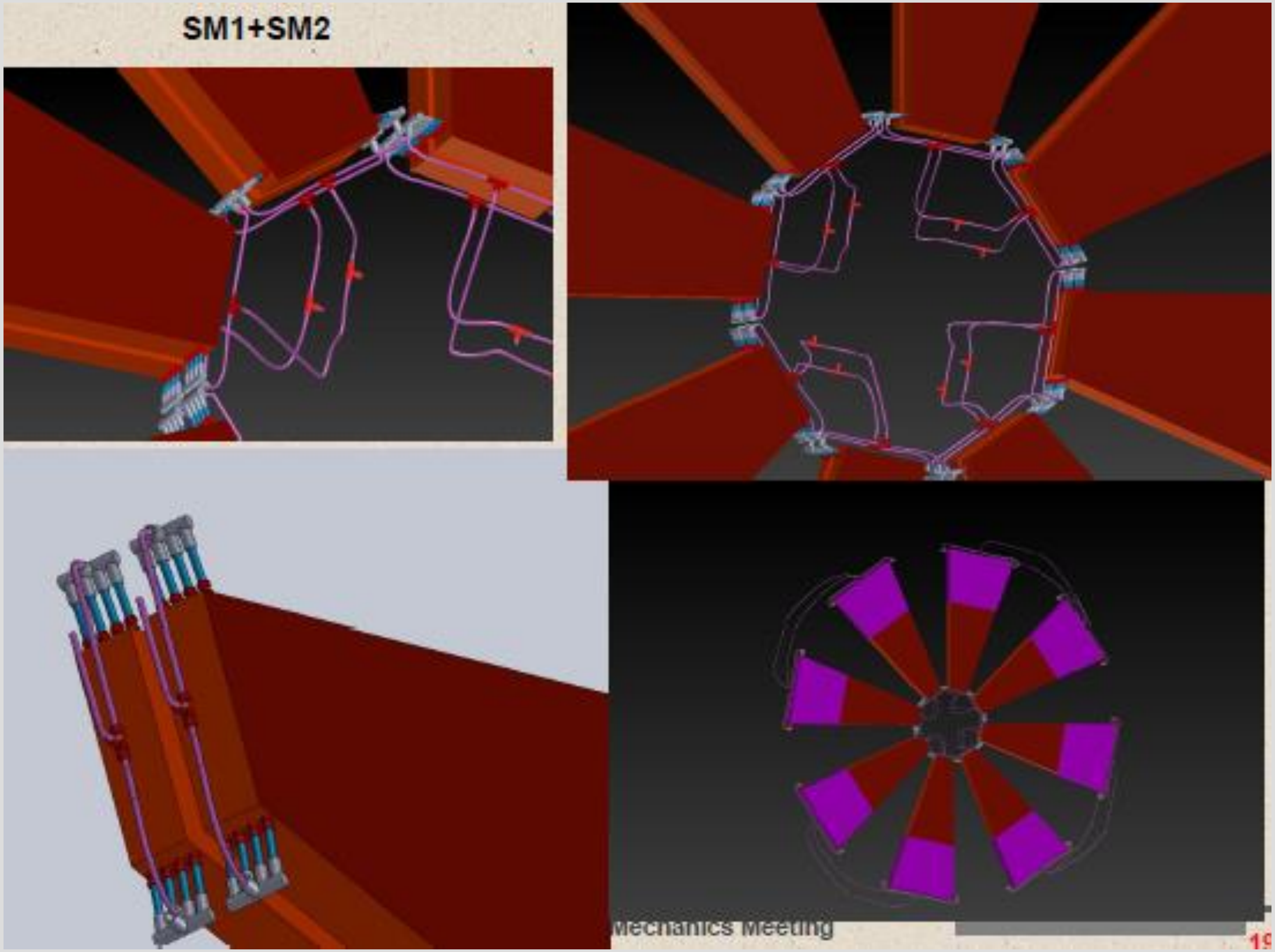
For the design we consider r=10 renewals per day



For each wheel:

16 sectors x 2 typeMM/sector x 8 planes/typeMM = 256 planes (MM types: LM1&2 or SM1&2)

3D representation of the gas distribution of NSW



Where we have to pay attention?

- **Uniform gas flow along the Multiplets**
- **As small as possible pressure in the detector planes (average pressure less than 2 mbar)**
- **Avoiding negative pressure values in the gas outlets (because of risk of O_2 insertion)**
- **Controllable pressure in the outlet points very close to 0. Thus, preferably, the gas return lines have to be connected to the outlets with lower variation of elevation (coming from inner circle of wedges).**

Fundamental equations from Fluid Mechanics

Bernoulli's equation

$$p_1 + \frac{1}{2}\rho\alpha_1\upsilon_1^2 + p_{z1} = p_2 + \frac{1}{2}\rho\alpha_2\upsilon_2^2 + p_{z2} + \Delta p_{visc-loss}$$

α_i is equal to1 for turbulence flow (uniform profile of the velocity) and equal to 2 for laminar flow (parabolic profile of the velocity). The equation is applied in two particular cross-sections (1 and 2) along the fluid flow. Also we have:

$$\Delta p = p_1 - p_2 = \frac{1}{2}\rho\left(\alpha_2\upsilon_2^2 - \alpha_1\upsilon_1^2\right) + p_{z2} - p_{z1} + \Delta p_{visc-loss}$$

In case of pipe segments initiating from elevation 0 and going back to 0:

$$p_{z2} - p_{z1} = \sum_{i=1}^{N}\Delta p_i = \rho g\sum_{i=1}^{N}\Delta z_i = 0 \Rightarrow \Delta p = \frac{1}{2}\rho\left(\alpha_2\upsilon_2^2 - \alpha_1\upsilon_1^2\right) + \Delta p_{visc-loss}$$

