JET FAN SYSTEM IN CLOSED CAR PARKS

1. INTRODUCTION

The car parks whose total area of the open spaces on the external walls is less than 5%of whole car park area is defined as a closed car park and they require mechanical ventilation. Also, the carparks located underground are in the closed car park class because they don't have any open spaces.

Mechanical ventilation must be applied in closed car parks by taking all floors in car parks into consideration to exhaust dust, CO and other harmful gases generated by vehicles and provide daily ventilation. Required smoke exhaust air flow values are calculated by considering in case the fire occurs in the floor having the highest volume in order to create a proper jet fan system.

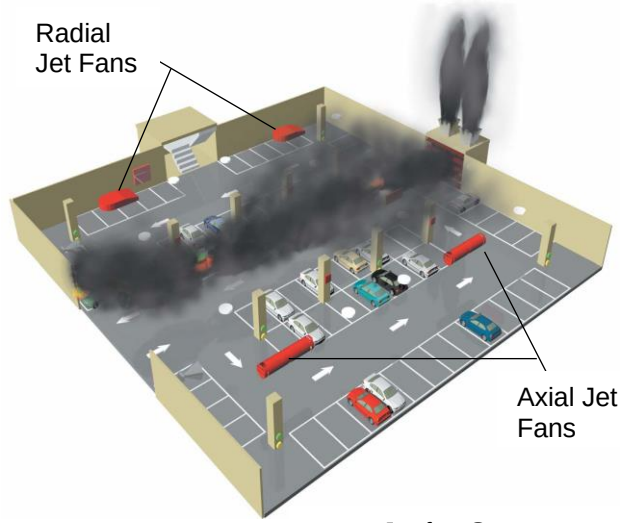
Mechanical ventilation and smoke exhaust system can be designed in two types in the closed car parks whose total are more than 2000 m2;

1- Ducted system which exhausts and supplies air through the ducts
2- Jet Fan System

Jet Fan System is going to be analyzed in this article.

2. FEATURES of JET FAN SYSTEM

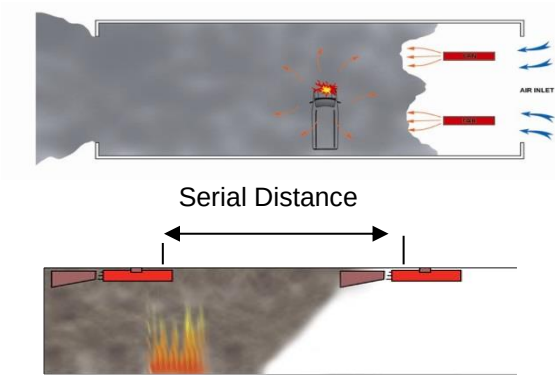
- Jet Fans move air mass in front of them by pushing and sweeping air in a wide area through their high thrust. They have a huge impact in a wide area by moving air around them.



Jet fan System
Image 1

Jet Fans are selected depending on their thrust value such as 20N, 30N, 50N, 80N and100N. They are selected also based on architectural design and their impact area to ensure there is no stagnant air in the car park(Image 2).

