Large Scale Industrial-Use Dust Injectors: Modeling, Evaluation

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Outline

- Introduction
- Objective
- Model Description
- Numerical Results of Two Different Dust Injectors under Various Inlet Pressures
- Preliminary Results of Experiments
- Summary and Future Work

Introduction

- ISO dust injectors are used to disperse particles, e.g. A2 dust.
- The equipment can be a dust generator for testing internal combustion engines and compressors.
- The dispersed particles have different size distributions from the ones provided by manufacturers.
- Reasons for the difference:
  - ✓ Manufacturers' methods: wet sample dispersion, surfactants, ultrasonication, laser diffraction instrument.
  - ✓ General users' methods: ISO dust injectors, compressed air, aerosol instrument (e.g. APS).

Objective

- To perform numerical simulations on the air flow inside dust injectors.
- To conduct CFD analysis on the velocity, temperature and pressure fields of 2 different injector configurations.
- To test the particle size distributions of dust injectors using shadowgraphy method.
- To compare the numerical results with the experimental data.
- To design a new injector with better performance of dust dispersion according to the comparison.

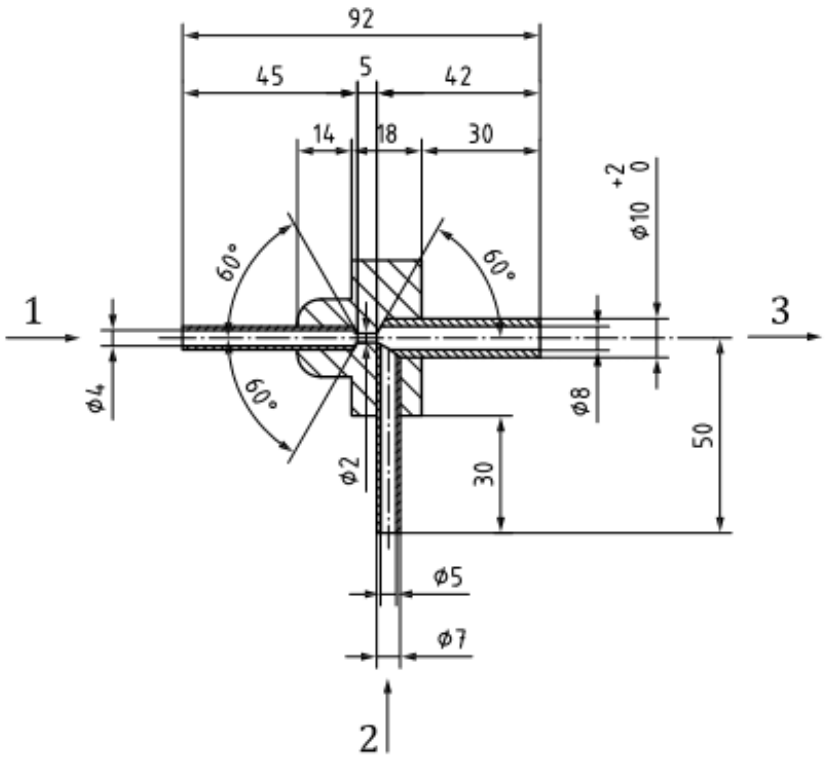
Flow Configurations of ISO Dust Injectors

ISO dust injector

ISO heavy-duty dust injector

[1] ISO 5011:2000 Inlet air cleaning equipment for internal combustion engines and compressors - Performance testing.

