Design of local exhaust ventilation for preventive maintenance in the semiconductor industry using CFD

1. Background
- When the chemicals are remained or generated by-product in equipment, which causes defects the product thus maintenance tasks are necessary periodically.
- The maintenance tasks are performed manually by workers.
  - Removal parts, troubleshooting and wiping out a chamber with an ethanol or de-ionized water soaked wipe
  - At this time, there are potential risks that the maintenance workers might be exposed the reactant or by-products during the work. Additionally, the contaminants are released which may disperse in the room, so workers who work surrounding area might be exposed as well. [1,2]

2. Objectives
- Design local exhaust ventilation(LEV) for maintenance tasks in order to improve working environment and protect worker's health in semiconductor manufacturing process.
- The primary focus in designing the hood was convenience and un-disturbance of the work.

3. Methods
1) Experimental and numerical Model
   - 300 mm semiconductor wafer fabrication facility, ISO class 5 (South Korea)
   - Metallization process chamber was used.
     - A cylindrical chamber : 600(d) x 100(h) mm
   - LEV : A cylindrical shape (same size with the chamber, D = 600 mm)
     - To place on the chamber.
     - Control the contaminants before disperse out of chamber.
     - The circularly was made of acrylic were used in the experiments.
     - The measurements of face velocity: Hot-wire anemometer (TSI 9515) at 30 distributed points

2) Numerical method
   - The commercial code : Fluent Ver. 19.2 (Ansys Inc.).
   - SIMPLE(Semi-implicit Method for Pressure-Linked Equations) algorithm
   - Turbulence model : realizable k–ε model
   - Wall boundary condition for the wall of chamber used
   - The number of slot decreased when the velocity were improved and
   - Inc.) at 30 distributed points
   - When the number of slot decreased, the face velocity were improved and uniformly were advanced
   - Case 5 and 6 different layer with same area [there were no significant differences in slot layer  
   - when the 1 layer, the velocity exceeded 2.0 m/s (ratio of maximum and minimum velocity was not more than twice)

3) Boundary conditions
   - Flow rate : 2.41 m³/min
   - Capture efficiency (CE) = \( \frac{\text{flow rate of registered contaminants}}{\text{flow rate of generated contaminants}} \times 100\%
   - The ratio of the captured contaminants to the total generated emission rate
   - Source : a metalloid that is a member of group 15 of the periodic table
   - The number of slot decreased, the face velocity were improved and
   - Inc.) at 30 distributed points
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4. Results
1) Comparison to numerical analysis and experimental results
   - Overall simulation results agree quite well with the experiments data of measurement to the center line velocity on circular planar surface
   - The accuracy within 300 mm of the duct opening matched the experimental value within 20%

2) Rectangular type opening
   - The speed in the vicinity of the duct opening was up to 2.61 m/s, on the contrary, the number of hood face, the higher the velocity and the efficiency were the smaller, when the number of slot decreased, the face velocity were improved and uniformly were advanced.
   - When the number of slot decreased, the face velocity were improved and uniformly were advanced
   - Case 5 and 6 different layer with same area

5. Conclusions
- Slot hood had a higher capture efficiency than a rectangular hood.
- The slot hood provided uniform air flow and higher face velocity
- There were no vortex in the planum for slot, that is why slot had better efficiency than rectangular even though they had same face area
- The number of slot
- The smaller the number of hood face, the higher the velocity and the efficiency
- When the number of slot decreased, the face velocity were improved and uniformly were advanced
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- Case 5 and 6 different layer with same area

6. References
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