

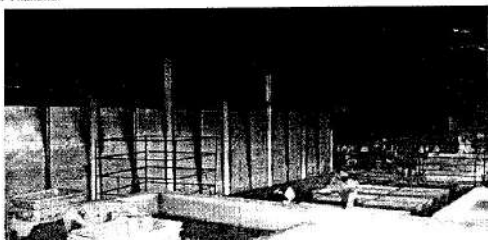
CFD study of flow in a natural rubber sheet smoking-cooperative

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1. Introduction

Thailand is the largest natural rubber producer in the world. One of the main products is the ribbed smoked sheet (RSS) rubber. There are totally about 500 rubber sheet smoking cooperatives (RSSC) under going RSS production business in Thailand.



- Burning of wood results in a large portion of fine smoke aerosol particles.
- RSS production results in thick smoke cloud containing fine aerosol in the workplace.
- Improvement of airflow is then necessary to reduce the risk to workers' health by exposing to these smoke particles.
- Particle trajectory of the smoke, velocity distribution and temperature distribution inside of the RSSC are investigated.

2. Methodology

- Study velocity distribution, temperature distribution and smoke particles trajectory using FLUENT along with GAMBIT.
- Measurements at boundaries were performed to obtain boundary conditions.
- Measurements at several positions were performed and these data were used for validation. Measurement positions are shown in Fig. 2.

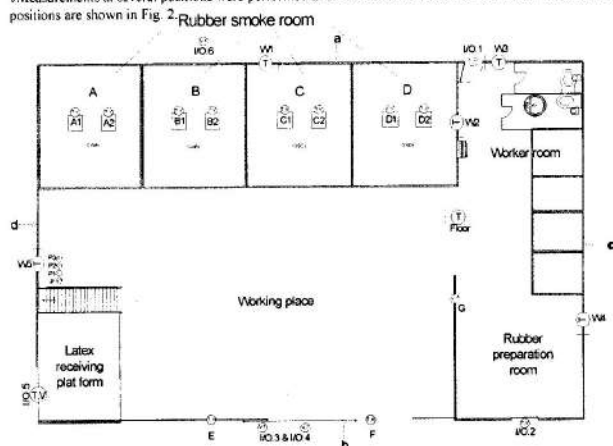


Fig. 2 Diagram of Measurement positions (Top view)

- To consider whether the flow is mixed convection or natural (free) convection, calculation of ratio between Grashoff number and Reynold numbers was performed.
- The suitable meshing to the geometry was performed by using GAMBIT. Result is shown in Table 2.

Elements	Tet Hybrid
Type	TGnd
Size	1 (mm)
Mesh Volumes Generated	461,999

3. Results

Value of velocity near the walls is less than 0.01 m/s or zero.

$$\frac{Gr}{Re^2} = \frac{g \beta (T_s - T_\infty) H^3}{\nu^2 U^2} = \infty \rightarrow \text{free or natural (pure) convection and}$$

$$Nu = \frac{h D}{k} = \frac{0.62 + 0.43 Re^{1/4} + 0.75 Pr^{1/4}}{[1 + (0.4/Pr)^{1/4}]^{1/4} [1 + (0.7/Re)^{1/4}]^{1/4}} = 5.388 \times 10^6 \text{ to } 33.200 \times 10^6 \text{ for } \theta = 1.2 \text{ to } 7.4 \text{ degree} \rightarrow \text{flow is turbulent}$$

All conservations were converged with respect to the convergence criteria by default of FLUENT (shown in Fig.3)

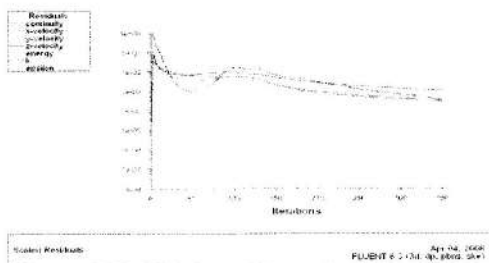


Fig. 3 Scaled Residuals: 350 iterations reach (solution of) convergence [10⁻³: continuity, momentum, turbulence, 10⁻⁶: energy]

Velocity distribution inside of the RSSC is shown in Fig. 4. The highest velocities located at the ventilating lids

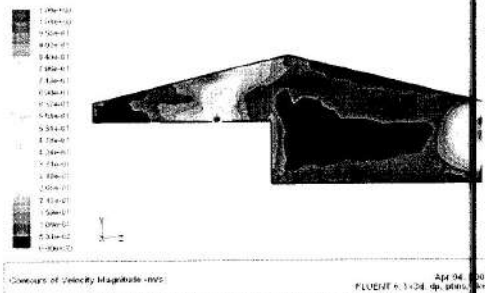


Fig. 4 Contour of Velocity view from direction d at plane B1

Temperature distribution inside of the RSSC is shown in Fig. 5. The highest temperature takes place at the surface of the plane B1 and plane B2. These plane surfaces area are the outlets of hot-airflow to the RSSC.



Fig. 5 Contour of Temperature view from direction d at plane B1

Smoke particles trajectory is shown in Fig. 6.

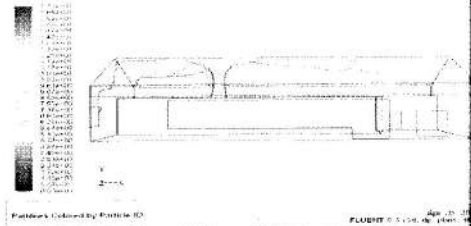


Fig. 6 Smoke particles trajectory which release from B1 and B2 (about 200 m)

Table 3 Comparison between measurement and simulation results

Parameters	Velocity (m/s)		Temperature (K)	
	Mea	Sim	Mea	Sim
P	0.14	0.01 - 0.15	347.9	346.9
G	0.02	0.01 - 0.02	347.6	347.5
B1	1.83	1.83 - 1.85	321.9	321.6
B2	1.62	1.62 - 1.65	321.7	321.6
IO1	0.79	0.59 - 0.67	341.7	347.2
IO2	0.19	0.41 - 0.46	354.9	346.1
IO3	0.32	0.06 - 0.40	349.2	344.9
IO4	0.25	0.33 - 0.57	347.4	344.6
IO5	0.35	0.43 - 0.71	266.6	347.2
IO6	0.04	0.00 - 0.23	348.2	341.7

4. Discussion and Conclusion

- Hot air (smoke, aerosol particles from the sources) flows mainly from ventilating lids to the workplace area.
- The Discrete Phase Model of FLUENT can apply to show the trajectory of the particles.
- Conclusions from measurement and simulation:
 - Results between CFD Simulation and Measurement are in good agreement.
 - Location of the fastest velocity measurement and simulation is at the ventilating lid.
 - Location of the highest temperature measurement and simulation is at the ventilating lid.
 - Proper ventilation is needed.

References:

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