Optimization Study of Air Pollutant Recirculation using CFD

C2D Solutions Pte Ltd

Concepts To Design Solutions

Overview of C2D

C2D Solutions Pte Ltd is a holistic knowledge-based engineering solutions provider with a wealth of experience. We are committed to deliver the most optimal solution based on sound engineering principles.

Problem Statement

Study of potential fire hazard and evaluation of extent of pollution from exhaust vent. To analyse extent of recirculation for original design and propose optimizations to reduce recirculation. Evaluate proposed optimizations and make recommendations to client.

Challenge

In the event of a train carriage fire, Tunnel Vent Fans (TVF 1 and TVF 2) will activate to vent out the smoke and prevent the smoke from infiltrating into the station and suffocating passengers. The TV (Tunnel Vent) outlet louver shown in Figs. 1 & 2, is the discharge grille for TVF1. The development of the mall and the interfacing with the existing train station caused the TV outlet louver to be located within 13m of the VS inlet louver (supply vent grill). Although a separation of 13m satisfies the code requirement, the authority was concerned that the large amounts of smoke from a train carriage fire from TV grille may be aided by wind effects to re-circulate back into the station through the VS grille.

Solution

Computational Fluid Dynamics (CFD) fire and pollution simulation was used to study the extent of re-circulation. The amount of CO and soot released from TV grille was determined by simulating a 10MW train carriage fire in the tunnel. The CO and Soot concentrations that are extracted by TVF1 (and consequently exhausting from the TV grille) were predicted as 240ppm and 211ppm respectively. As the smoke exhaust temperature from the TV grille is unknown, several temperatures were considered (28°C, 35°C, 65°C).

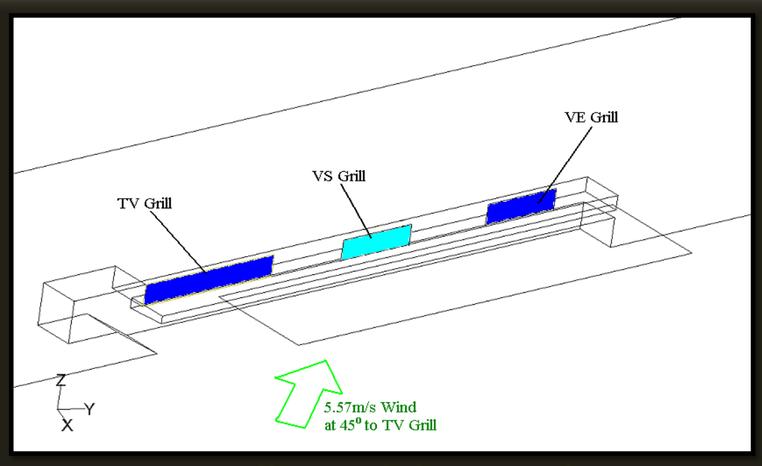

Fig. 1: Vent Grille Model Original Concept)

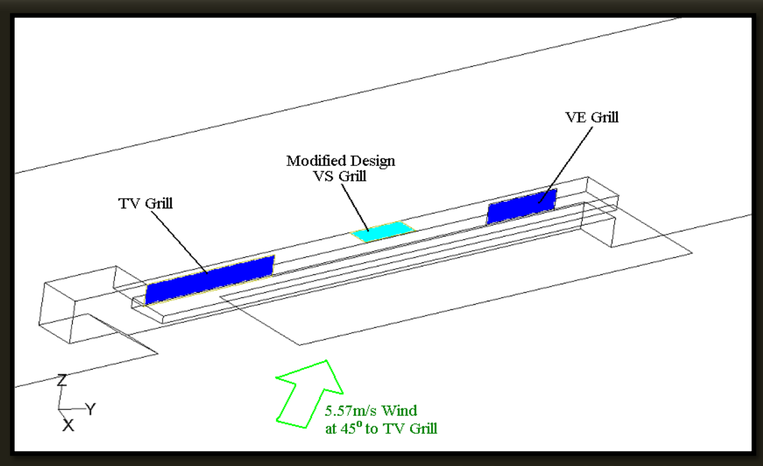

Fig. 2: Vent Grille Model Modified VS Grille Facing Downwards

	5.57m/s Wind with Original Vent Grille Design	
Temperature (°C)	Soot PPM	CO PPM
28	68	80
35	57	65
65	19	22

Table 1: Concentration of CO and Soot entering into the VS grille (Original Design)

	5.57m/s Wind with SV Grille Downwards	
Temperature (°C)	Soot PPM	CO PPM
28	25.7	29.7
35	24.7	28
65	11.7	13.1

Table 2: Concentration of CO and Soot entering into the VS grille (SV Grille Modified to Face Downwards)

	5.57m/s Wind with SV Grille Downwards and TV Grille with an Upward 45° Louver	
Temperature (°C)	Soot PPM	CO PPM
28	4.8	5.4
35	3.8	4.4
65	2.4	2.5

Table 3: Concentration of CO and Soot entering into the VS grille (SV Grille Modified to Face Downwards and TV Grille with an Upward Louver of 45°)

Results

For the Original Design (Table 1), the max. re-circulation for CO and Soot are 68ppm and 80ppm respectively (Threshold Limit Values for CO and Soot are 25ppm and 30ppm respectively). To reduce this re-circulation, an alternative design with the VS grille opening facing downwards was proposed. For this 1st Optimization (Table 2), the max. re-circulation for CO and Soot are 25.7ppm and 29.7ppm respectively. To further reduce this re-circulation, another alternative design with the VS grille opening facing downwards and TV grille with an upward louver of 45° was proposed. For this 2nd Optimization (Table 2), the max. re-circulation for CO and Soot are 4.8ppm and 5.4ppm respectively. The 2nd optimized design was proposed to the client, but caution was advised to design the TV grille louver system to mitigate rain infiltration issues. Both proposals were favorable to the client and were implemented successfully.