KAPALI ORTAMLARDA HAVALANDIRMANIN BULAŞ RİSKİNİN AZALTILMASINA YÖNELİK TASARIMI

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KAPALI ORTAM NEDİR?
BULAŞ RİSKİ NEDEN YÜKSEKTİR?

Duvar etkisi

Türbülans

Akış-kirletici etkileşimi

Menfez

Çözümleme

Doğrulama

Yöntem bilgisi

AKIŞI YÖNETEN DENKLEMLER

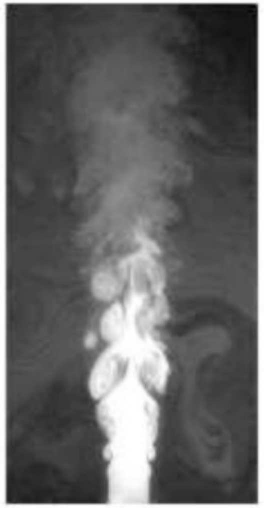
- Taşınım
- Yayınım
- Yayılım ….DUVAR

$$\underbrace{\rho\,(\partial v_i)/\partial t}_{eylemsizlik} + \underbrace{\rho\, v_j \frac{\partial v_i}{\partial x_j}}_{taşınım} = \underbrace{-\frac{\partial p}{\partial x_i}}_{kaynak} + \underbrace{\mu \frac{\partial^2 v_i}{\partial x_j \partial x_j}}_{yayılım} + \underbrace{\rho f_i}_{kaynak/kuyu}$$

$$\rho c_p\left(\frac{\partial T}{\partial t} + v_i \frac{\partial T}{\partial x_i}\right) = \phi + \frac{\partial}{\partial x_i}\left(k \frac{\partial T}{\partial x_i}\right) + q'''$$

$$\Phi = 2\mu S_{ij} S_{ij}$$

TÜRBÜLANS VE DUVAR



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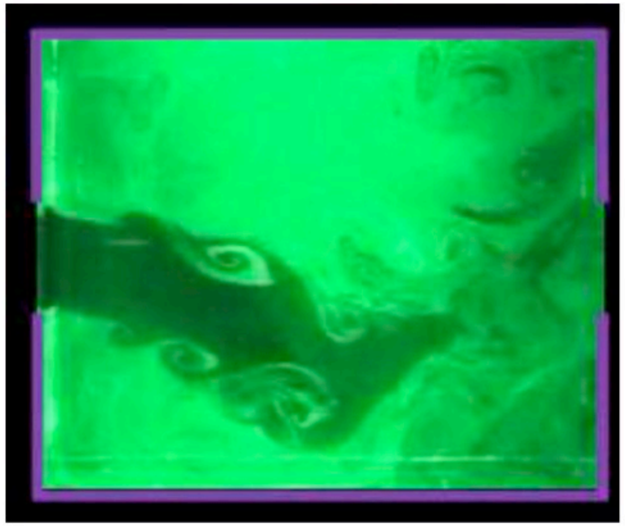

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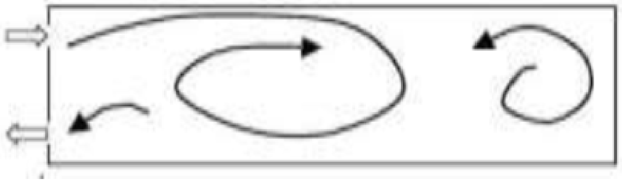

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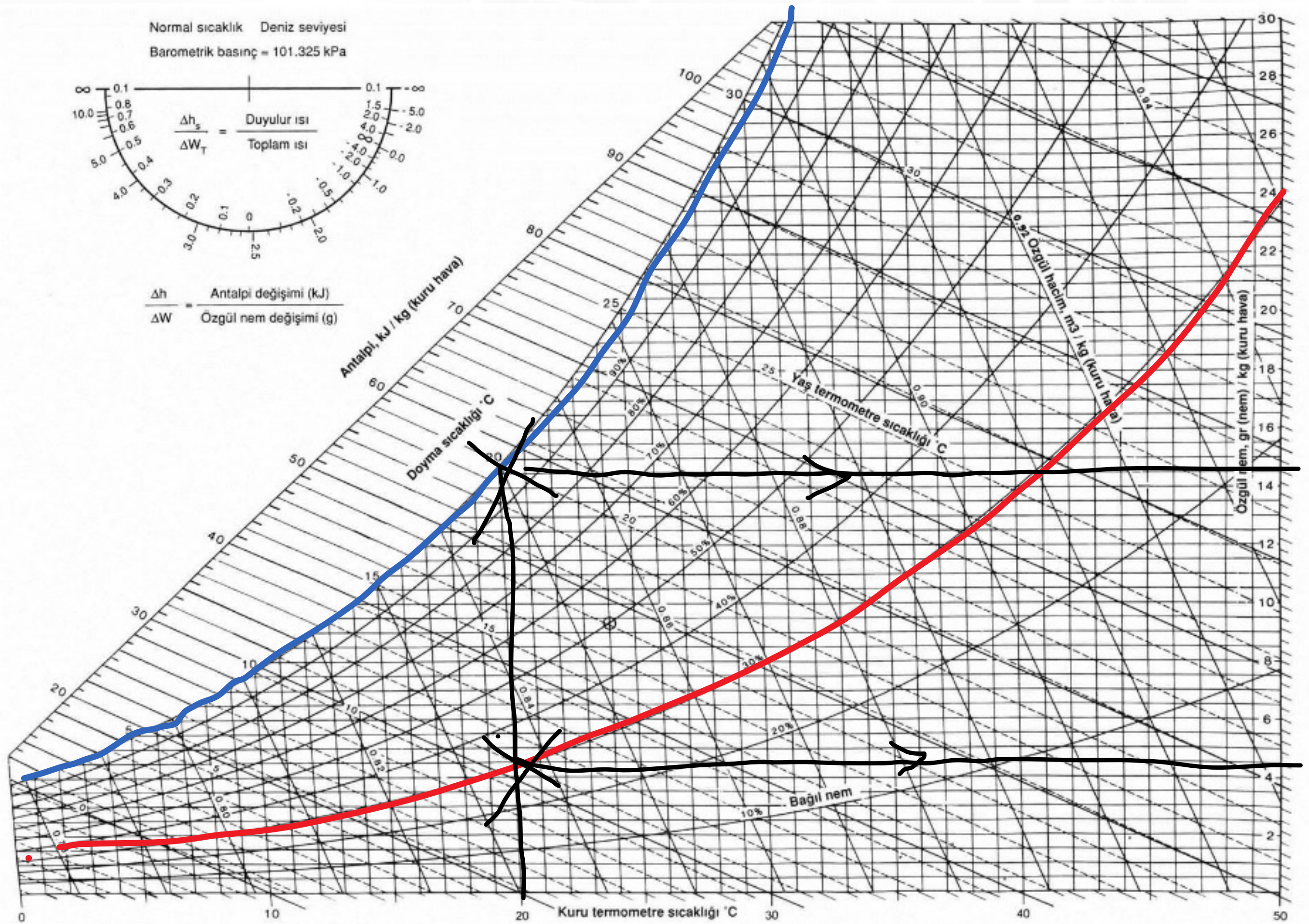
*Schiestel, 2008. **Tominaga and Blocken, 2016, ***Tapsoba et al., 2007

İKLİMLENDİRME VE VİRÜSLÜ DAMLACIĞIN BUHARLAŞMASI

- i-) sıvı durumdaki damlacık
- ii-) oluşan su buharı
- iii-) bozunan virüs zarfı

$$\frac{\partial C}{\partial t} + v_i \frac{\partial C}{\partial x_i} = S + \frac{\partial}{\partial x_i}\left(D \frac{\partial C}{\partial x_i}\right)$$



DAMLACIĞA LAGRANJİYEN YAKLAŞIM

- $\frac{d\overrightarrow{u_p}}{dt} = F_D(\vec{u}\text{-}\vec{u}_p)+\frac{\vec{g}(\rho_p-\rho)}{\rho_P}+\vec{F}$

$$F_D=\frac{18\mu}{\rho_p d_p^2}\frac{C_D Re}{24}$$

$$Re\equiv\frac{\rho d_p\left|\vec{u}_p-\vec{u}\right|}{\mu}$$

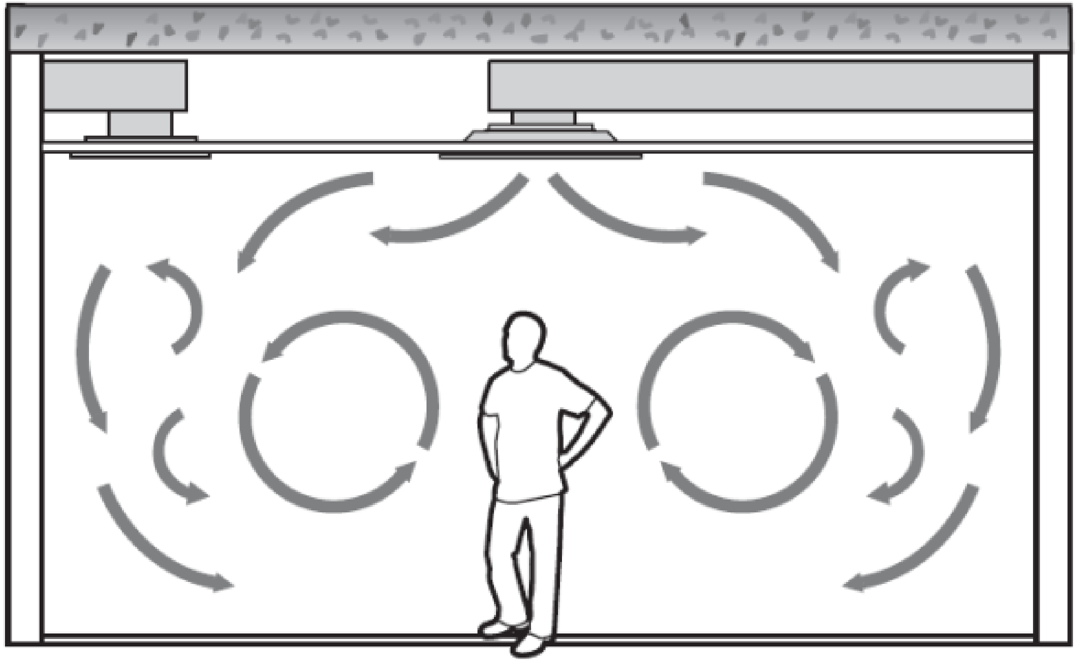
Sıvı damlacık:
Parçacık çapı: 3 µm
Parçacık hızı<<Akış hızı
O(Re)=10^{-1} Doğal
O(Re)=10^{0} Zorlanmış

