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FIRE SIMULATION IN THE GARAGE

Aleksandar Kijanović[1] Dragiša Ivanišević[2] Snežana Ilić[3] Milica Mirković Marjanović[4]

Abstract: This article presents a fire simulation of a simple garage which is a template for learning fire simulation in garages. This model is used for academic purposes created in PyroSim Software with an academic license. First of all, the garage is drawn in AutoCAD 2D. After that geometry is imported into PyroSim as a 2D object. The 3D model was created in PyroSim. Boundary and initial conditions are declared for the developed model. Also, jet fans are modeled like HVAC elements with predefined flow. In the simulation, the five jet fans are used. The simulation time is 50 s. The results are shown as graphical results of smoke production, heat production, temperature, and velocity distribution. It could be concluded that jet fans work on the exhaust of the smoke.

Key words: Fire Simulation in Garage, PyroSim, FDS, Jet Fans, CFD

1. INTRODUCTION

This paper shows garage fire simulation using PyroSim Software with academic permission. The model of the garage is used just for educational purposes. The software simulated a car burning in the garage positioned in the worst place in the garage according to the standard BS 7346-7 [1]. That position is in the middle of the garage. The smoke control system comprises five jet fans with a constant flow of 1.7 m^3/s. The exhaust of all fans is in one direction, and fans work all the time. The published paper aims to simulate car fire behavior for small garages with jet fans. Results show that using these jet fans is useful for a short time like 50 s, and for a longer time. Without a jet fan fire could propagate to other cars or someone who is in the garage could be in danger. The results section shows smoke and heat propagation caused by burning cars and also temperature and velocity profiles in garages and on jet fans. It could be concluded that fans work good and that they are well-dimensioned.

2. PHYSICAL MODEL OD GARAGE

Garage was drawn as a 2D drawing in AutoCAD (Figure 1). Then DWG file was imported into PyroSim Software with an Academic license. Dimensions of the garage are 40 m x 20 m, while the height of the garage is 3 m. The garage has three openings on both sides with dimensions of 6 m. It represents the OPEN Boundary condition [2]. The OPEN Boundary conditions represent ambient conditions or other fire or pressure zones. Inside the garage is a car that burns and produces smoke. Inside, there is also a smoke control system (jet fans). The task of these fans is to export gases out of the garage.

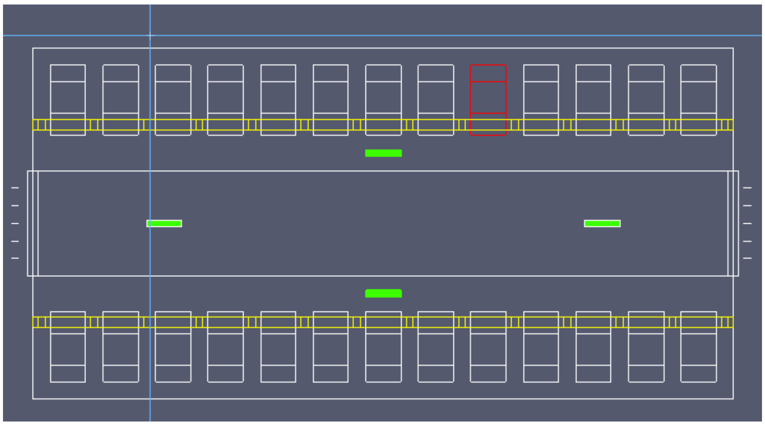

Figure 1 –2D drawing from AutoCAD

[1] M.Sc, Institute IMS, Bulevar Vojvode Mišića 43, aleksandar.kijanovic@institutims.rs
[2] M.Sc, Institute IMS, Bulevar Vojvode Mišića 43, aleksandar.kijanovic@institutims.rs
[3] M.Sc, Institute IMS, Bulevar Vojvode Mišića 43, snezana.ilic@institutims.rs
[4] M.Sc, Institute IMS, Bulevar Vojvode Mišića 43, milica.mirkovic@institutims.rs

On the 2D plan is created 3D garage structure like on the next Figure 2.

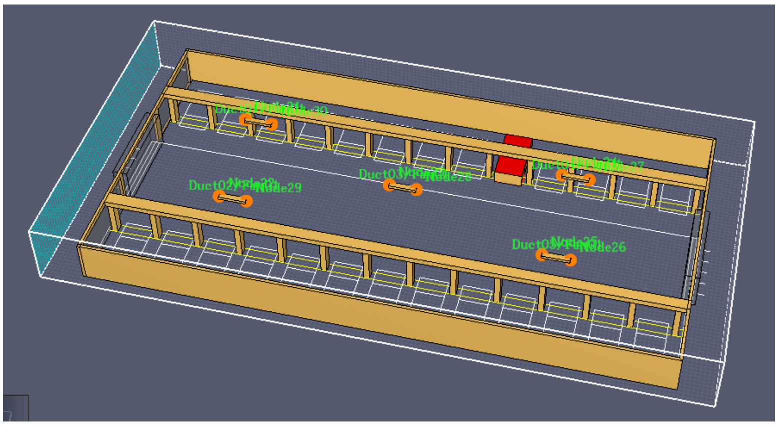

Figure 2 –Physical model of garage

Burning car with standard dimensions, 5 m x 2 m, according to the standard BS 7346-7 [1]. The maximum heat release rate per unit area of a car is 500 kW/m^2. Burning of the car is set at 180 s. The next table gives the ramping function of a burning car where the fraction is a share of 500 kW/m^2.