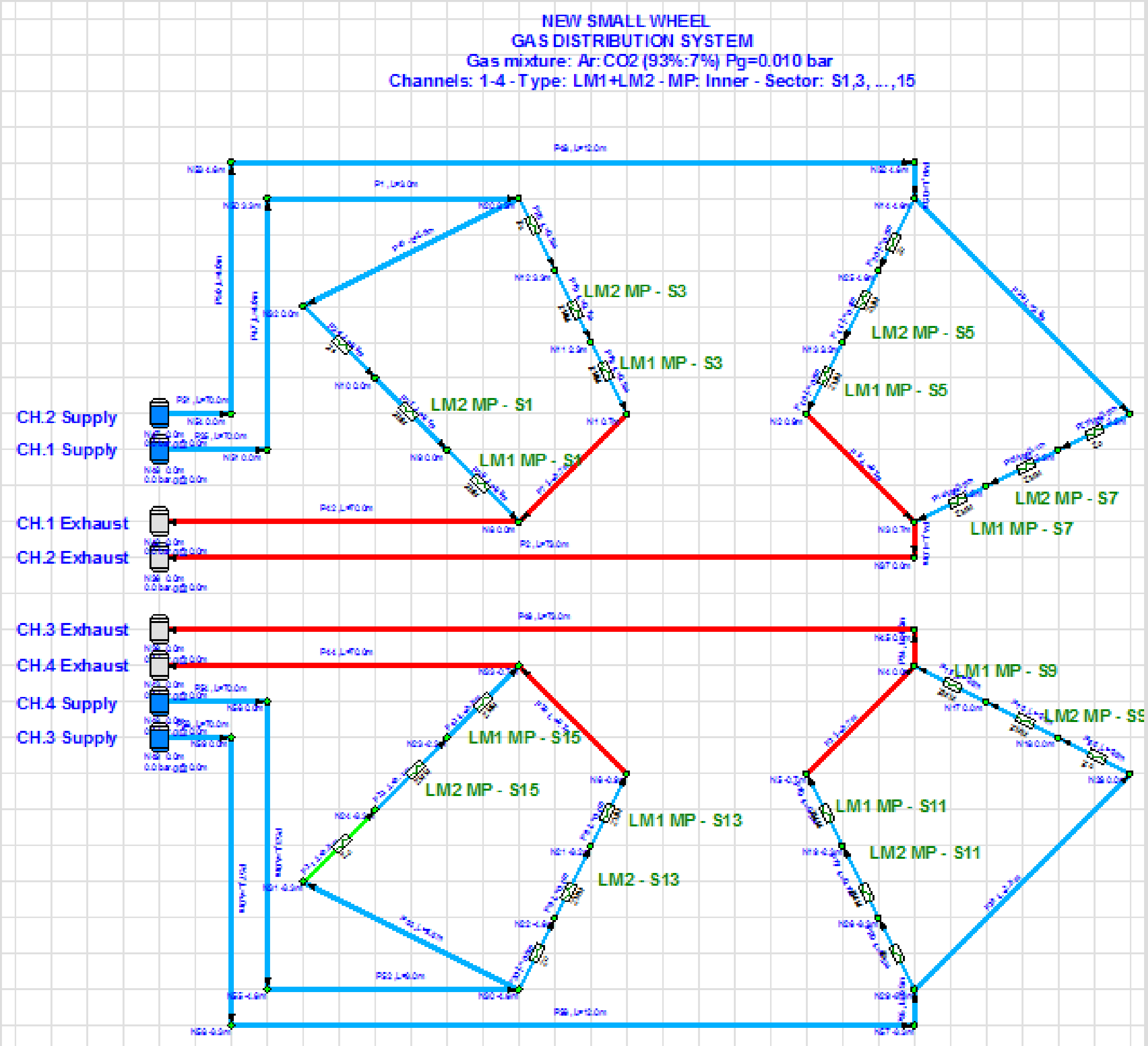
Poiseuille's law and impedance expression (holds only for laminar flow)

$$\Delta p_{visc-loss} = \frac{128L\eta}{\pi D^4}Q \Rightarrow Z = \frac{\Delta p}{Q} = \frac{128L\eta}{\pi D^4}$$

In case of turbulence flow the impedance *Z* becomes nonlinear.