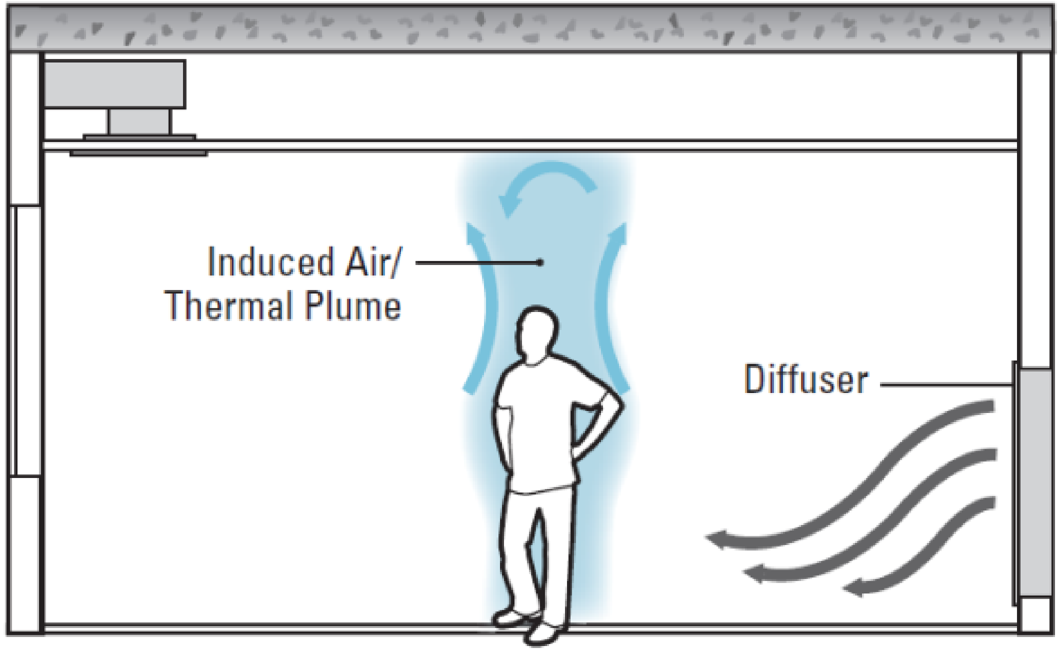
$$\vec{F}=\frac{2K\nu^{1/2}\rho d_{ij}}{\rho_p d_p(d_{lk}d_{kl})^{1/4}}\left(\vec{u}-\vec{u}_p\right)$$

Saffman kaldırma kuvveti *

* Saffman, 1965. (ANSYS, 2020den aktarıldı).

HAVALANDIRMA YÖNTEMLERİ





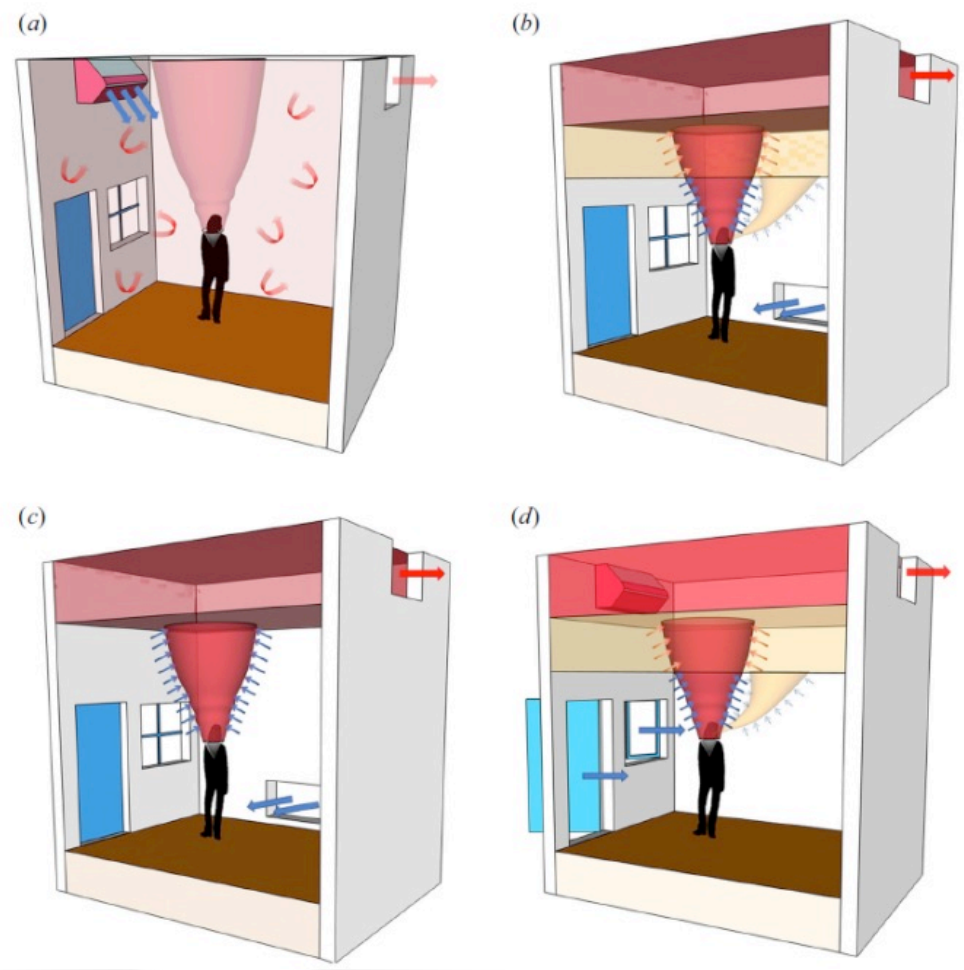
Price Industries Engineering Guide-
Displacement Ventilation

BULAŞ RİSKİ ve WELLS-RILEY EŞİTLİĞİ

$$P = \frac{n_I}{n_S} = 1 - \exp\left(-\frac{q}{Q}\Gamma t_S\right),$$

1978

$$\Gamma = \sum_{i=1}^{n_E} \gamma_i)$$



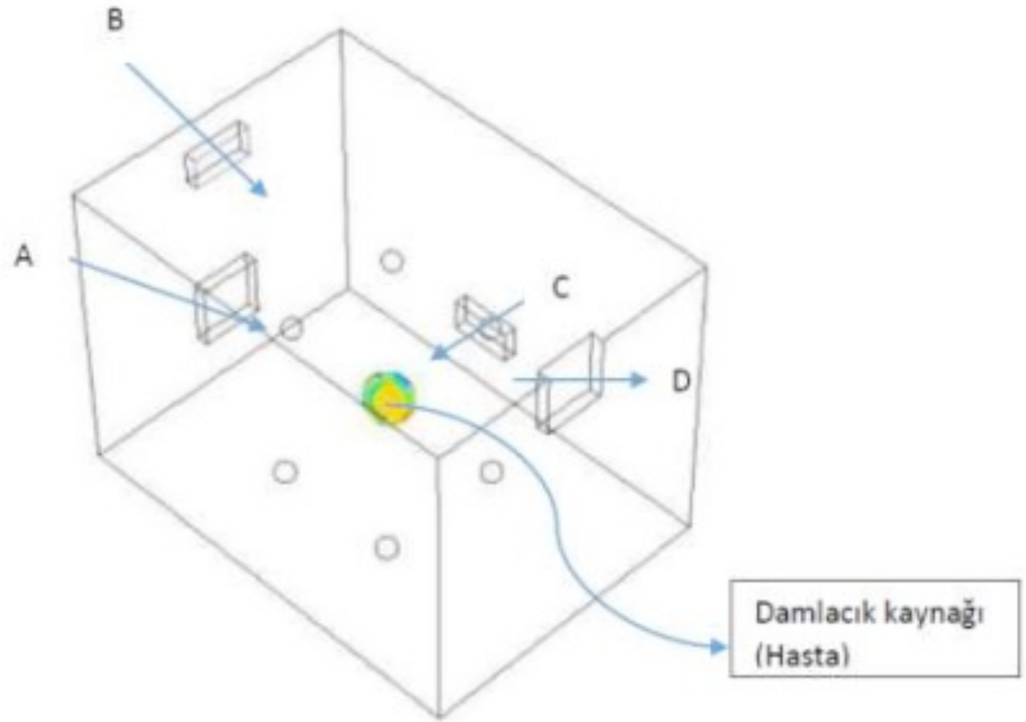
10 l.s.p

q: verilen nefes debisi [m^3/s]
Q: taze hava debisi [m^3/s]
I: Bulaş olması beklenen
S: Duyarlı
E: virüs yayan
Γ: Toplam virüs yayma hızı

