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COMPUTATIONAL FLUID DYNAMICS SIMULATION ON DIFFERENT GAS MASK FILTER CARTRIDGE GEOMETRY

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ABSTRACT

Gas masks play a vital role in protecting individuals from airborne toxins. Central to their performance is the filter cartridge, which purifies inhaled air. Environmental factors such as temperature and humidity significantly affect filter efficiency, often increasing pressure drop and reducing lifespan. While previous studies have examined these influences, limited research has focused on how filter geometry impacts flow dynamics. This study employs CFD to analyze airflow behavior in different filter designs under varying humidity, focusing on pressure drop and air residence time to identify inefficiencies.

KEYWORD

Gas Mask Filter, CFD, Preferential Flow, Humidity Influence, Filter Geometry

MATERIAL AND METHODOLOGY

Three cartridge geometries modeled using CAD were simulated using ANSYS Fluent. The setup included condition of temperature: 30°C, Humidity: 25%, 55%, 85%, Flow rates: 30 L/min and Mesh type: Tetrahedral for flow-critical zones. The Solver: Pressure-based, steady-state with Models of Realizable k-ε turbulence and species transport additional UDF for dynamic diffusivity and air age calculation tracking. The study employed mesh independence testing and validation against Chun-Chi et al.'s model. Performance metrics were analyzed via contour and vector plots for each geometry and environmental condition.

Figure 1: meshing for Type 1 geometry

RESULT AND DISCUSSION

Results highlighted differences across geometries types:

- Pressure Drop: Figure 2 show that Type 1 consistently exhibited the lowest pressure drop (<60 Pa) across all humidity levels as the limit 60 Pa pressure ensure beneficial for user inhalation and more comfortable breathing conditions.

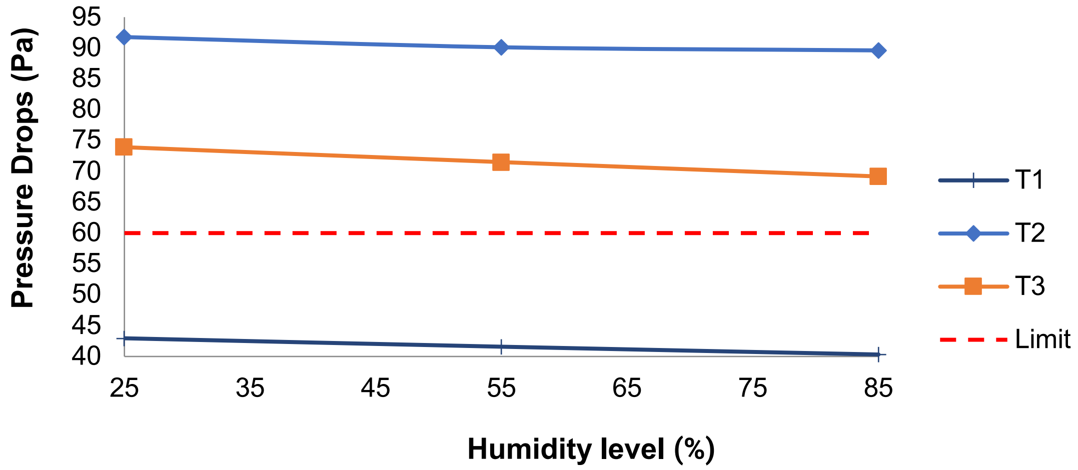

Figure 2: Pressure drops each geometry type with level of humidity

- Pressure Drop: Figure 3 shows cross-section in all type of geometry.