Table 1 –The ramping function of the burning car where fraction is share of 500 kW/m^2

Time [s]	Fraction
0	0
30	0.25
60	0.5
90	0.75
100	1.0
120	0.8
140	0.4

The length of jet fans is 2 m, while volume flow is set to be constant at 1,7 m^3/s. There are five jet fans.

3. NUMERICAL MODEL

The garage is created by mesh with the cell size dimensions 0.3 m x 0.3 m x 0.3 m. To achieve more accurancy it is common to use cell dimensions 0.1 m x 0.1 x 0.1 m. This is common for simulation performed in Serbia according to National Regulation for garages [3] The number of cell nodes is 169830. It is neccessary to calculated pressure, velocity – x direction, velocity - y direction, velocity – z direction, density, and temperature in every node. This simulation also calculate smoke production and smoke levels inside the garage. Turbulence is modeled with Very Large Eddies (VLES). The simulation time is 50 seconds. Other simulation parameters are automated. The numerical model with a mesh is shown in the next figure.

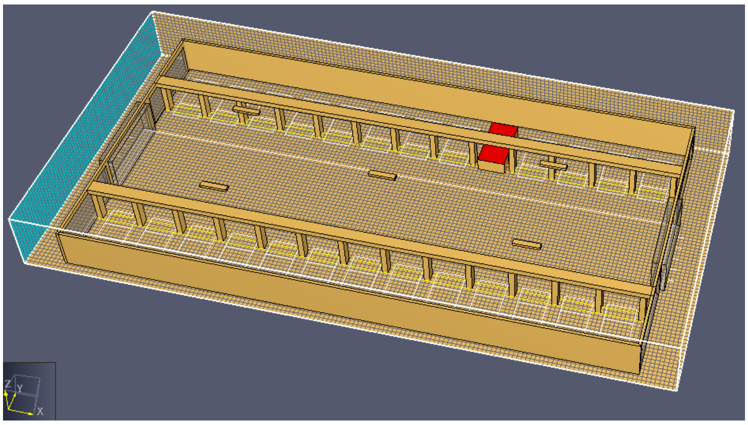

Figure 3 –Numerical model with mesh

4. GRAPHICAL RESULTS

4.1. Smoke production

The next figures show situations at the start, the middle, and at the end of the simulation. In simulation is used fuel Polyurethane GM27 which has high production of the smoke (soot yield od 0.198). High production of smoke is useful to check properties of jet fans installed in garage.