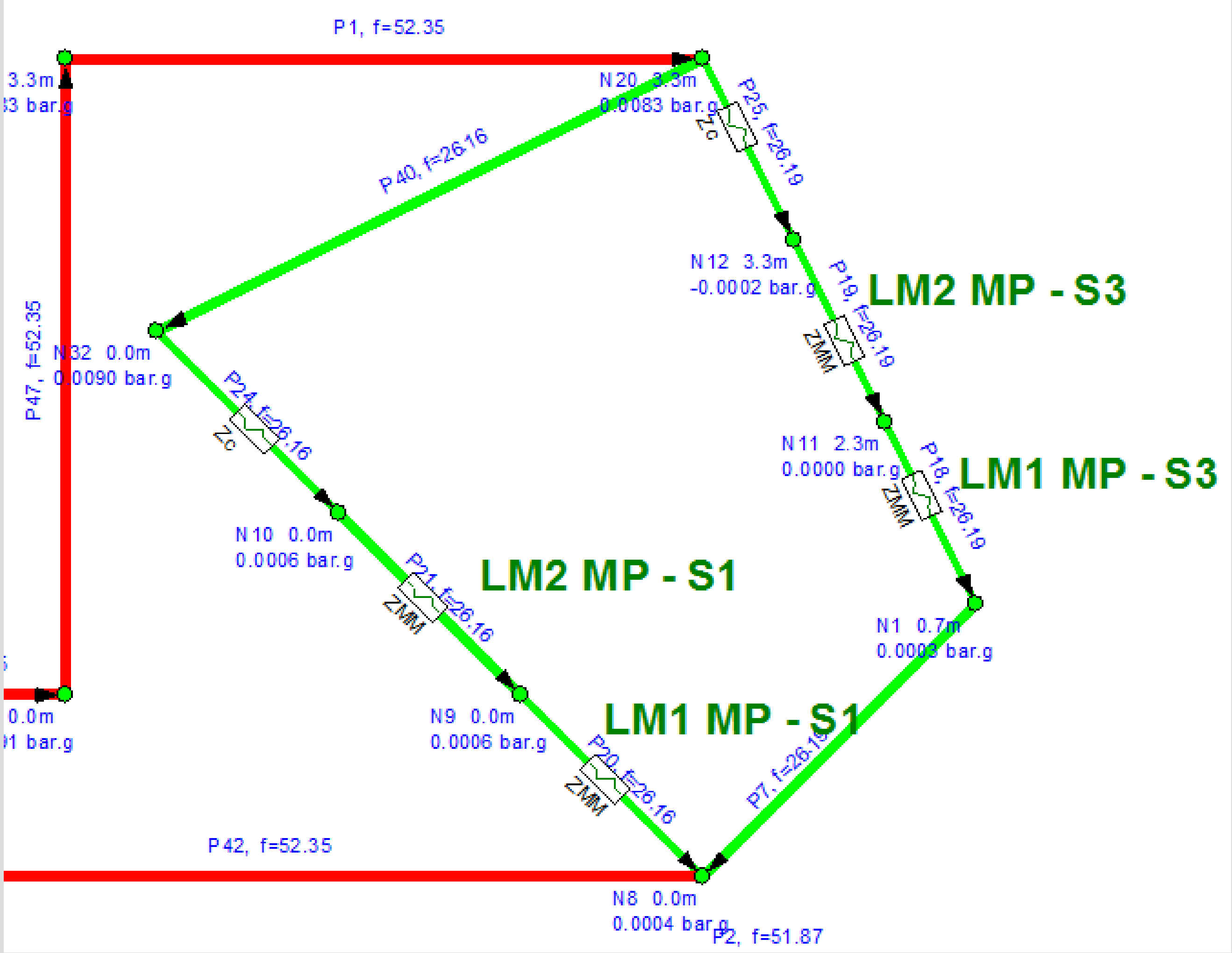
Simulation with Pipe Flow

A typical diagram showing the simulation of the LM wedges



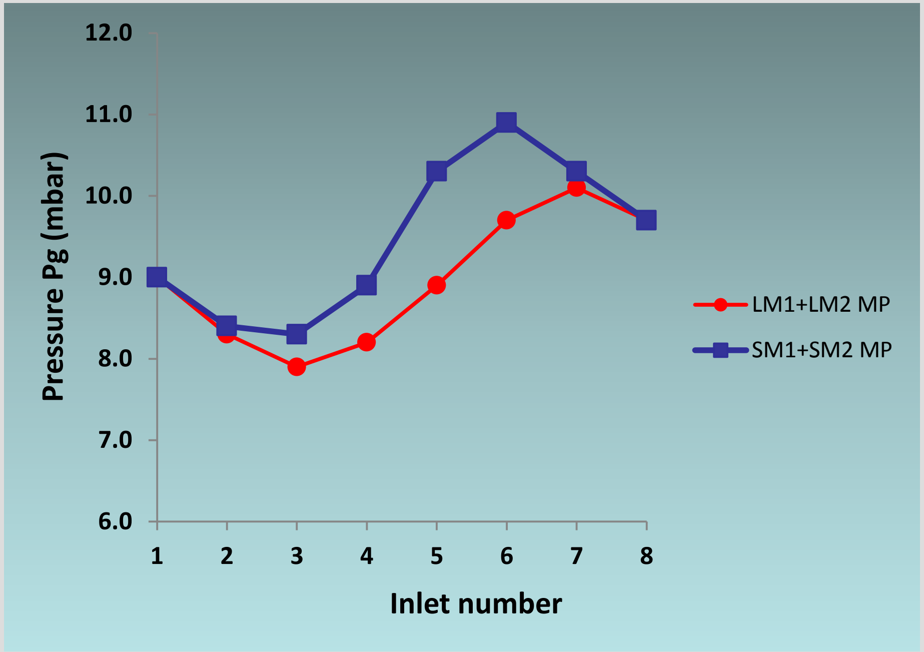
Simulation with Pipe Flow (magnified)