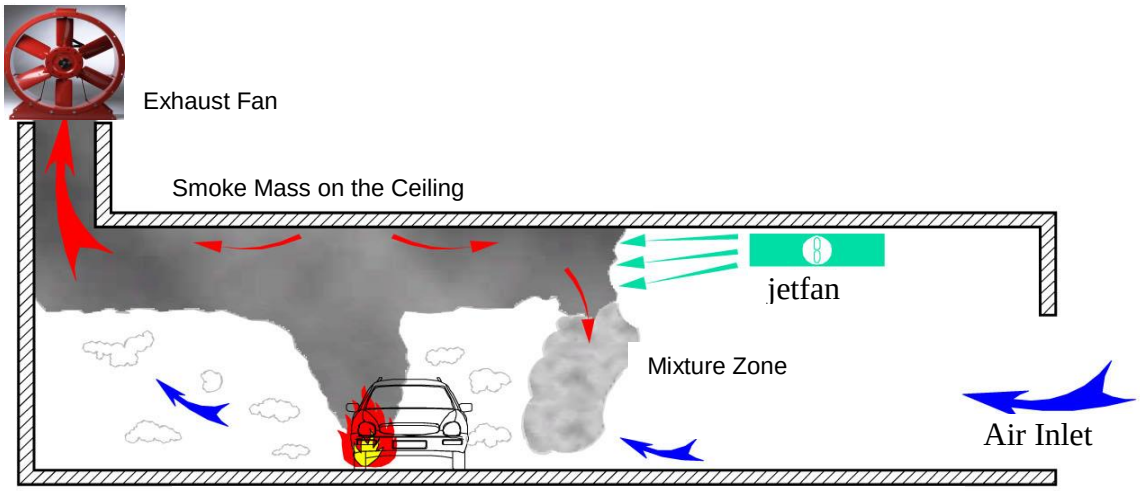
Thrust value (N):
Velocity at fan outlet (m/s) x Air flow value (m^3/s) x Air Density (kg/m^3)



Distance between Jet Fans
Image 2

Thrust Value	Parallel Distance	Serial Distance
30N	8-10 m	20 m
50N	15 m	35 m
80N	15-17 m	50 m
100N	15-20 m	70 m

Jet Fans move dust, CO and other harmful gases to shaft extract points in order to prevent spread of fire (Image 3)



Jet Fan Working Principle
Image 3

- Jet Fans reduce the density of CO and other harmful gases by fresh air to enable that there is no stagnant air in the car park.
- Required exhaust capacity for daily ventilation is calculated by considering in case there is pollution in all floors of the car park. Calculation method differs depending on relevant country and standard.
  6 air changes in an hour are required in the BS 7346-7 standard in England.
  12 m3/h-m2 for commercial buildings and 6 m3/h-m2 for residential buildings are used in the VDI 2053 standard in Germany to find out the required capacity. Alternatively, CO emission values can be used in this standard as well.
  12 m3/h-m2 for commercial buildings and 6 m3/h-m2 for residential buildings are used in the TS 3419 standard in Turkey to find out the required capacity.
- The speeds of jet fans, smoke exhaust fans and fresh air fans are adjusted depending CO level signal received by CO sensors placed in the whole car park(approximately a piece in each 400 m2, 1,5 m height from floor)
- The car park must be divided into fire zones and each zone must have at least an extract shaft or open space to exhaust the smoke.

- BS 7346-7;

1- <u>Smoke reducing and exhaust system with 10 air changes in an hour:</u>

Fire zones can't be more than 5000 m2 in this jet fan system. The smoke spreads in a wide area but visibility is high and smoke temperature is low because the smoke density is reduced. For example; required minimum exhaust air capacity for a fire zone with 60m *80m*3m dimensions (width, length, height) is 60m x 80m x 3m x 10 air changes/per hour = 144.000 m3/h.

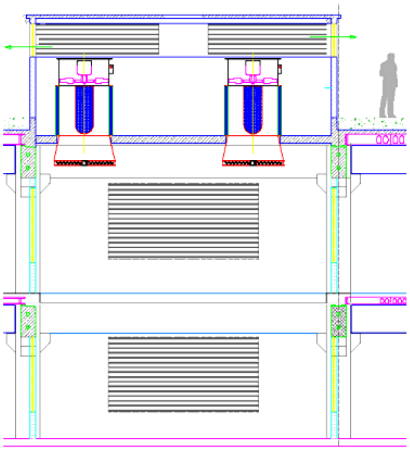
The jet fan system with 10 air changes per hour is applied in the general-purpose car parks. The investment and operating costs are low. Daily ventilation and smoke exhaust of the car parks are carried out fast with low energy consumption.