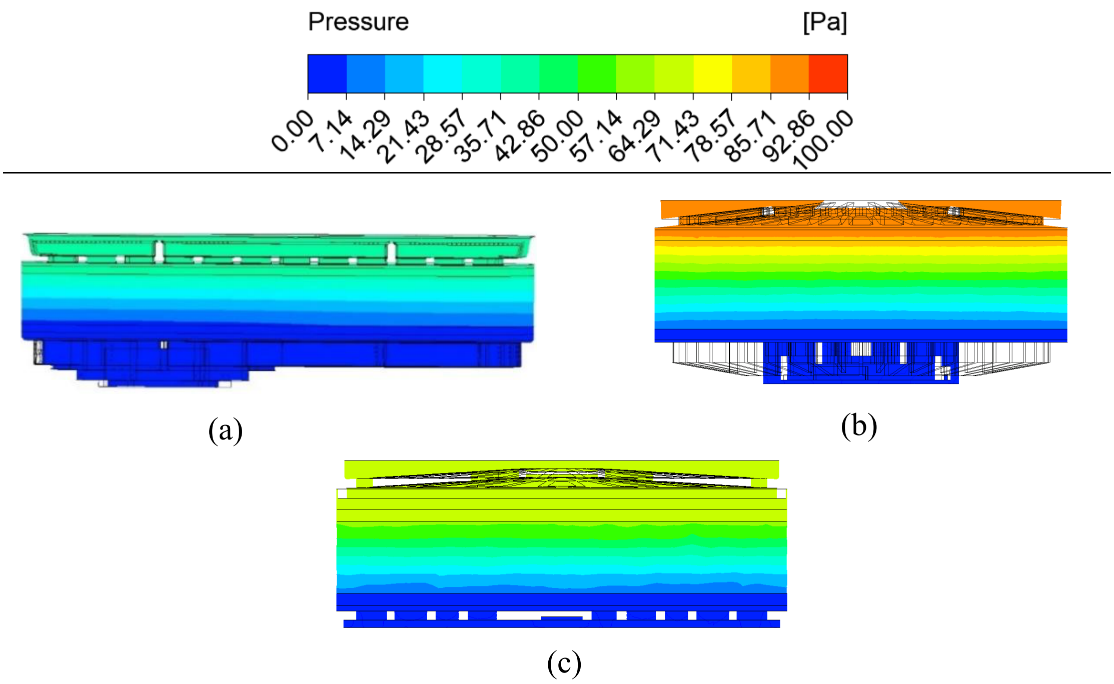

Figure 3: Pressure drops each geometry a) Type 1, b) Type 2, c) Type 3

- Pressure Drop: Figure 4 display on the activated charcoal region or the absorbent area that had clarify on reason of the lower pressure drop for type 1 came from flow distribution problems. We can see the upper region in Type 1 having much higher pressure compared to lower region, this may create a preferential flow exist at lower side of filter and dead zone region on the upper side region. Ultimately this can reduce the absorbent utilization and overall performance.

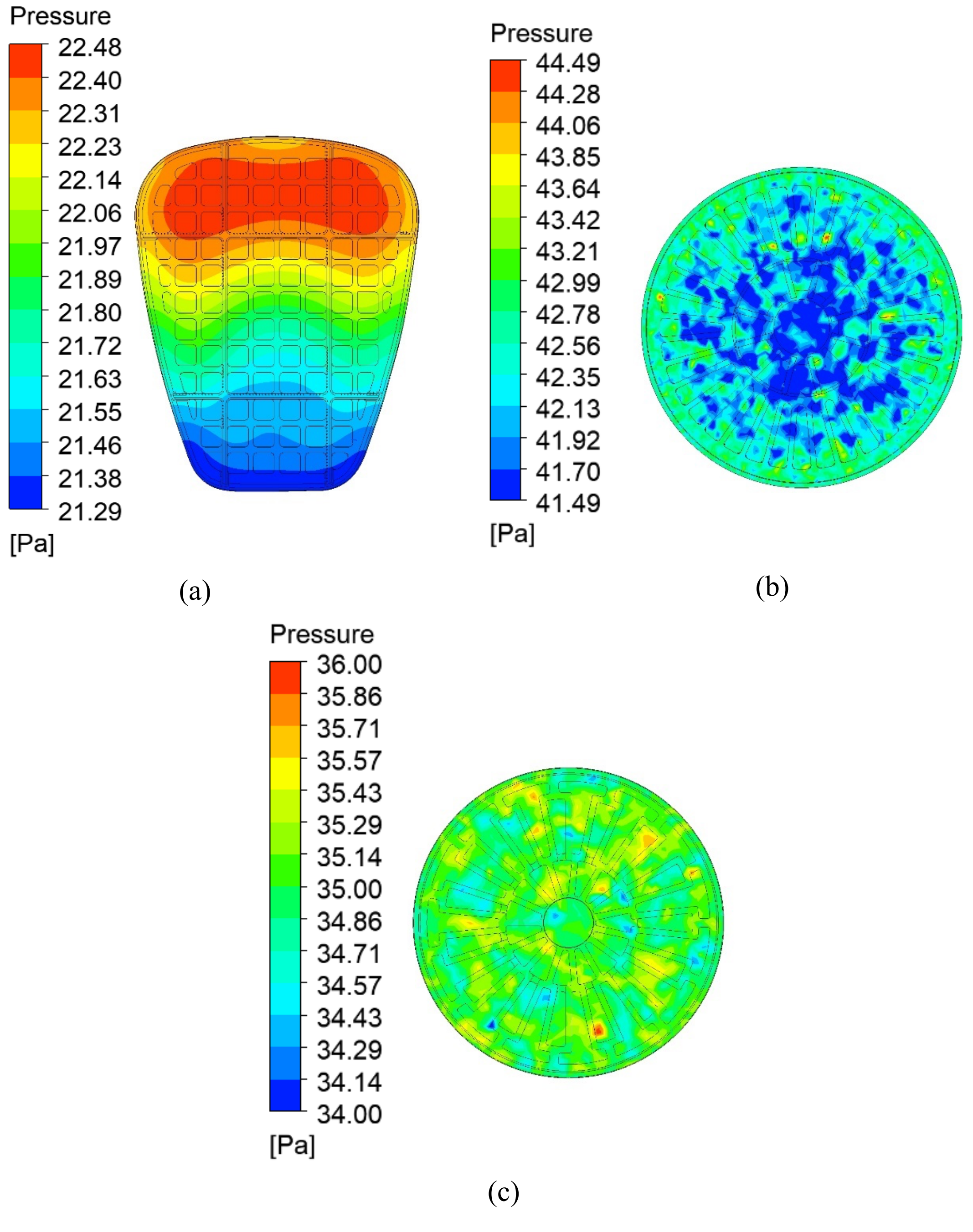

Figure 4: Pressure drops each geometry a) Type 1, b) Type 2, c) Type 3

CONCLUSION

This study confirms that gas mask cartridge geometry can influences performance of filter which been showed result of pressure drop. Type 1 geometry showed lower pressure drops compared to other geometry yet still have issue of preferential flow and dead zone forming within the absorbent region. Type 2 and 3 even comes with much higher pressure drops value yet are still better in flow distribution across the absorbent. Based on this result, Type 3 been determining a better compared to other types as having intermediate pressure compare to Type 2 but still having proper flow distribution in absorbent region to Type 1. These findings underscore the need for design optimization in gas mask filters to improve as safeguarding the user from inhale toxic and hazardous airborne particles. Future studies could explore on particular part of the.

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