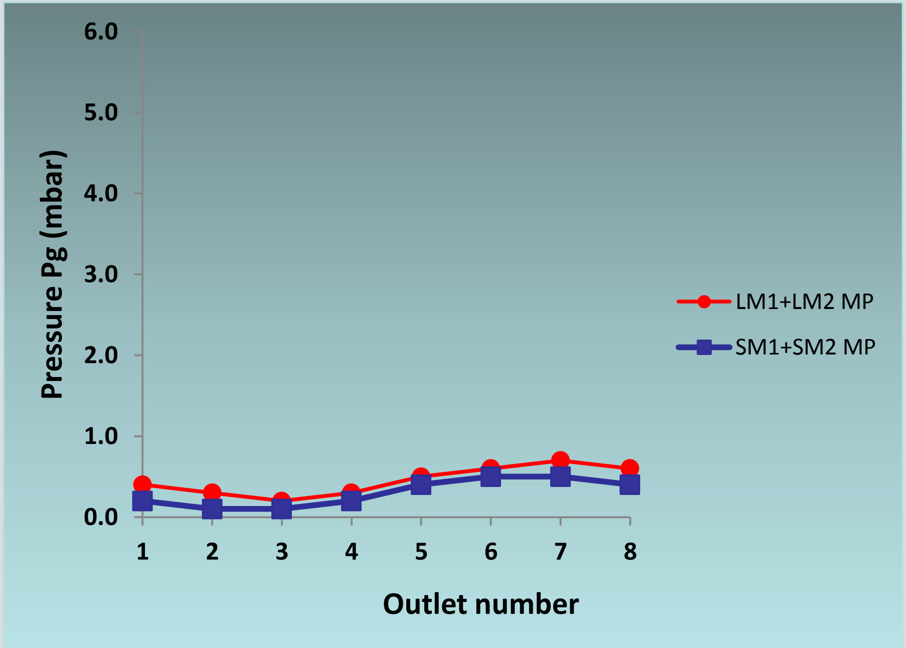
Magnified part for the sectors 1 and 3



Simulation Results: Configuration 1

Gas supply from outer circle





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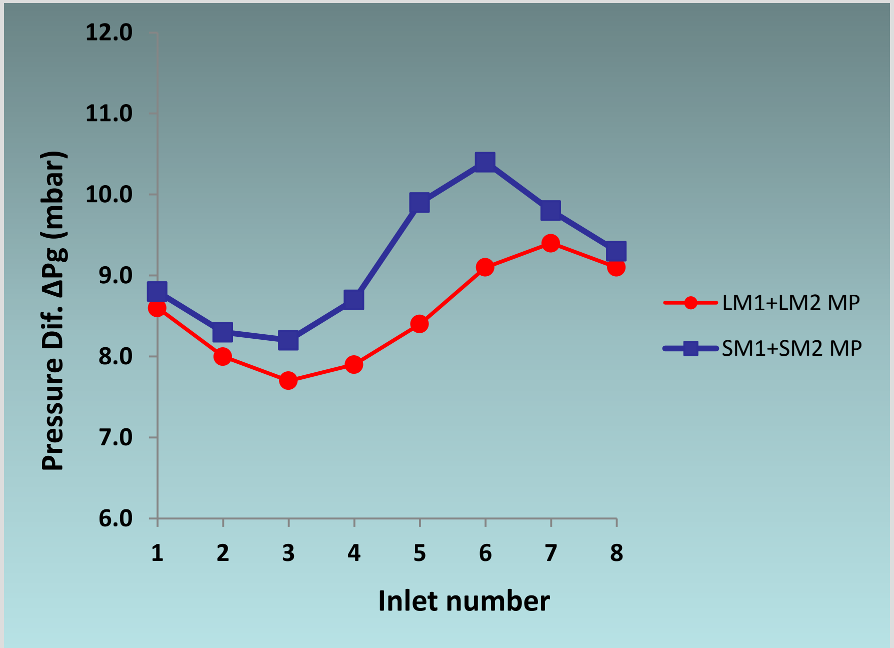