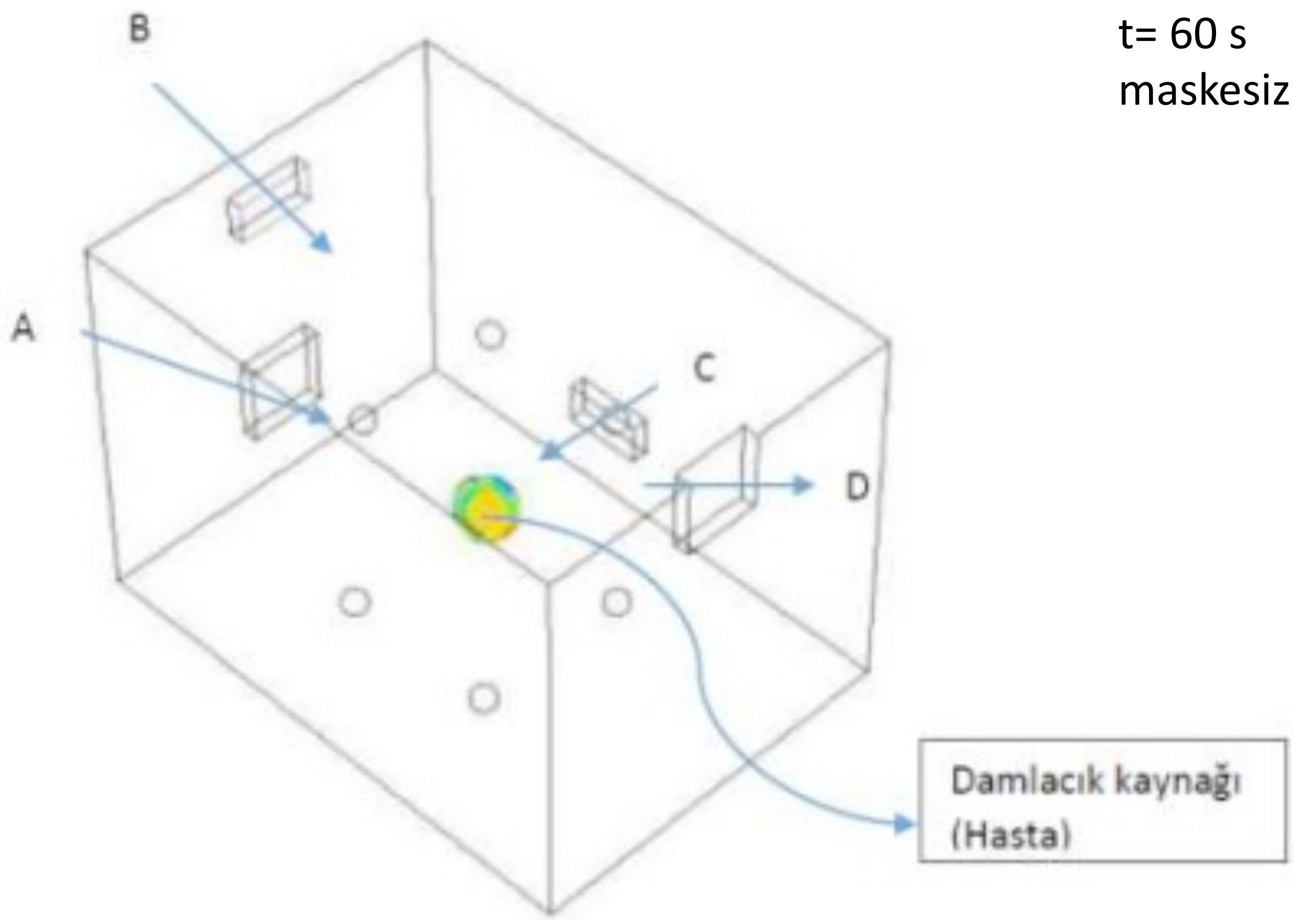
Bhagat et al. 2020

MODEL

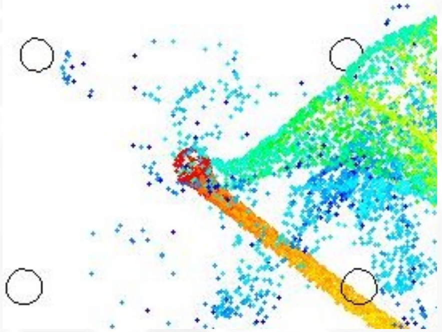
- Virüs yükü…Parçacık sayısı
- Parçacıkların terketme oranı ve izledikleri yolların uzunluğu



SOLUK VERME İLE YAYILAN DAMLACIKLAR

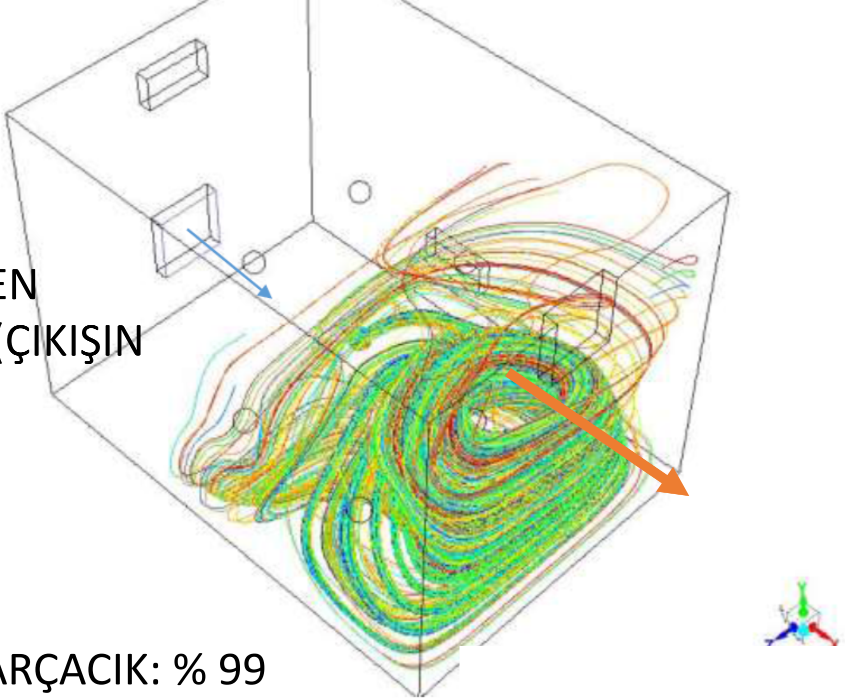


t= 60 s
maskesiz



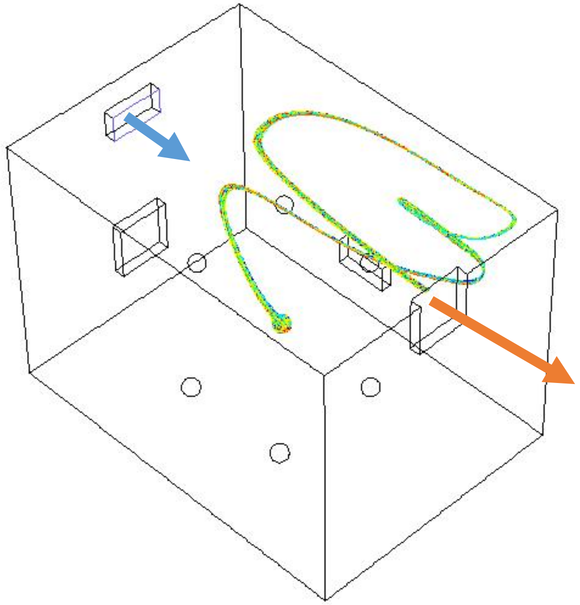
-Virüs içeren damlacıkların çapı: 3 µm (* Bhagat et al., 2020)
-Damlacık debisi: 10^-03 kg/s

A: PENCEREDEN DOĞAL GİRİŞ (ÇIKIŞIN KARŞISINDA)



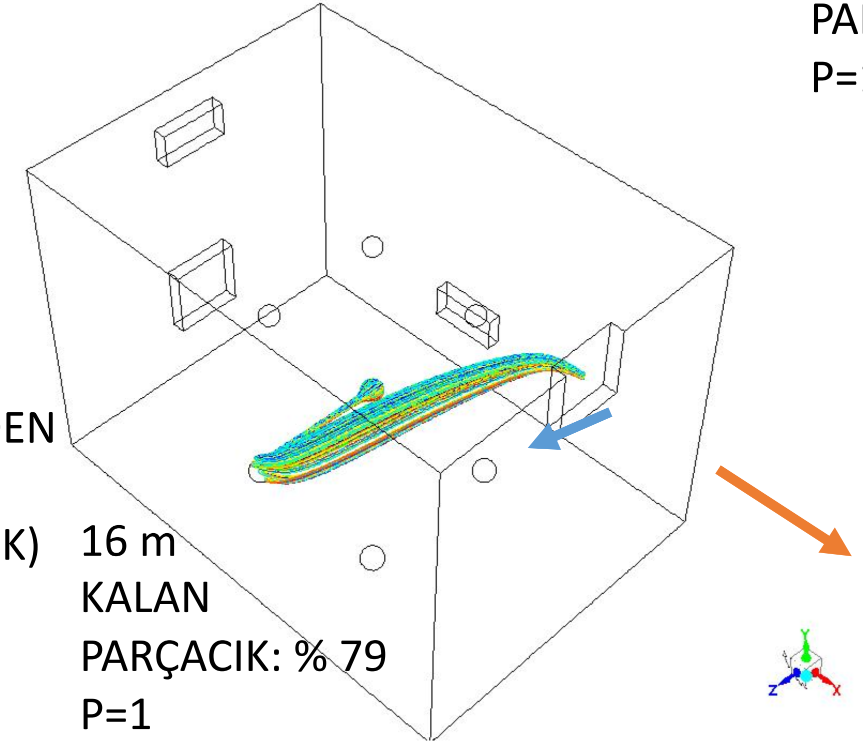
L = 21 m
KALAN PARÇACIK: % 99
P=1

B: ÜST MENFEZDEN GİRİŞ (ÇIKIŞIN KARŞISINDA)