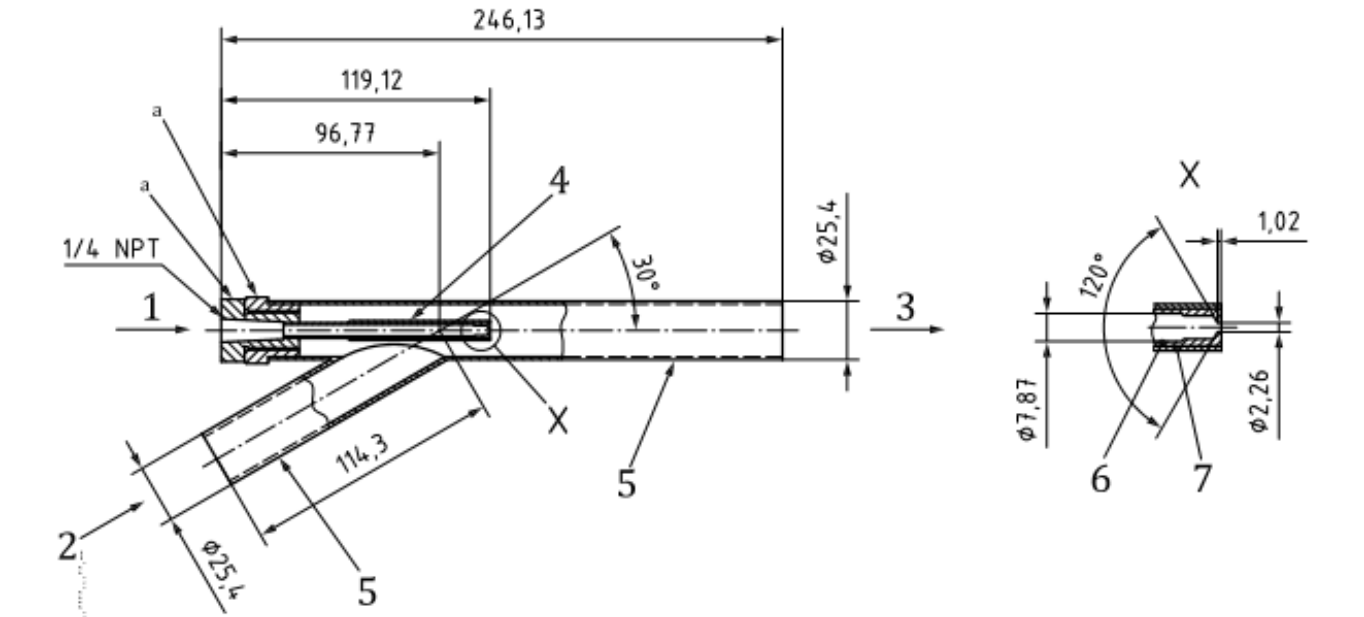
2D Drawing of ISO Dust Injector



Key

1 Air entry
2 Dust entry
3 Dust/air exit

2D Drawing of ISO Heavy-duty Dust Injector



Key

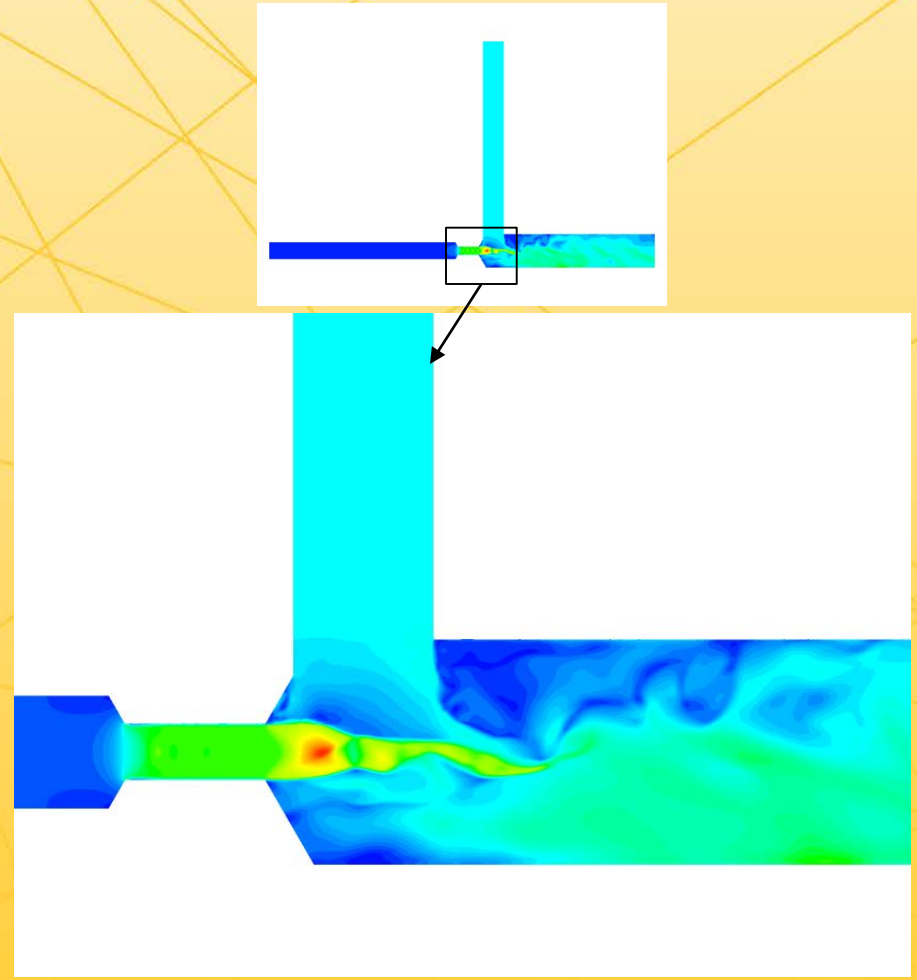
1 Air entry
2 Dust entry
3 Dust/air exit
4 Vinyl tubing erosion shield
5 Stainless-steel tubing of wall thickness 1,65 mm