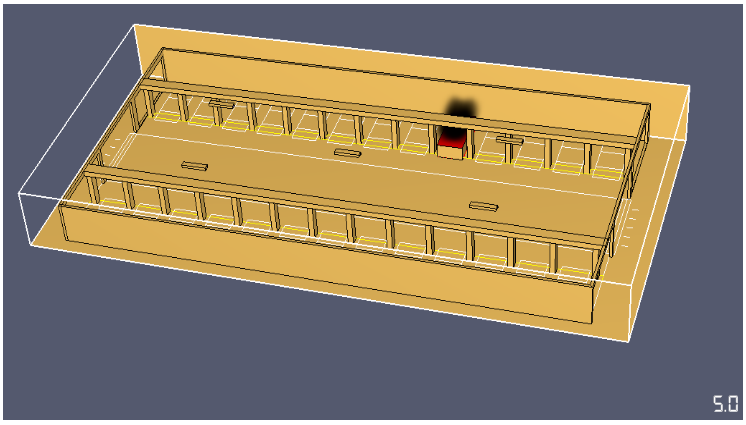

Figure 4 –The beginning of the simulation

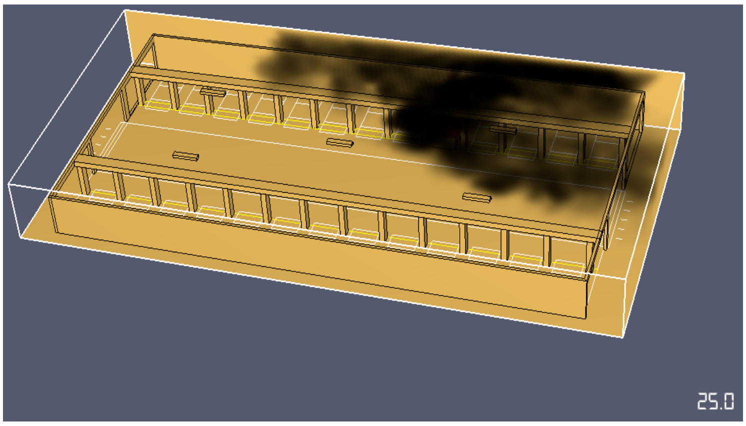

Figure 5 –Middle of the simulation

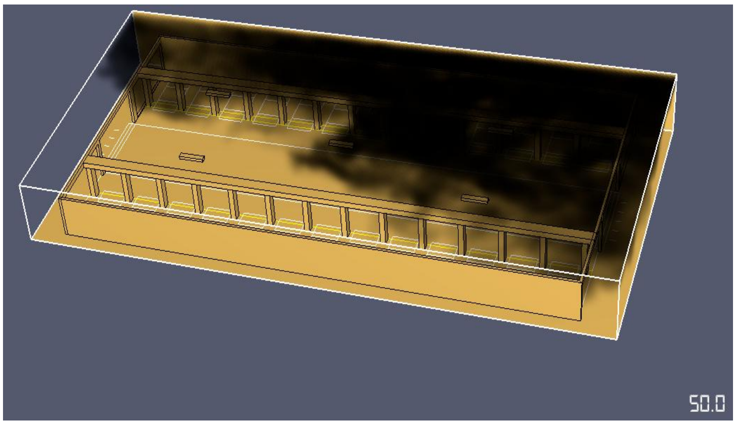

Figure 6 –The end of the simulation

4.2. Heat production

The next figures show situations at the start, the middle, and at the end of the simulation.