22.5 m
KALAN PARÇACIK% 100
P=1

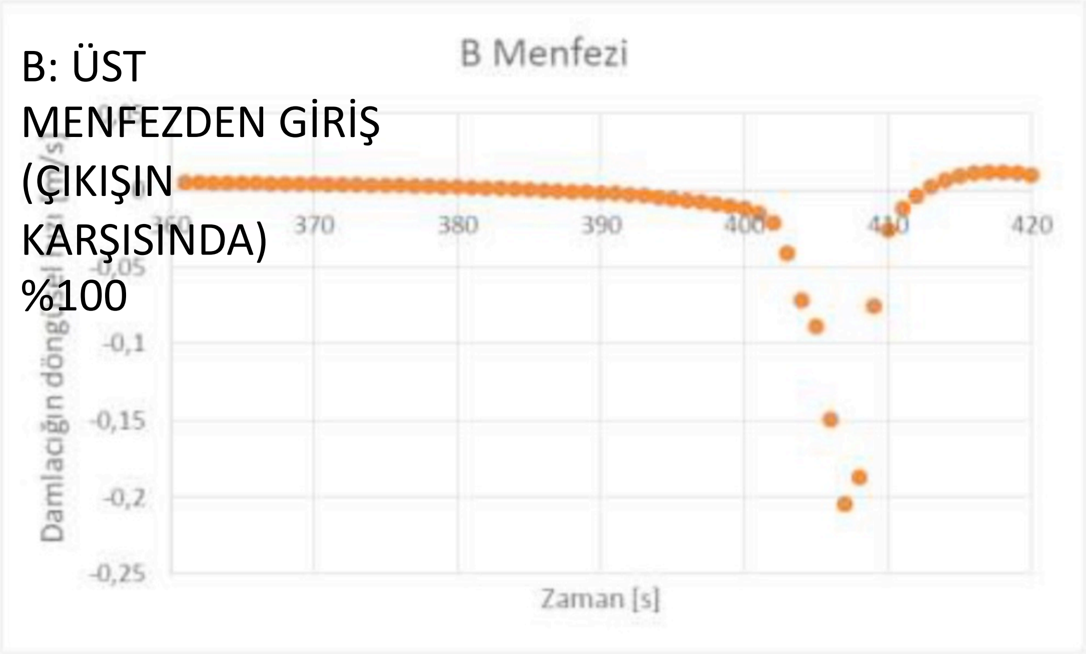
C: ALT MENFEZDEN GİRİŞ (ÇIKIŞA DİK)