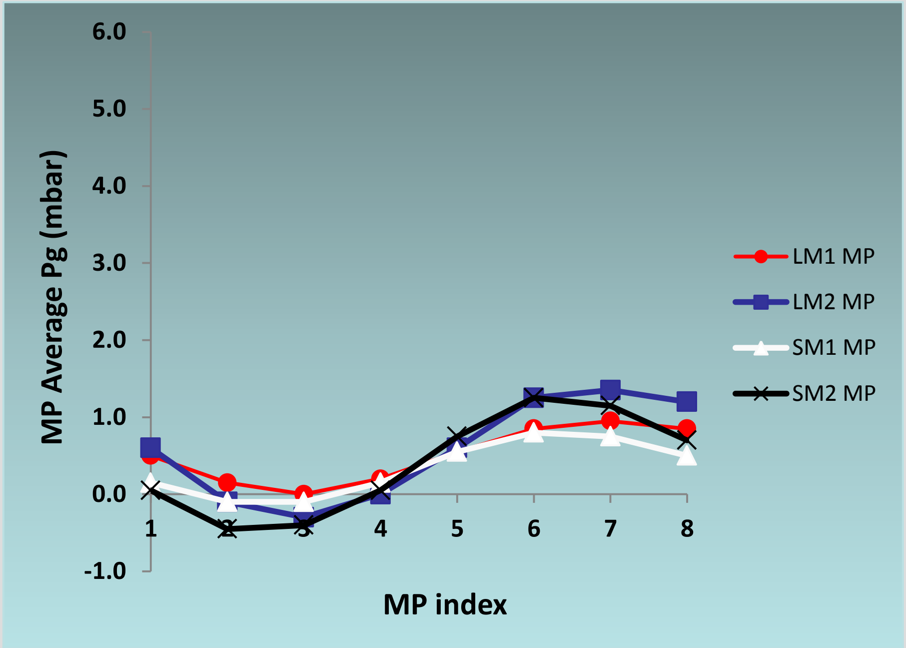

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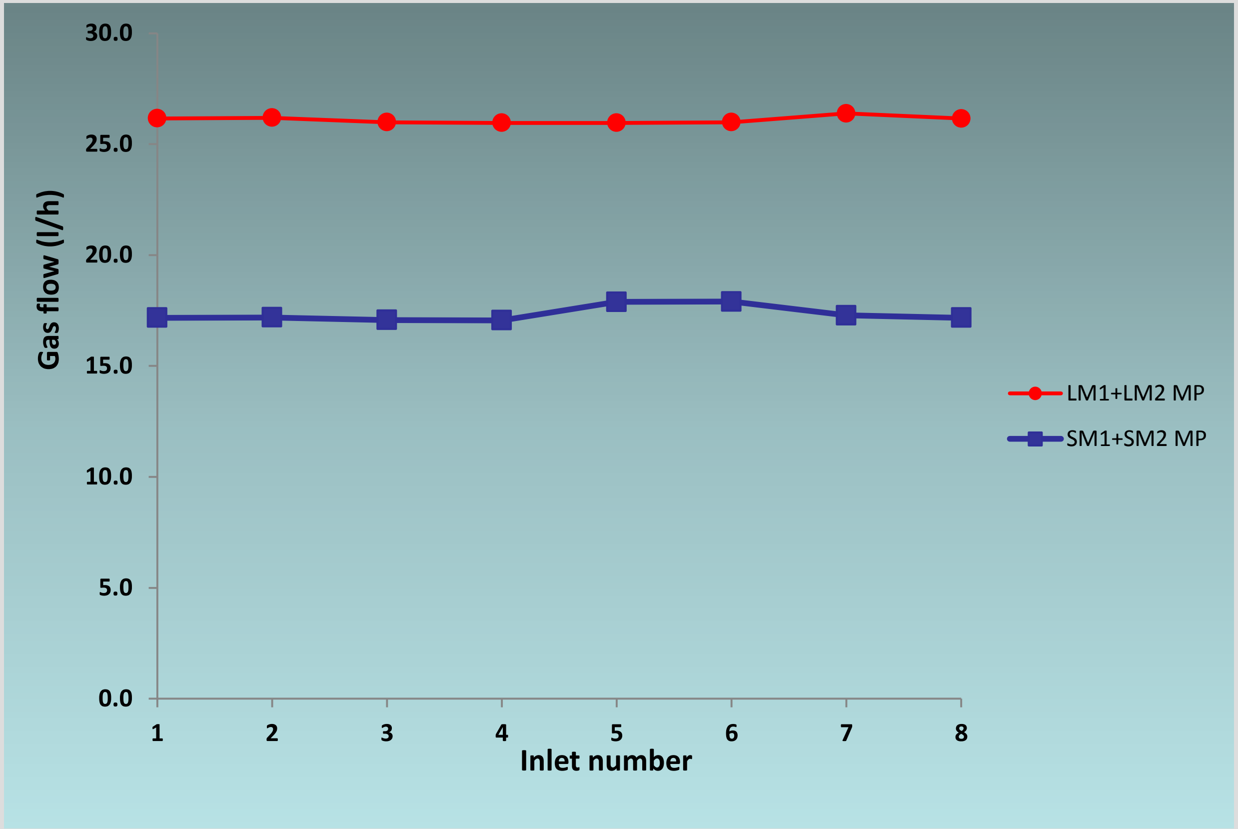
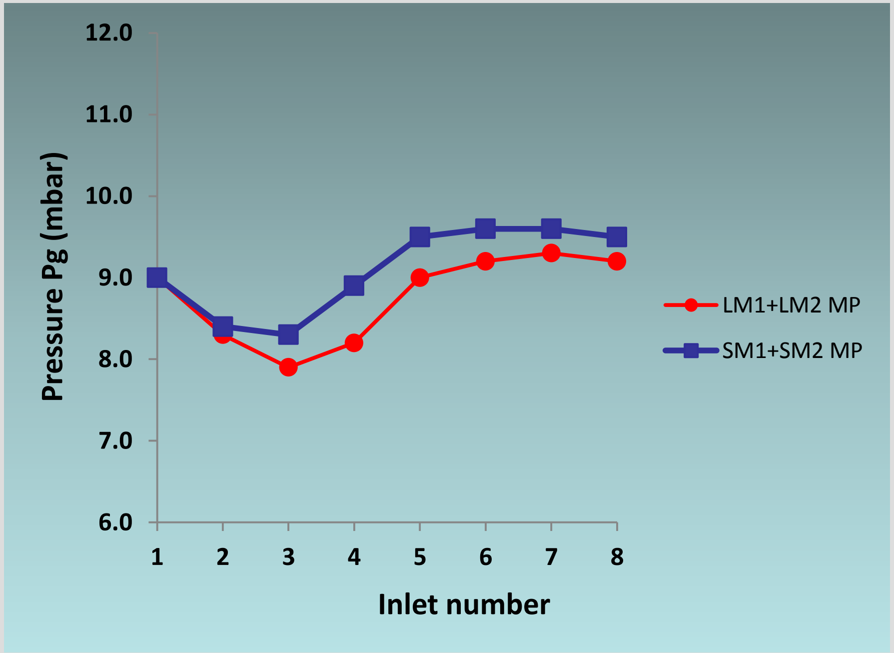
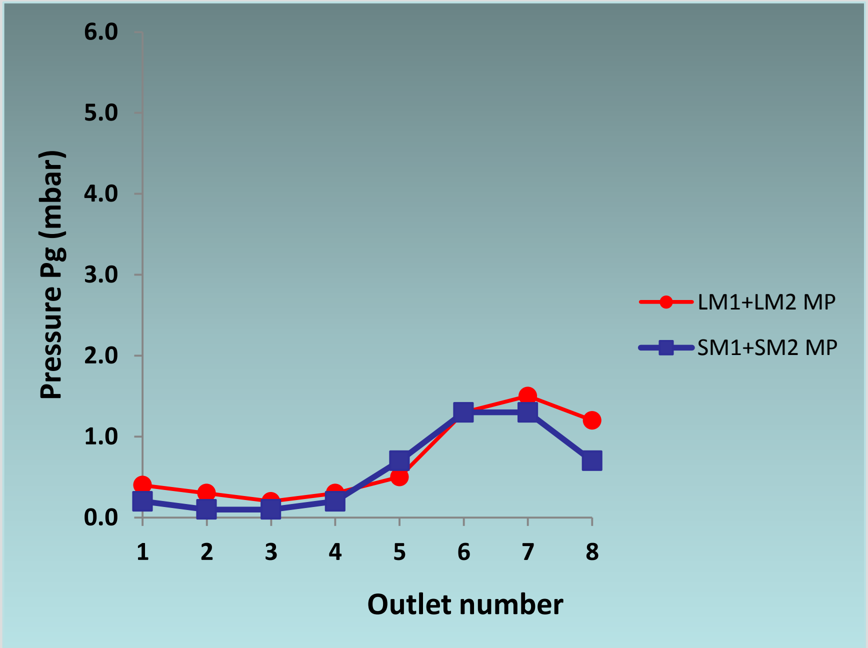