6 Stainless-steel tubing of wall thickness 0,81 mm
7 Vinyl tubing of diameter 9,53 mm

Model Discription

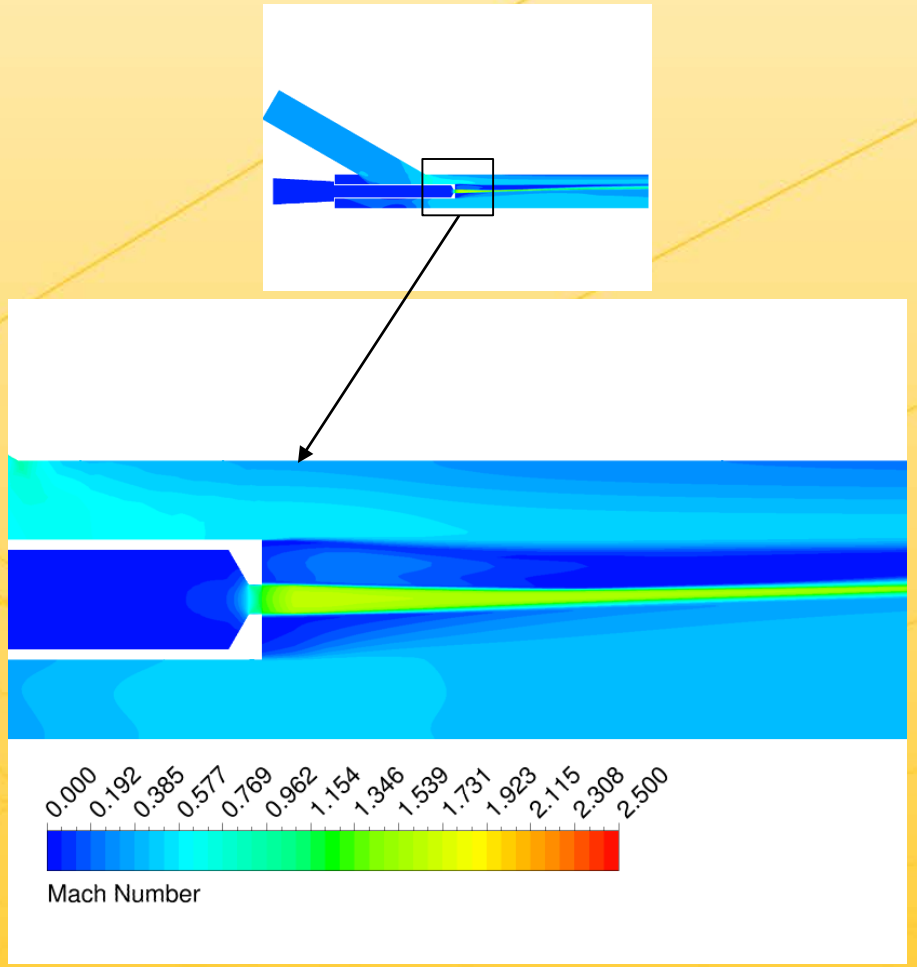
- Re >>4000, Ma >0.3
- Indicating Inviscid and compressible flow
- Equations solved in the Ansys Fluent software:
- Fully compressible Euler Equations
- Energy Equation