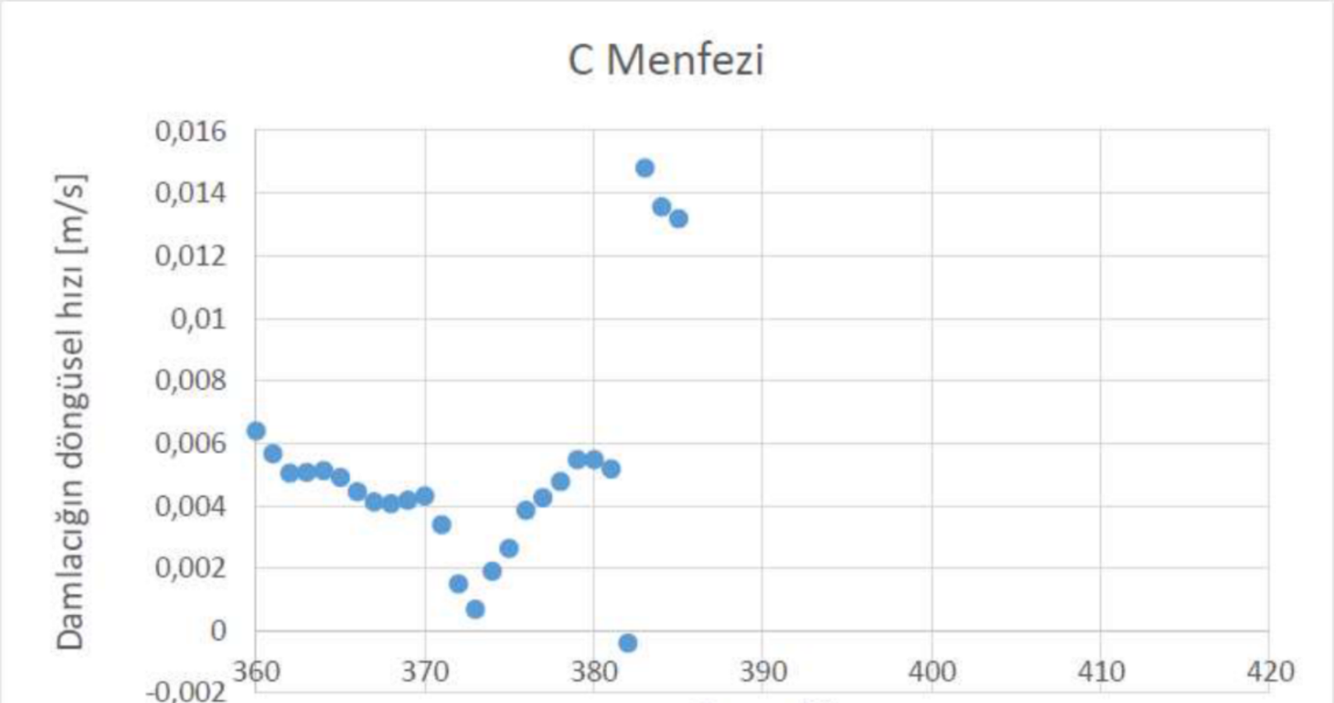
16 m
KALAN PARÇACIK: % 79
P=1

A: PENCEREDEN DOĞAL GİRİŞ (ÇIKIŞIN KARŞISINDA)
%99

B: ÜST MENFEZDEN GİRİŞ (ÇIKIŞIN KARŞISINDA)
%100

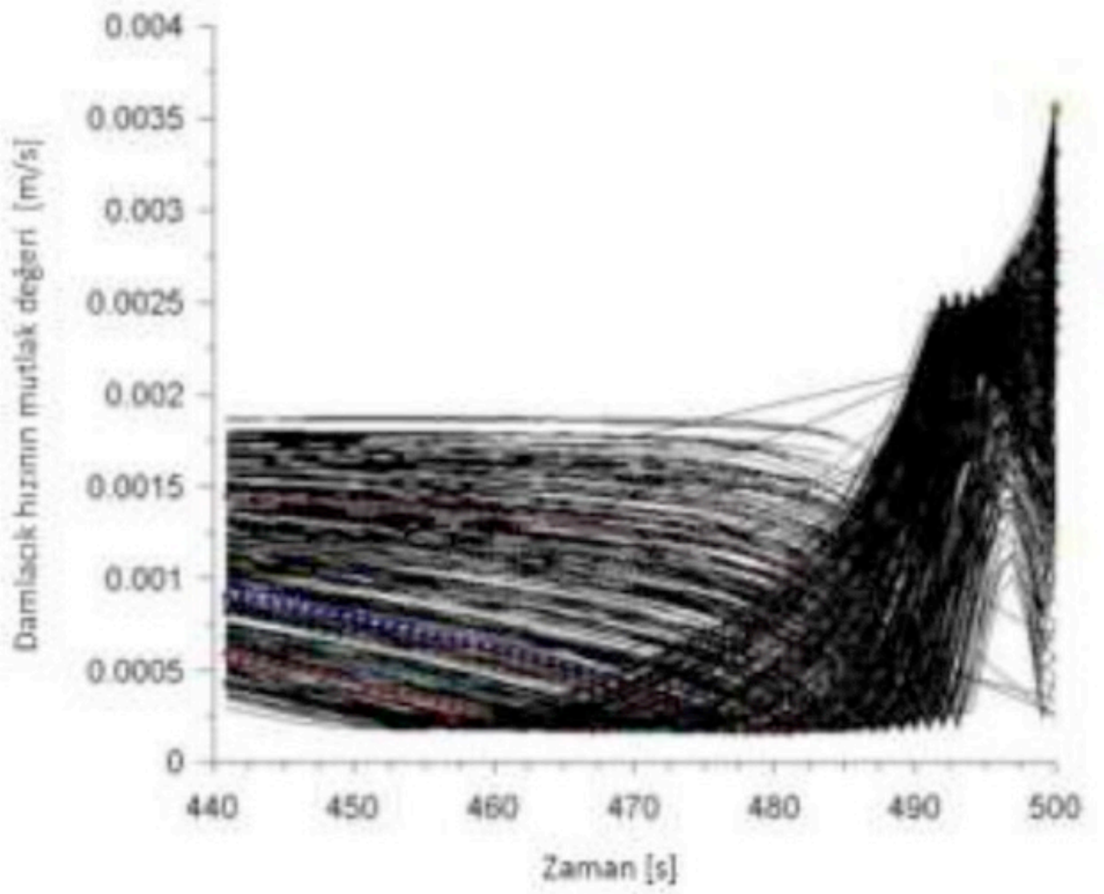


C: ALT MENFEZDEN GİRİŞ (ÇIKIŞA DİK)
%79

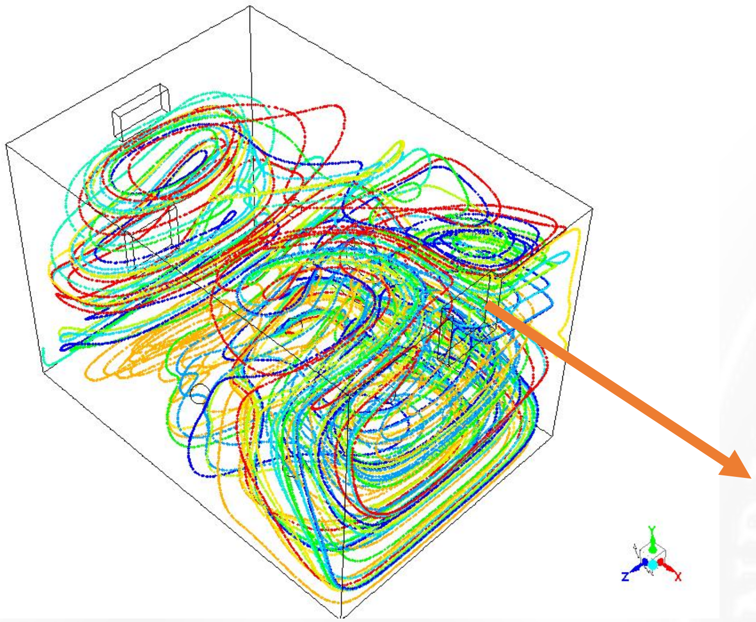


İSTATİSTİK ÇÖZÜMLEME

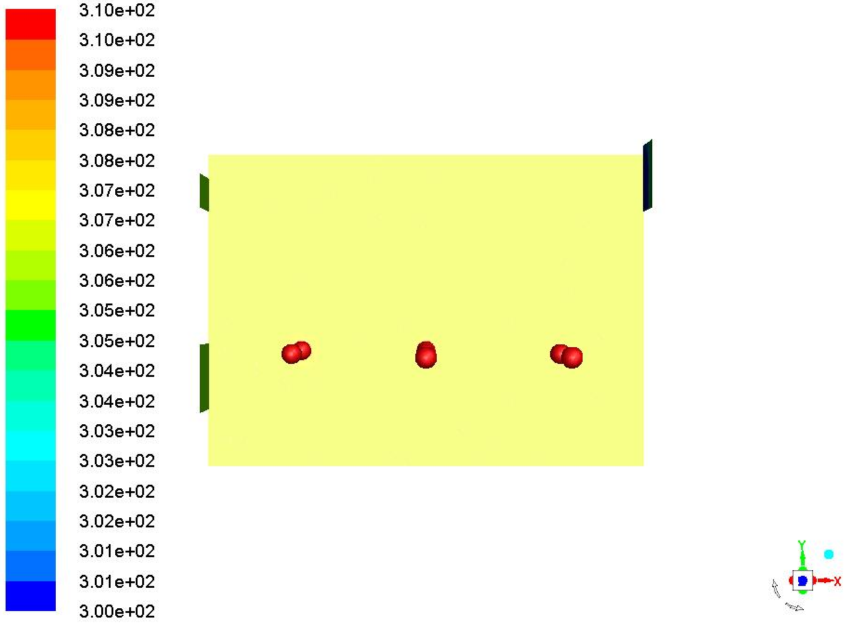
TÜM MENFEZLER
KAPALI,
ÇIKIŞ MENFEZİ AÇIK

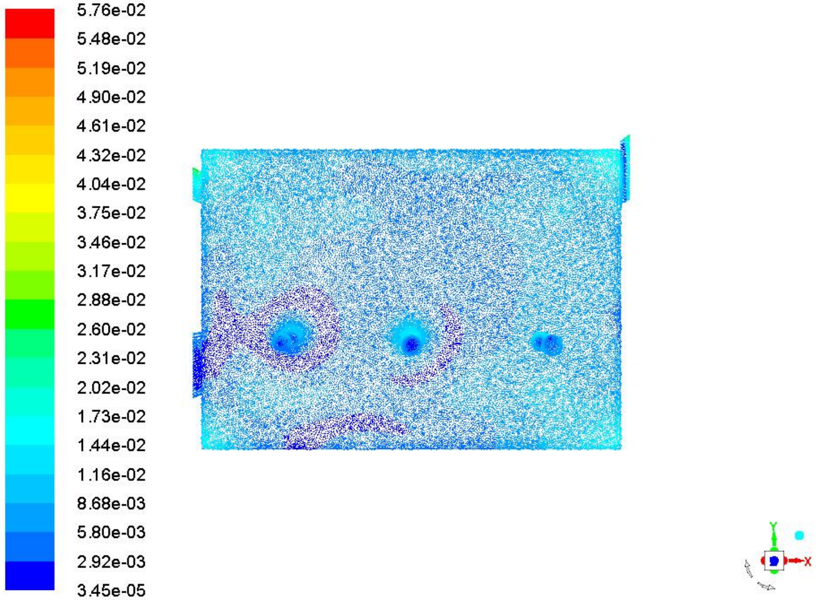


TÜM MENFEZLER
KAPALI,
ÇIKIŞ MENFEZİ AÇIK



L = 9 m
KALAN PARÇACIK: % 99.2
P=1

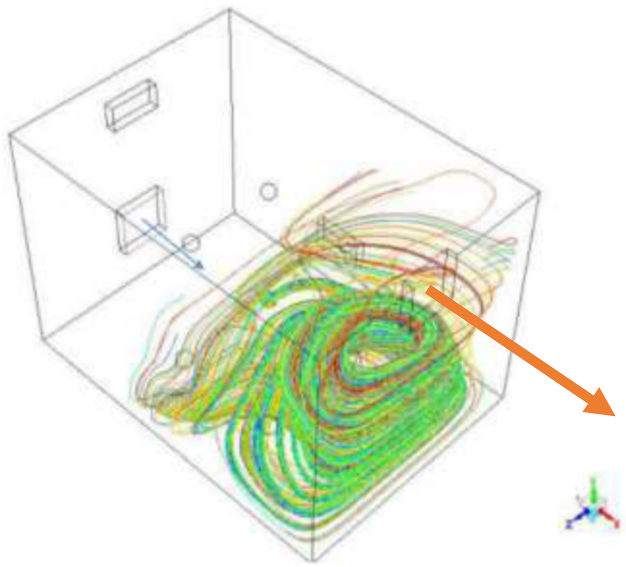


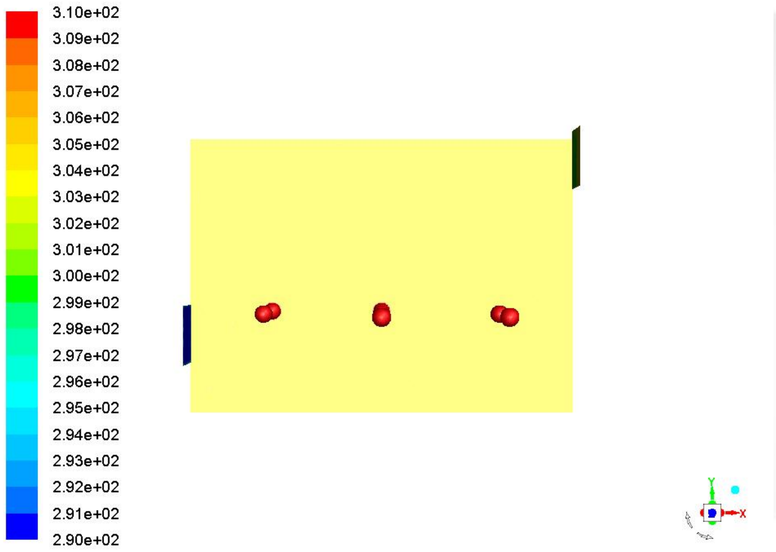


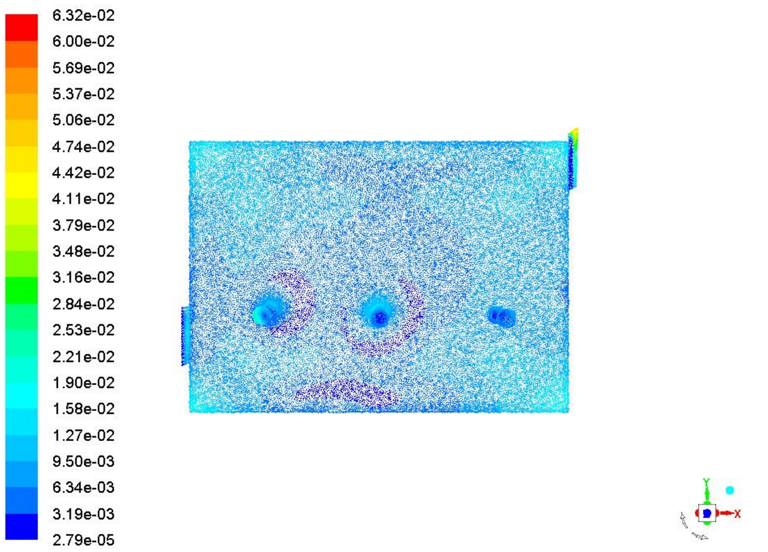
A: PENCEREDEN DOĞAL GİRİŞ (ÇIKIŞIN KARŞISINDA)