Simulation Results: Configuration 2

Gas supply from outer (upper half) and inner (lower half) circle





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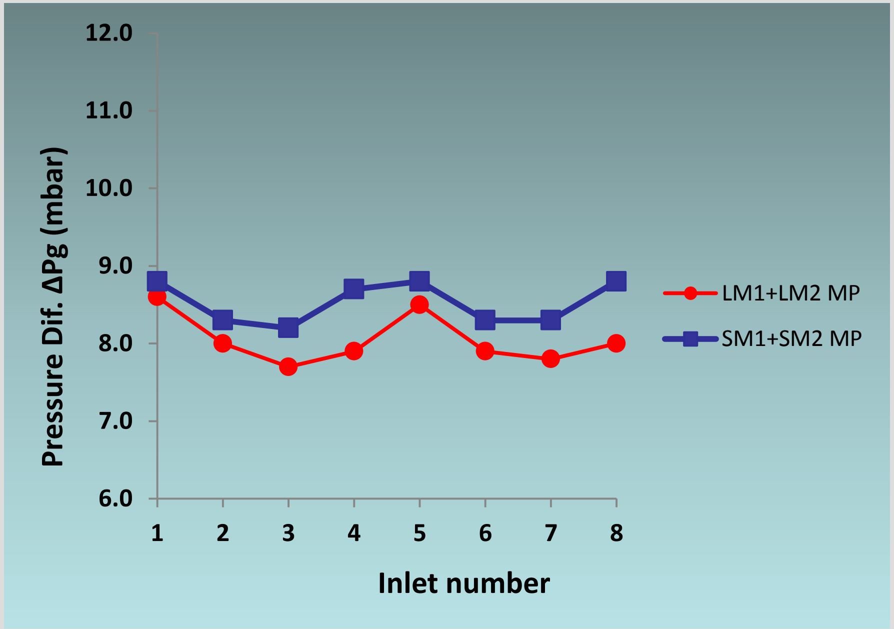