2- <u>Heat and Smoke Control System:</u>

Fire zones can't be more than 2000 m2 in this jet fan system. The air velocity at the fire area section without considering the impact of the jet fans must be at least 1 m/s. For example; required minimum exhaust air capacity for a fire zone with 40m *50m*3m dimensions (width, length, height) is 120 m^2 x 1m/s x 3600 s/h = 432.000 m^3/h.(The section area is 40m x 3m = 120 m^2)

This jet fan system can be selected if it requested by the client or high fire security requirements for the building are necessary. The fire is restricted in a small area with certain boundaries. The escape ways are protected from smoke but the investment and operating costs are high.

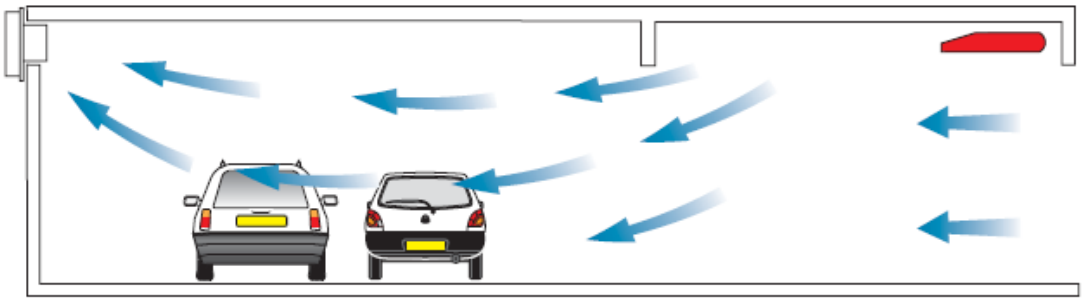
- Smoke exhaust fans, that are located on extract shafts built vertically throughout car park floors height, are used commonly for all floors in the multi floor closed car parks. Air dampers located on the extract shafts can be held in open position but if there are some floors with no cars in the closed car park, air dampers can be closed to decrease air flow volume of main smoke exhaust fans for energy saving.



Extract shaft and main smoke exhaust fans
Image 4

- In case a fire occurs, the air dampers of relevant extract shafts in the floor where the fire started must be open and the air dampers in other floors must be closed.
- Required smoke exhaust capacity must be provided by at least two fans at each extract shaft of fire zones. In case one of main smoke exhaust fans stops working, other fan keeps working with %50 of required capacity. One way dampers or motorized back draft dampers must be placed on main smoke exhaust fans to prevent short circuit of exhaust air.

- Required fresh air volume in line with exhausted air volume must be supplied in closed car parks. At least %80 of exhausted air volume must be supplied in car parks for proper daily ventilation. The car park is kept under negative pressure to prevent passing of harmful gases and dusts to other areas of the building.
- Air speed on the ramps and escape ways during a fire must not exceed 5 m/s and supply air speed must not exceed 2 m/s.
- The jet fans only in the fire zones run during a fire, other jet fans do not work. Thus, smoke spread to other zones is prevented.
- The jet fans increase visibility of the firemen by moving smoke and heat from fire zones fast and so they can approach to the fire zone up to 10 m distance. Thus, the firemen can extinguish fire in a short time so whole car park doesn't get damaged.
- Installation and commissioning are faster so jet fan system provides time and work force saving.
- It does not coincide with the other mechanical and electrical equipment since there is no ductwork.
- Service, maintenance and repair are easier since the jet fans can be easily reached by the workers. However, internal and external cleaning of ducts is hard and over costing.
- Installation of jet fans between downstream beams reduces height of car park floors so construction costs get lowered.



- There is not any loss of parking area since there is no vertical ductwork. Thus, number of parking spots increase compared with the conventional system.
- Total fan power is less since there is no duct pressure loss. Total energy consumption is 40% less than the conventional system.
- Emergency power generator will be smaller with lower cost because total installed system power is lower.