YÜK ORANI: % 38

21 m
% 99
P=1



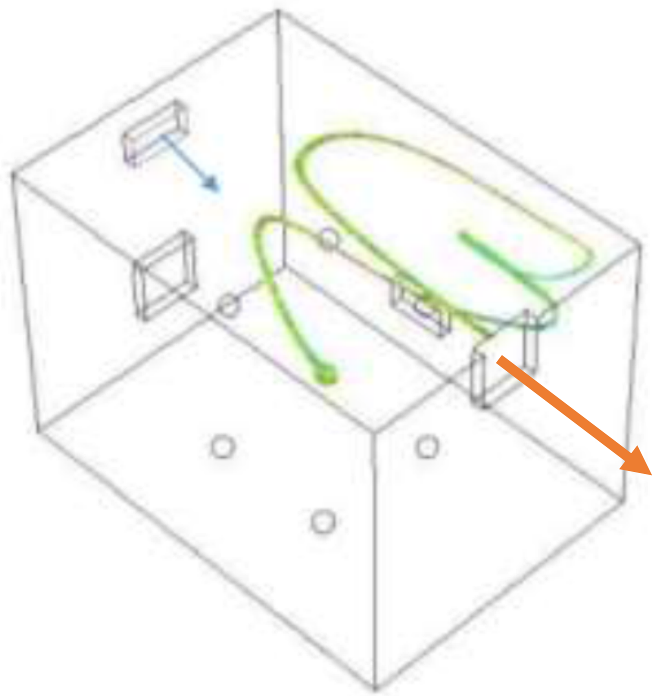


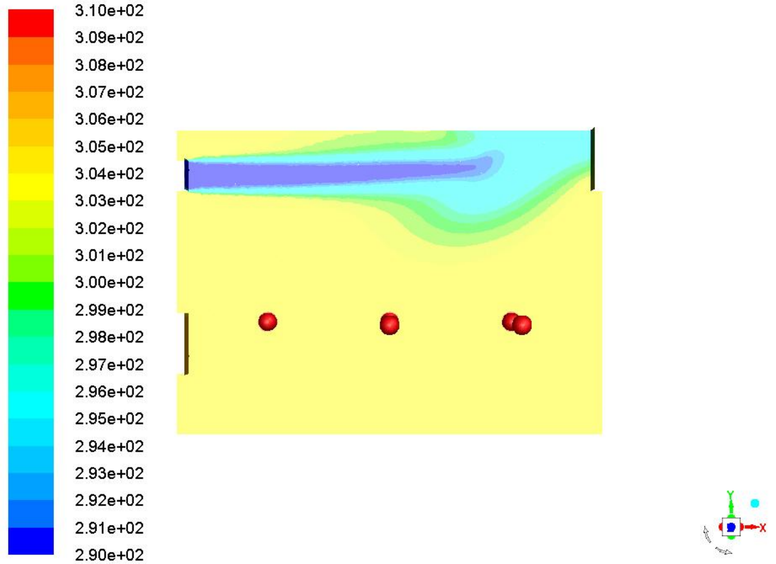


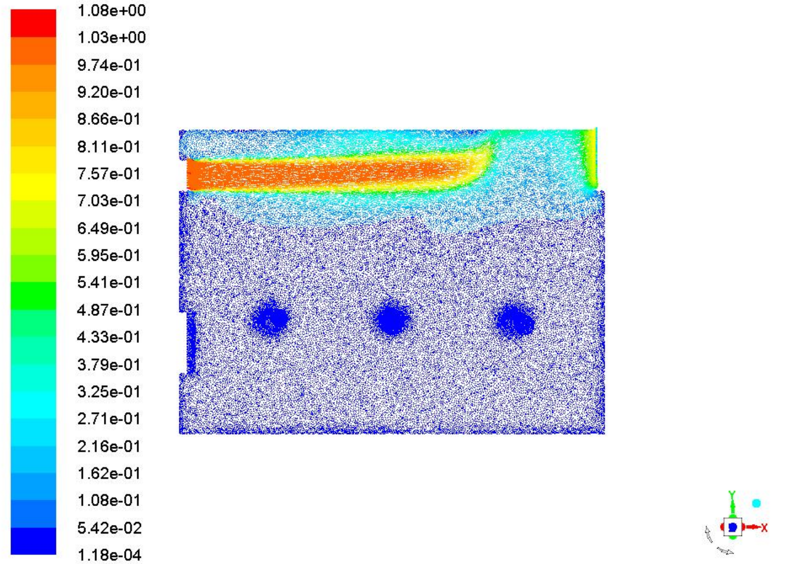
B: ÜST
MENFEZDEN GİRİŞ
(ÇIKIŞIN
KARŞISINDA)

YÜK ORANI: % 100

22.5 m
% 100
P=0.99

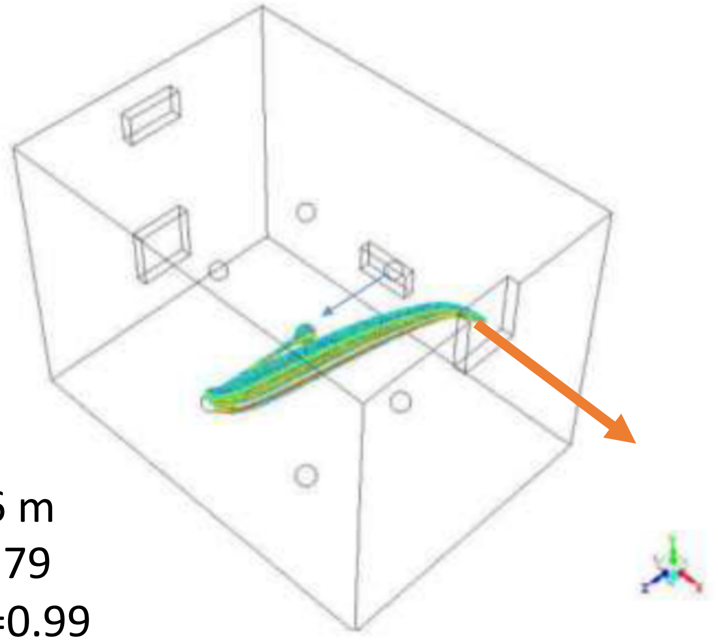




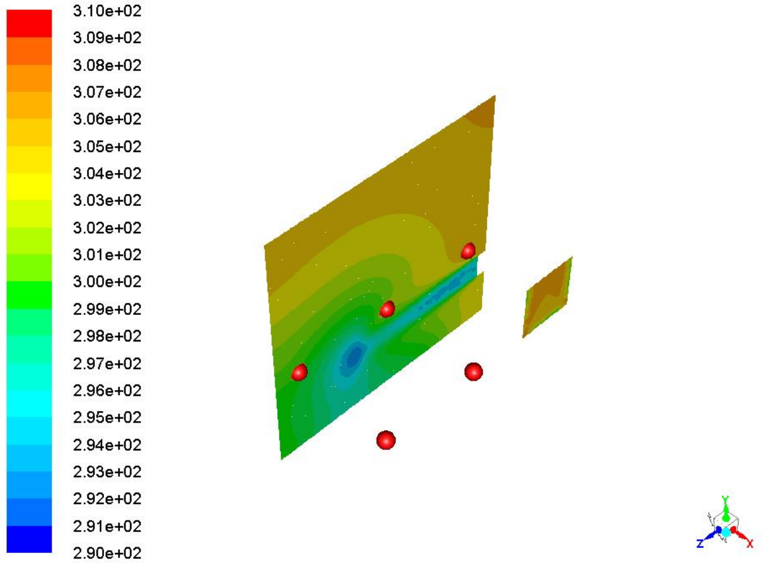


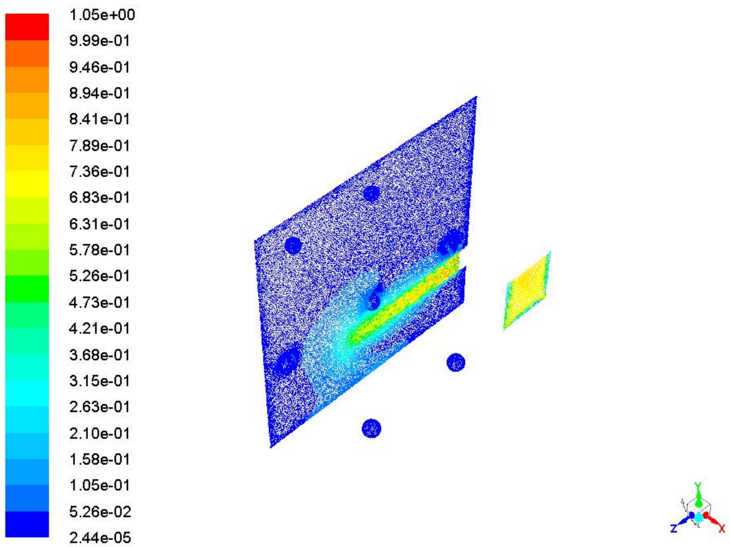
C: ALT MENFEZDEN GİRİŞ (ÇIKIŞA DİK)