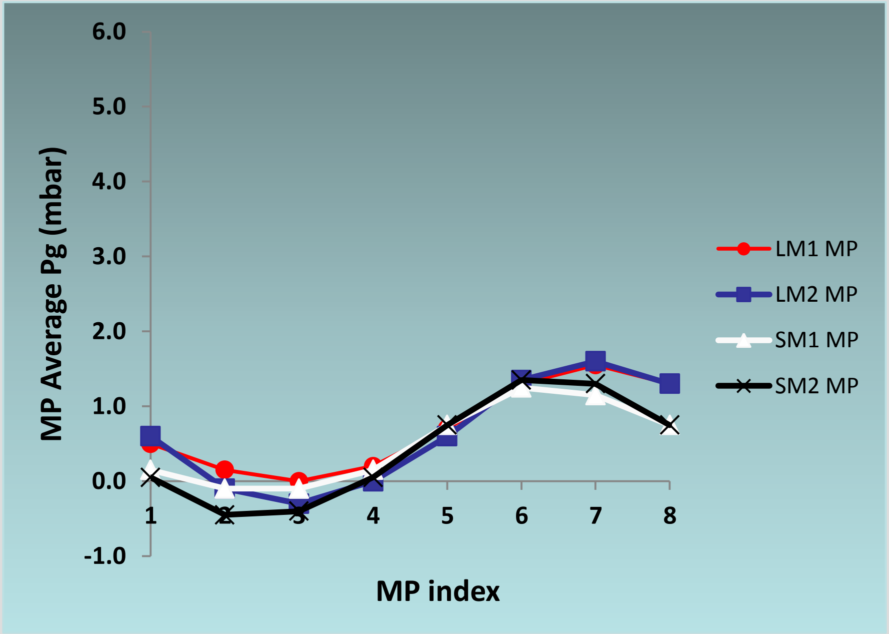

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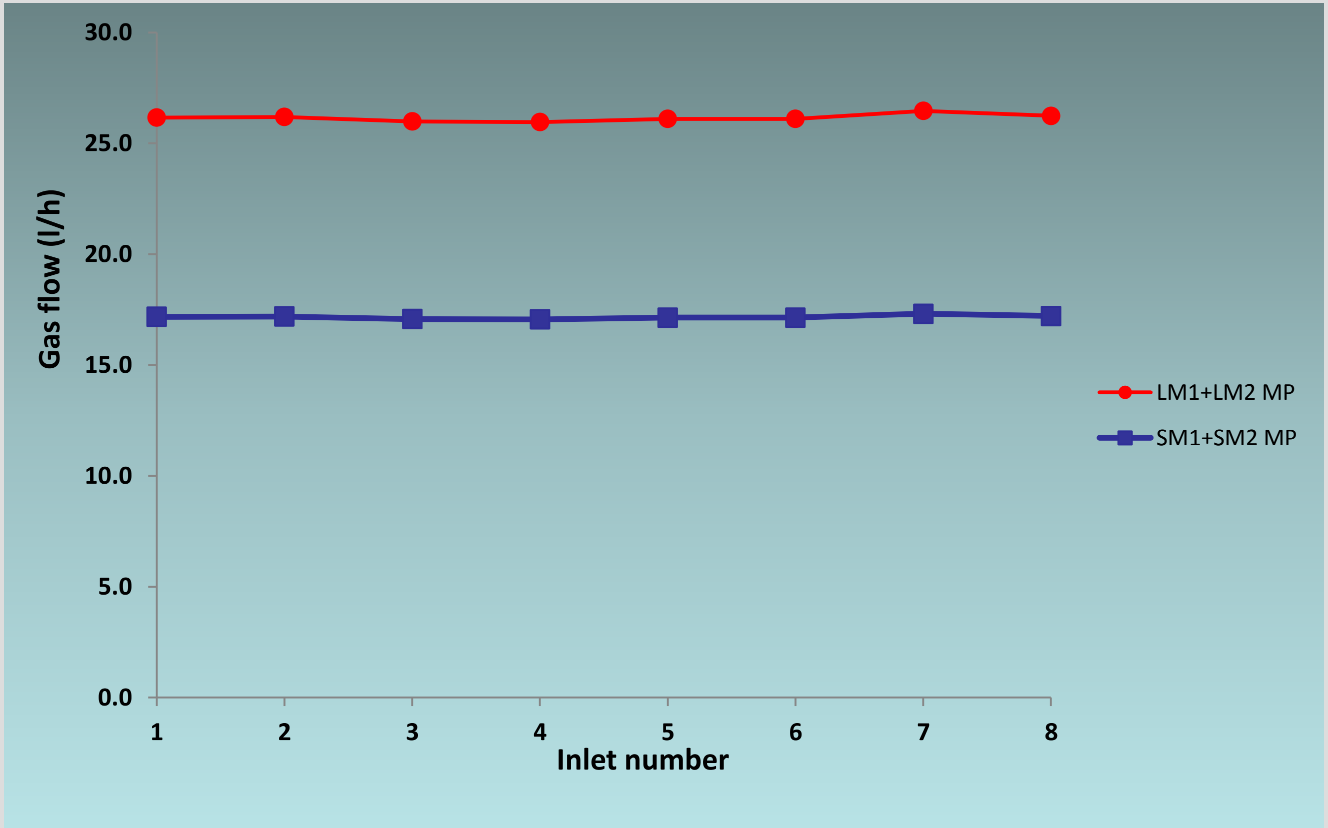
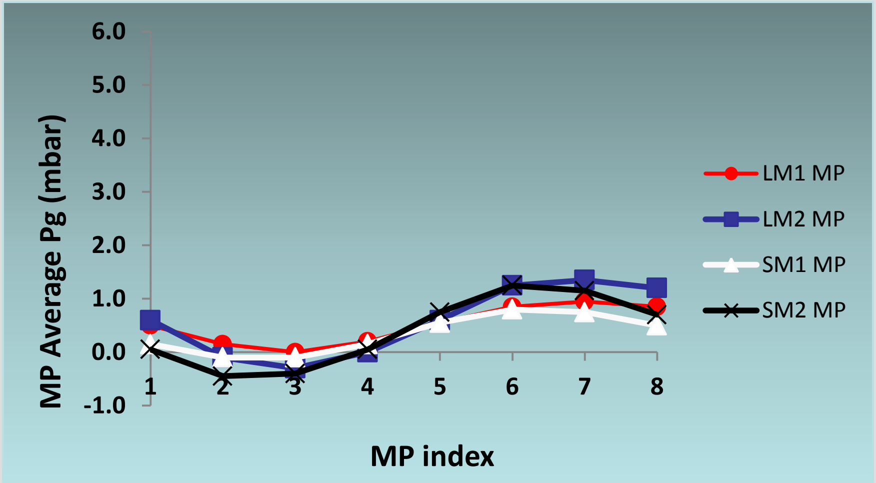
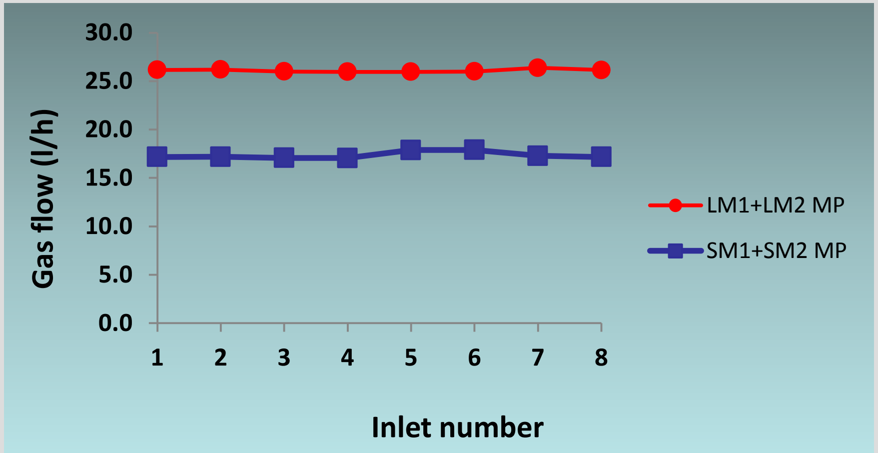


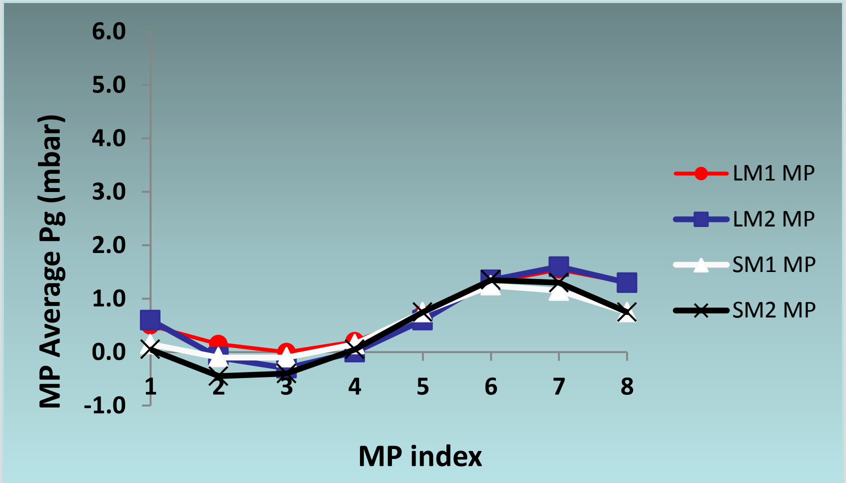
Simulation Results: Comparison between 1 and 2