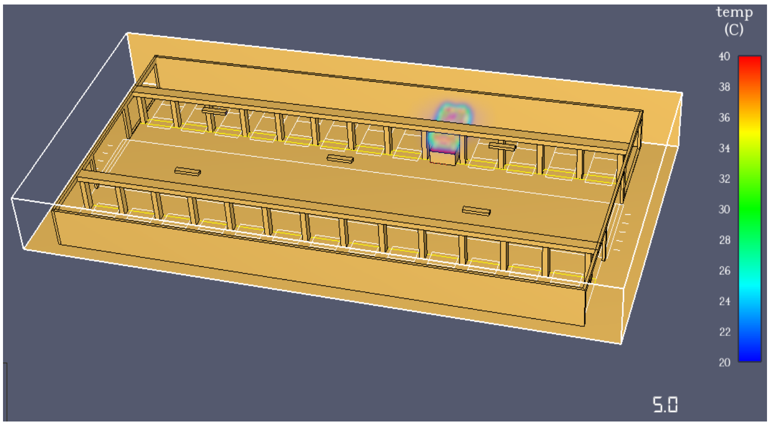

Figure7 –The beginning of the simulation

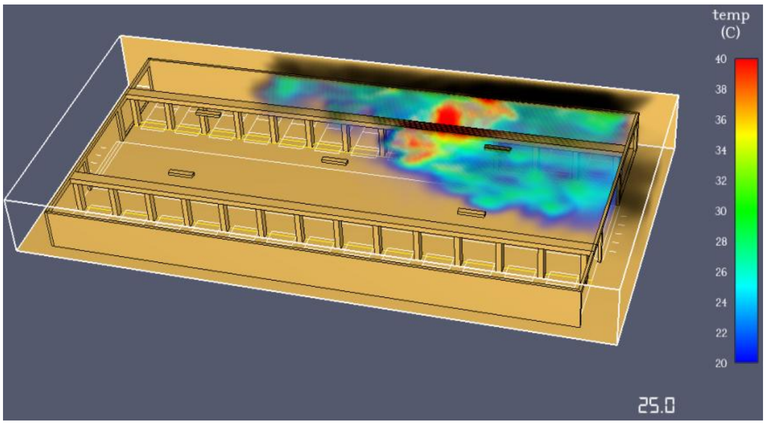

Figure 8 –Middle of the simulation

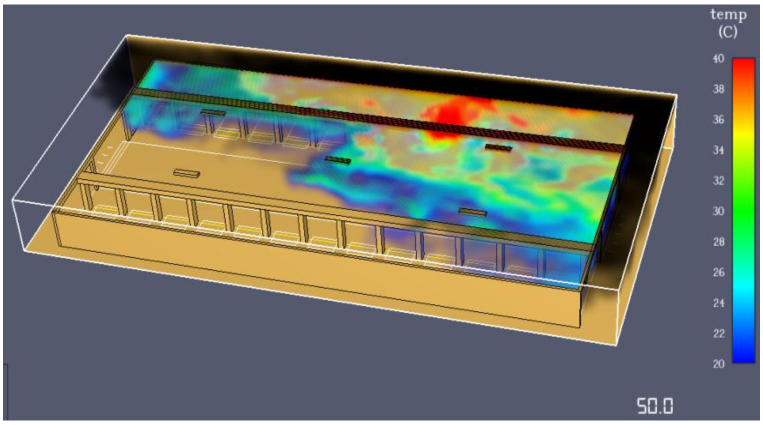

Figure 9 – The end of the simulation

4.3. Velocity and temperature in x direction (U Velocity)

The next figures show situations at the start, the middle, and at the end of the simulation. At the 3s is present developed flow profile of the fans. At the 25s is shown smoke on the exit of garage, which means jet fans are well designed and positioned.

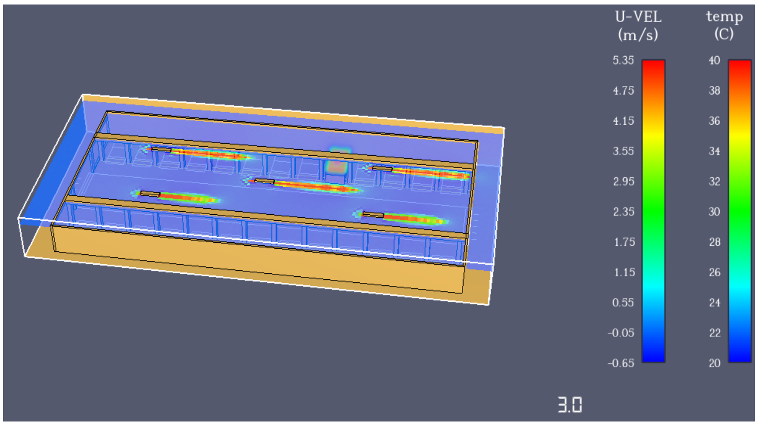

Figure 10 –The beginning of the simulation

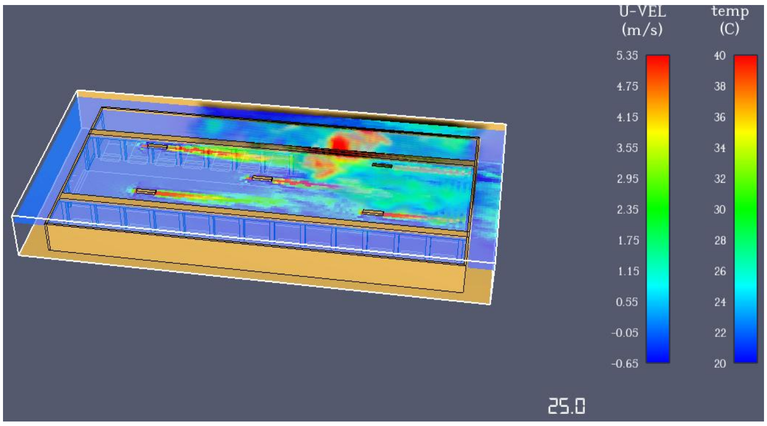

Figure 11 – Middle of the simulation

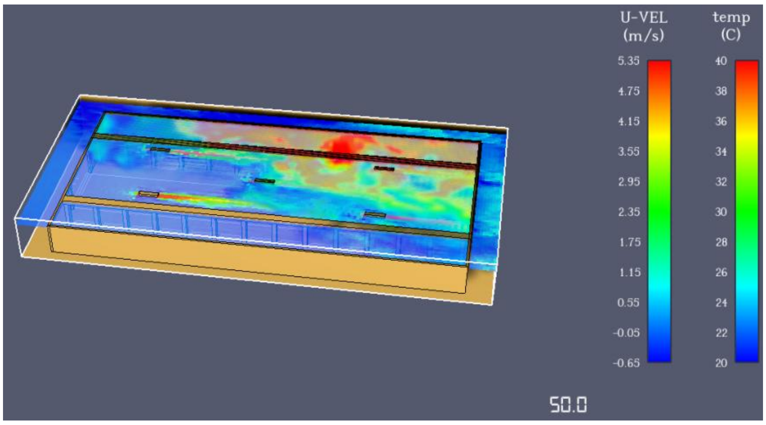

Figure 12 – The end of the simulation

5. CONCLUSION

Based on graphical results could be concluded that five jets with a length of 2 m and with a volume flow of 1.7 m3/s, could exhaust some smoke from the garage for the time of 50 seconds. If simulation time is larger all smoke could be exhausted. That is an idea for the future work of this simulation.

Burning car with standard dimensions, 5 m x 2 m, is dimensioned according to the standard BS 7346-7. The maximum heat release rate per unit area of a car is 500 kW/m2. Burning of the car is set at 180 s.

6. ACKNOWLEDGMENT

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7. REFERENCES

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