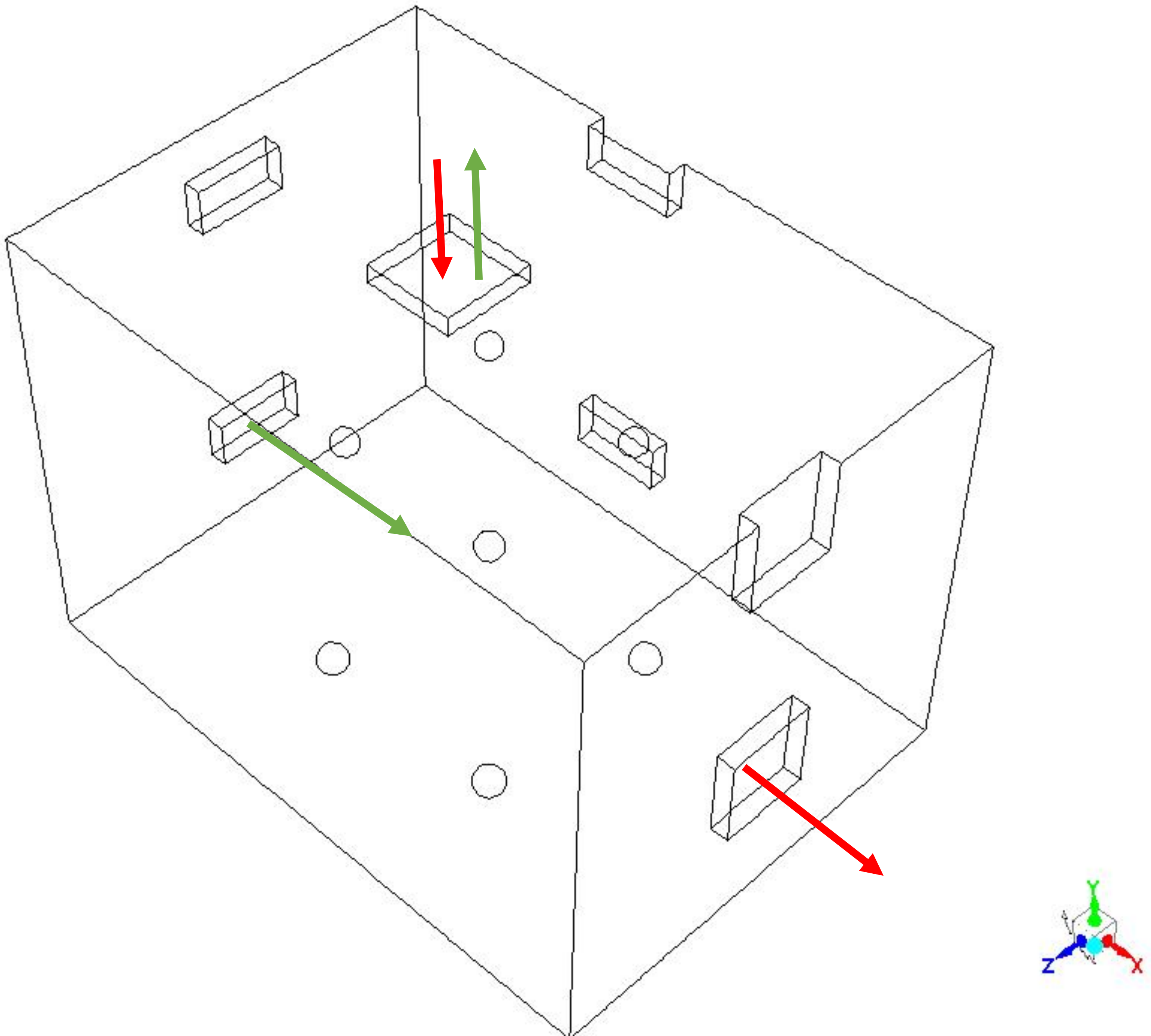
YÜK ORANI: % 65

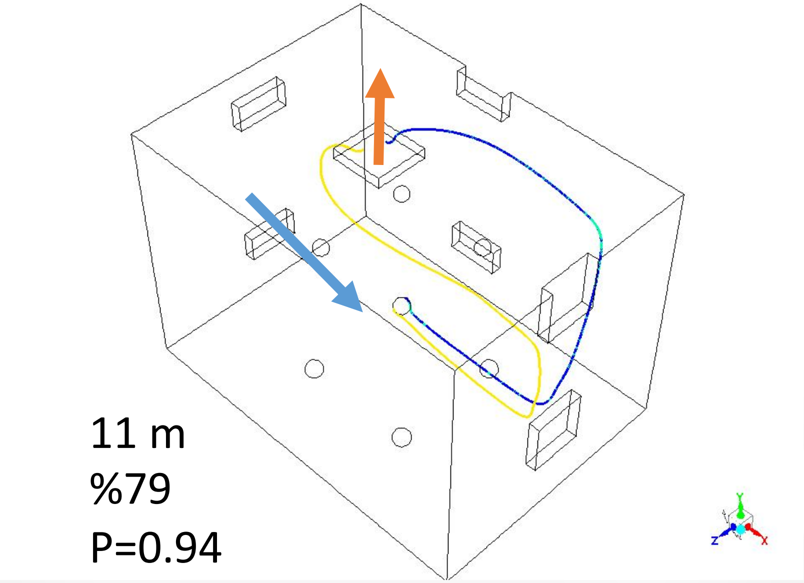


16 m
% 79
P=0.99



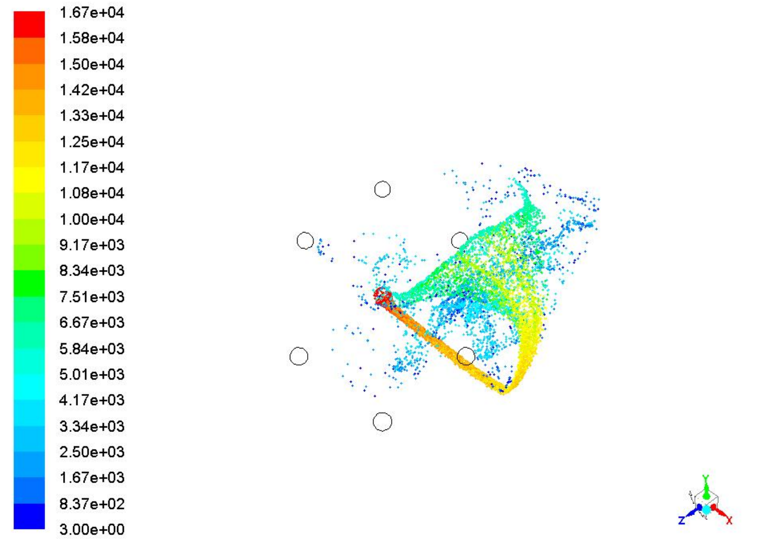


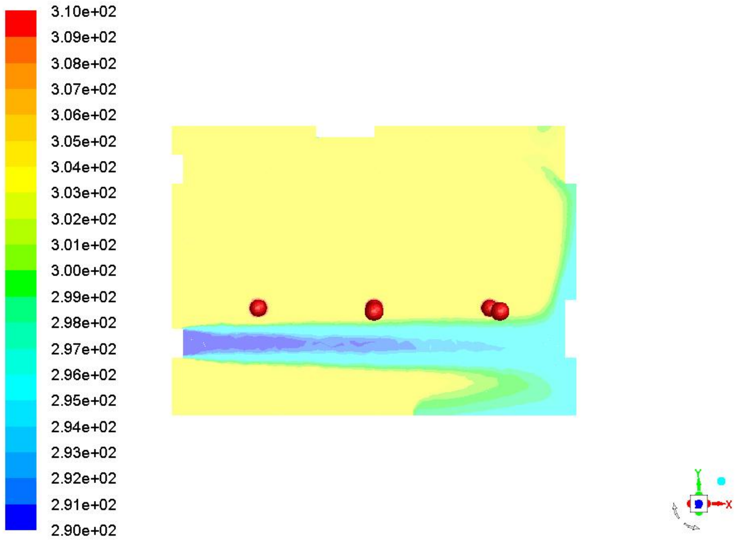

Y
Z
X

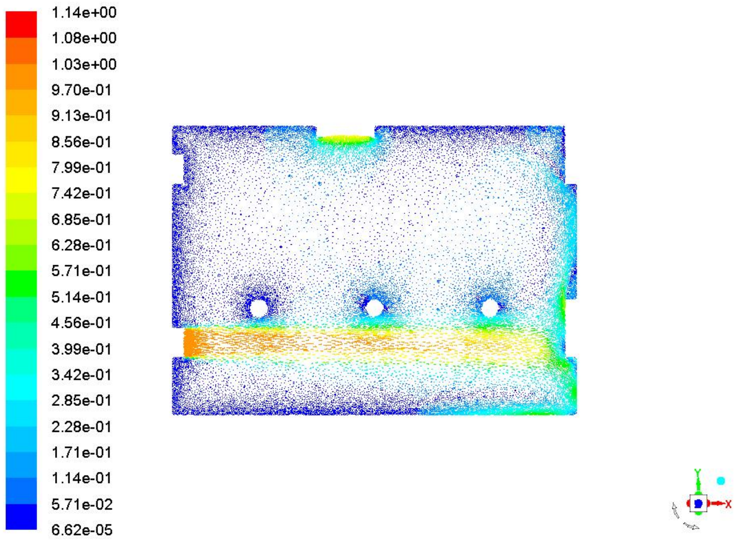


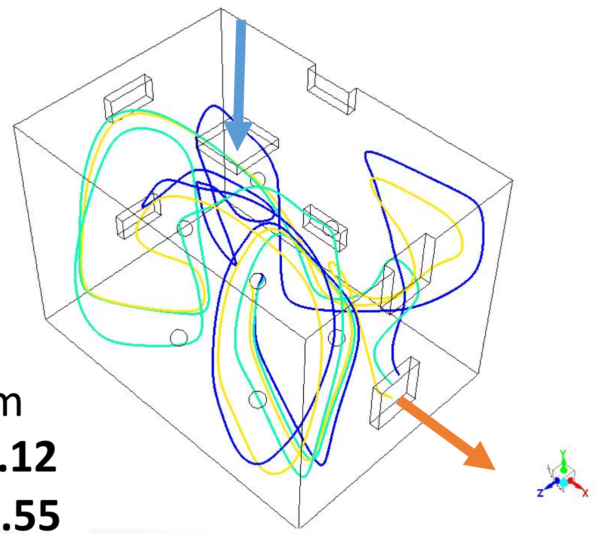
ALT DUVARDAN
GİRİŞ
TAVANDAN ÇIKIŞ

YÜK ORANI:
%17.5





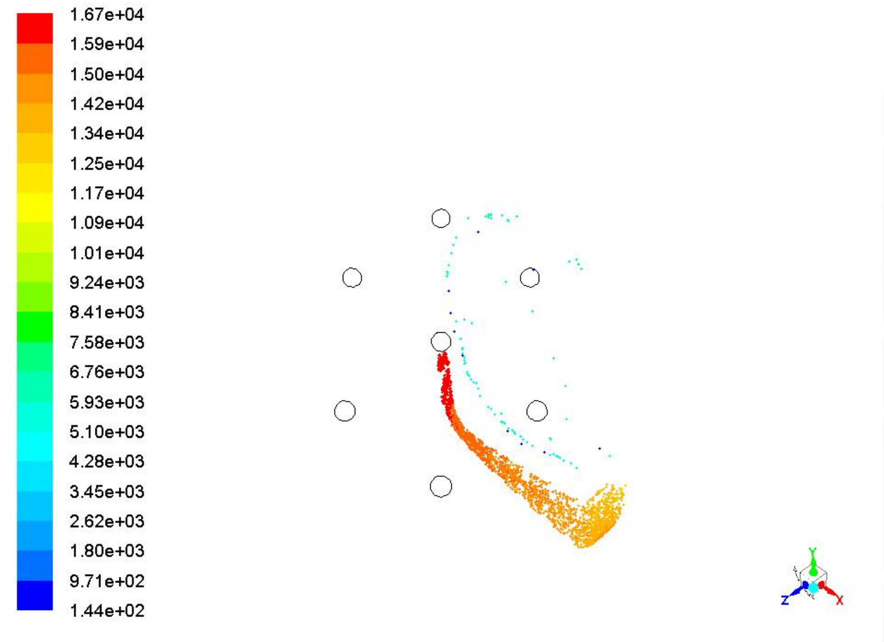


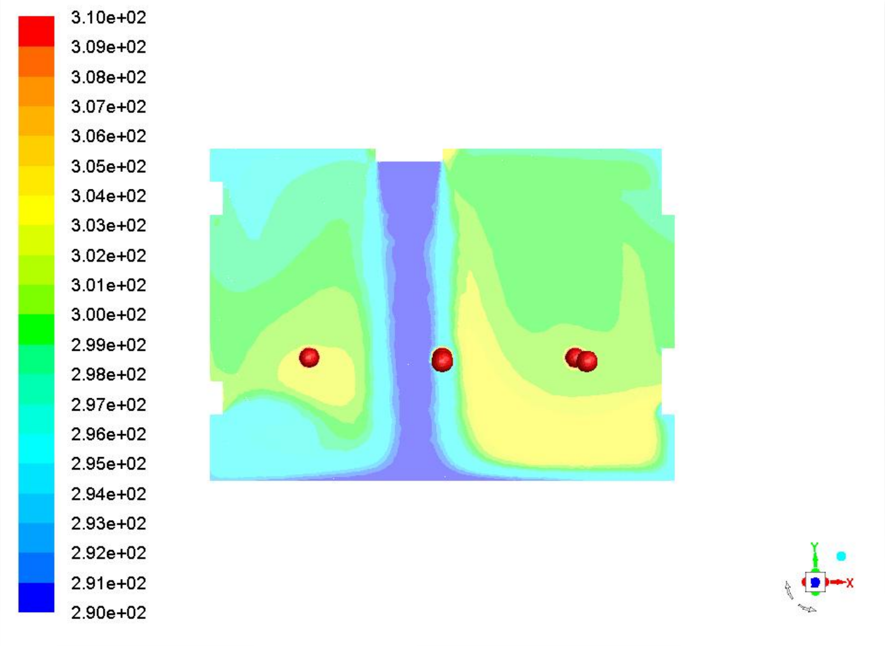


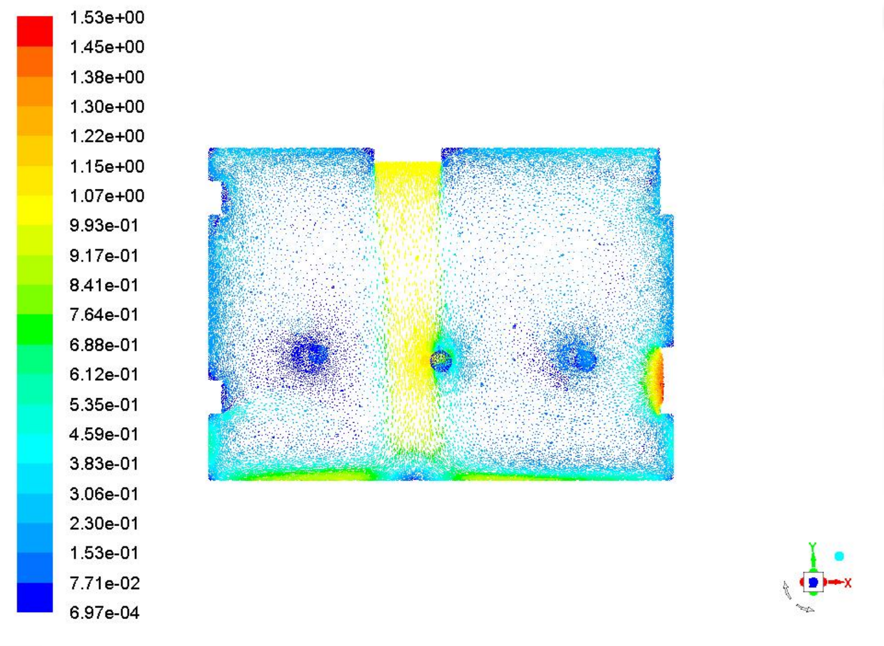
65 m
% 0.12
P=0.55

TAVANDAN
GİRİŞ
ALT