3. FANS

3.1 SMOKE EXHAUST FANS

- Smoke exhaust fans must be F400 or F300 certified harmonized with EN12101-3
- Electrical motors must have IP 55 protection class and H class insulation
- They can be in axial or radial types. However, axial type fans are preferred because they can run in both ways and their installation on extract shafts is easier.
- Inlets and outlets of main smoke exhaust fans must have wire guard to prevent entrance of harmful materials that can harm successful operation of the fans.

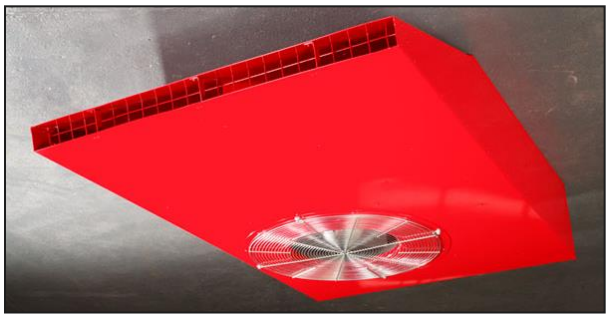
3.2 AXİAL JET FANS

- Axial Jet Fans must be F400 or F300 certified harmonized with EN12101-3
- Axial Jet Fans must have a circular silencer at both sides to provide a laminar air flow besides reducing noise level.(Image 5)
- Axial Jet Fans must have a maintenance and repair switch
- Uni-directional and reversible models provide flexibility for jet fan layout in a car park
- Uni-directional axial jet fans have a deflector at the outlet and a zinc plated guard at the inlet. Reversible axial jet fans have a deflector at both ends
- Fan impellers are cast aluminum and aerodynamic profiled
- Electrical motors must have IP 55 protection class and H class insulation
- Fan Casing is hot dip galvanized sheet metal or epoxy coated
- Axial Jet Fans provide energy saving due to their two-speed motor

Axial Jet Fan
Image 5

3.3 RADIAL JET FANS

- Radial Jet Fans must be F400 or F300 certified harmonized with EN12101-3
- Radial Jet Fans must have a maintenance and repair switch
- Radial Jet Fans are ideal for height restricted car parks due to their low casing height that is less than 350 mm(Image 6)
- Backward curved blade radial fans allow less turbulence of air
- Radial Jet Fans provide energy saving due to their two-speed motor



Radial Jet Fans
Image 6

4. INSTALLATION and COMMISSIONING

- There must be enough exhaust and supply distance between downstream beams and inlets and outlets of jet fans.

H (mm)	L min. (mm)
400	2000
500	2500
600	3000

Image 7

- Jet Fans must be hanged down with a proper construction to get rid of the obstacles in front of them if sufficient distances are not provided.(Image 8)

Image 8

- Sprinkler headings must not exist in front of inlets and outlets of jet fans because if sprinkler headings are exploded, water mass would prevent air movement(Image 9)

Image 9

- Mechanical and electrical equipment on the ceiling must not prevent air movement
- Required smoke exhaust capacity must be provided by at least two fans at each extract shaft of fire zones according to the standard.(Image 10)

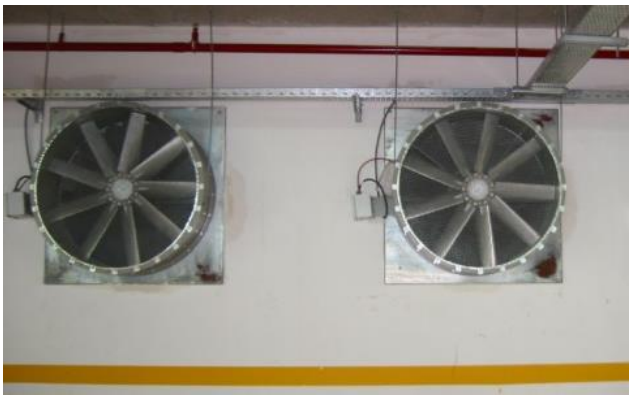


Image 10

- There must not be any obstacles at least one radius distance in front of inlets and outlets of axial fans
- Motorized back draft dampers must be placed on each main smoke exhaust fans to prevent short circuit of exhaust air in case one of the fans stops working. If one of the fans breaks down, the air damper should be closed.
- The motors used in air dampers must be On/Off Type.
- All mechanisms must be checked whether they are squashed into due to installation error, mortar or paint.(Image 11)