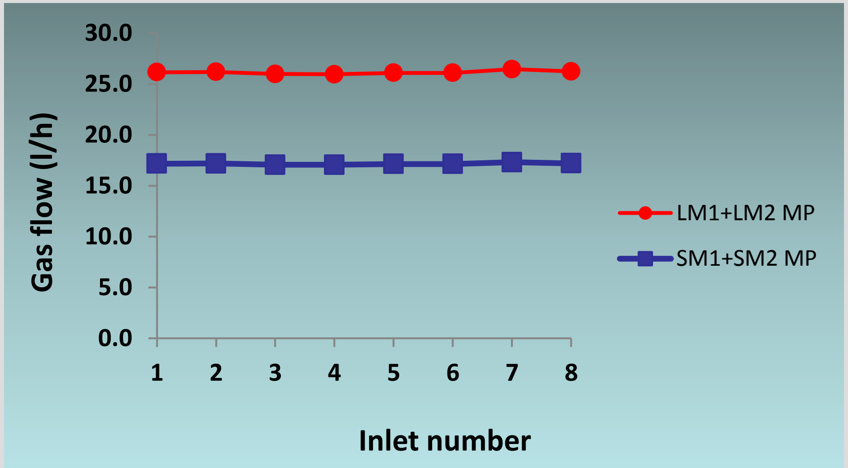
Gas supply from outer circle





Gas supply from outer (upper half) and inner (lower half) circle





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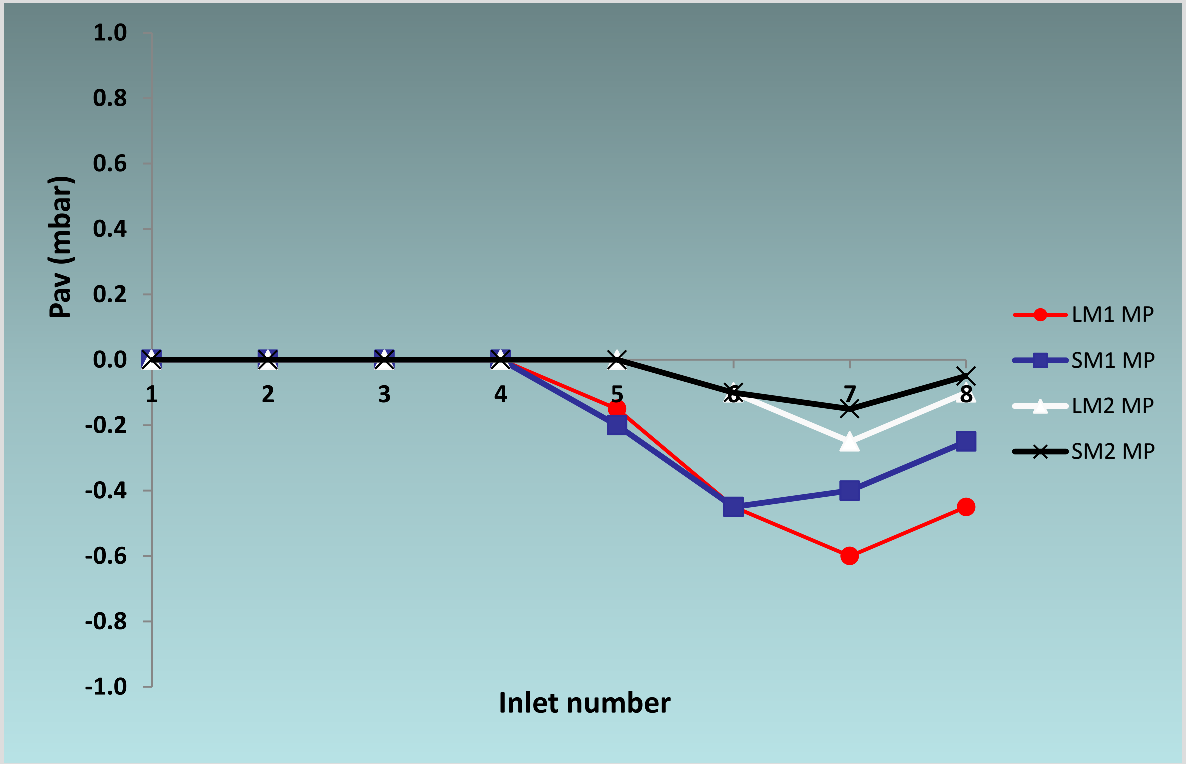


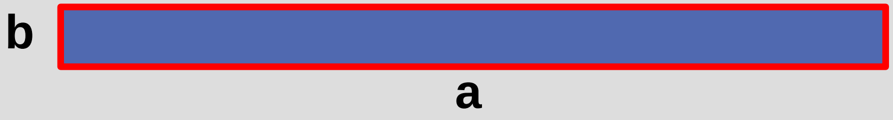
We establish that the pressure is lower in the configuration from outer circle compared to that from outer (upper half) and inner (lower half).

Design of a small scale natural model (1:4)

Our goal is to study the real dynamic behavior of the gas flow in a chamber plane recording the transient mixing with atmospheric air and the evolution of its pushing out by time.

In each section we have to:

- **Conserve the value of Reynolds number:** $Re = \frac{4\rho Q}{\pi \eta P}$
- **Specify the appropriate parameters, gas flow Q and characteristic size P**



Perimeter: $P = 2(\alpha + b) \approx 2a$

$$R'_e = R_e \overset{n'=n,\rho'=\rho}{\Rightarrow} \frac{Q'}{P'} = \frac{Q}{P} \Rightarrow Q' = \frac{P'}{P} Q \approx \frac{1}{4} Q$$

For LM Multiplets: $Q' \approx 1.6 \text{ l/h}$

For SM Multiplets: $Q' \approx 1.1 \text{ l/h}$

Conclusions and future work

- **We have investigated the optimal solution for the gas distribution scheme.**
- **We simulated the most candidate configuration providing gas to LM and SM multiplets in series.**
- **The appropriate direction of providing the gas mixture (from inner or outer diameter) has been studied and proposed.**
- **A study of small scale natural model is on the way expecting useful results for the transient gas flow in the detector planes.**