MENFEZDEN
ÇIKIŞ

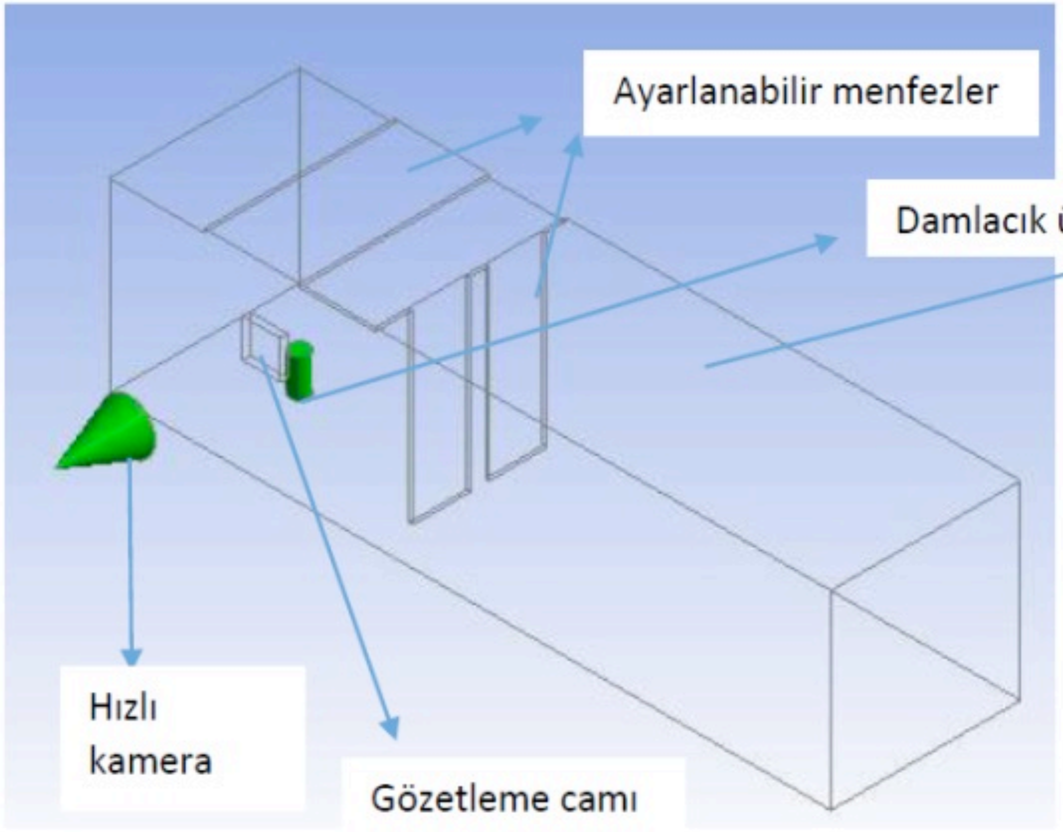
YÜK
ORANI: %5







DENEYSEL DOĞRULAMA DÜZENEĞİ



Ayçanur ATAK
Deniz CAN
Rahmi Mert AKKÜLAH

ÖNERİLER

- Modelleme
- Doğrulama
- İstatistik İnceleme

I

a) düzenek iyileştirilmeli/değiştirilmeli ya da

b) damlacıkların uzun süre kaldıkları yerler saptanarak filtreleme cihazları yerleştirilmelidir.

II

- İvedilikle havalandırma düzenekleri kurulmalıdır.

III

- Her koşulda, kapalı yerlerdeki kişi/alan oranı azaltılmalı ve maske kesinlikle çıkarılmamalıdır.