Image 11

5. AUTOMATIC CONTROL SYSTEM and MCC PANELS

- MCC Panels must be placed in the fire resistant rooms.
- Jet Fan System Control Panels must be integrated with both CO and Fire Panel and all scenarios must be checked out.
- Smoke Exhaust Fans and Fresh Air Fans must be run by frequency invertors.(Image 12)
- Main axial smoke exhaust fans must run at maximum speed in case of a fire.
- Exhaust directions of main axial smoke exhaust fans must be controlled separately to run directly or with frequency ınvertors.
- Each fan must be run individually by the control panel to ensure that correct fan/damper is running according to the project.
- Jet Fans must be run by checking exhaust and revolution ways at low and high speeds. One of common problems during installation of jet fan system is that high and low revolution speed

connections of jet fans are mixed. Also, accuracy of exhaust direction of jet fans must be controlled.

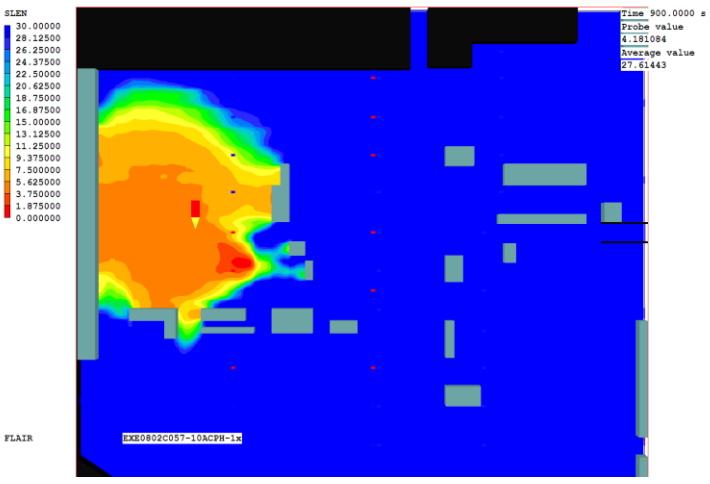
- Frequency convertors provide energy saving by regulating capacity and direction of main axial smoke exhaust fans according to CO level.
- There must be a manual emergency start button on the MCC Panel. When it is activated, all fans belonged to relevant MCC panel run at maximum speed in the exhaust direction.

Image 12

6. CFD (Computational Fluid Dynamics) ANALYSIS

Design control of Jet Fan System is conducted through CFD Analysis by making computational simulation of a fire process over time conducted according to a critical fire starting point in the car park.(Image 13) Temperature, smoke distribution and air speed over time are illustrated in the CFD Analysis according to a burning car whose total fire potential is 4MW.

It can be conducted for jet fans systems with 10 air changes per hour upon client request. CFD Analysis must be conducted for jet fans systems with Heat and Smoke Control. If the fire department approves CFD Analysis conducted for jet fans systems with Heat and Smoke Control, it is possible not to build a Sprinkler System in the car parks in some European countries.



CFD Analysis for 4 MW smoke distribution
Image 13

7. RESULT

Jet Fan System, which provides mechanical, electrical and architectural advantages, is a reliable, environmental friendly and energy saving daily ventilation and smoke exhaust system.

8. REFERENCES

(1) Türkiye Yangından Korunma Yönetmeliği, 2002
(2) BS 7346-7:2006, Components for smoke and heat control systems
(3) VDI-Handbuch Raumlufttechnik, VDI 2053 Air treatment systems for car parks, 2004
(4) Car Park Ventilation – An Application Guide, Eltafans, 2008
(5) CAR Park Ventilation System, Colt, 2007