Contours of Mach Number

$$M = \frac{V}{c}$$

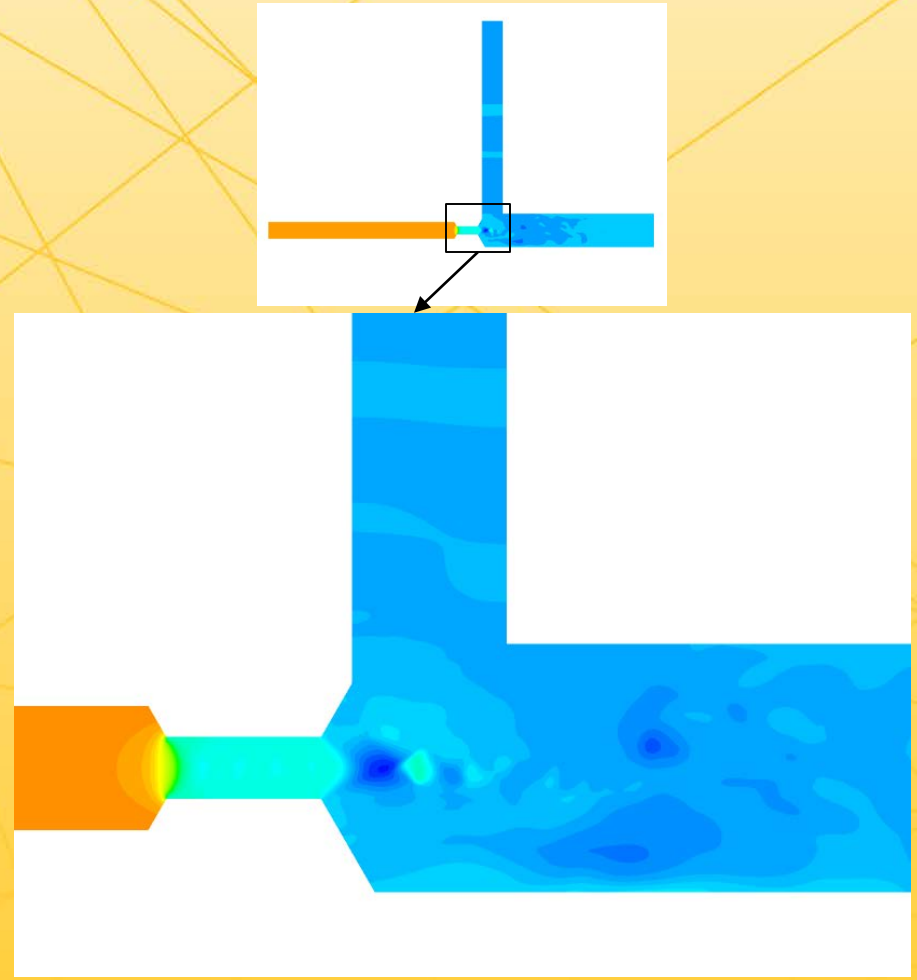


ISO dust injector

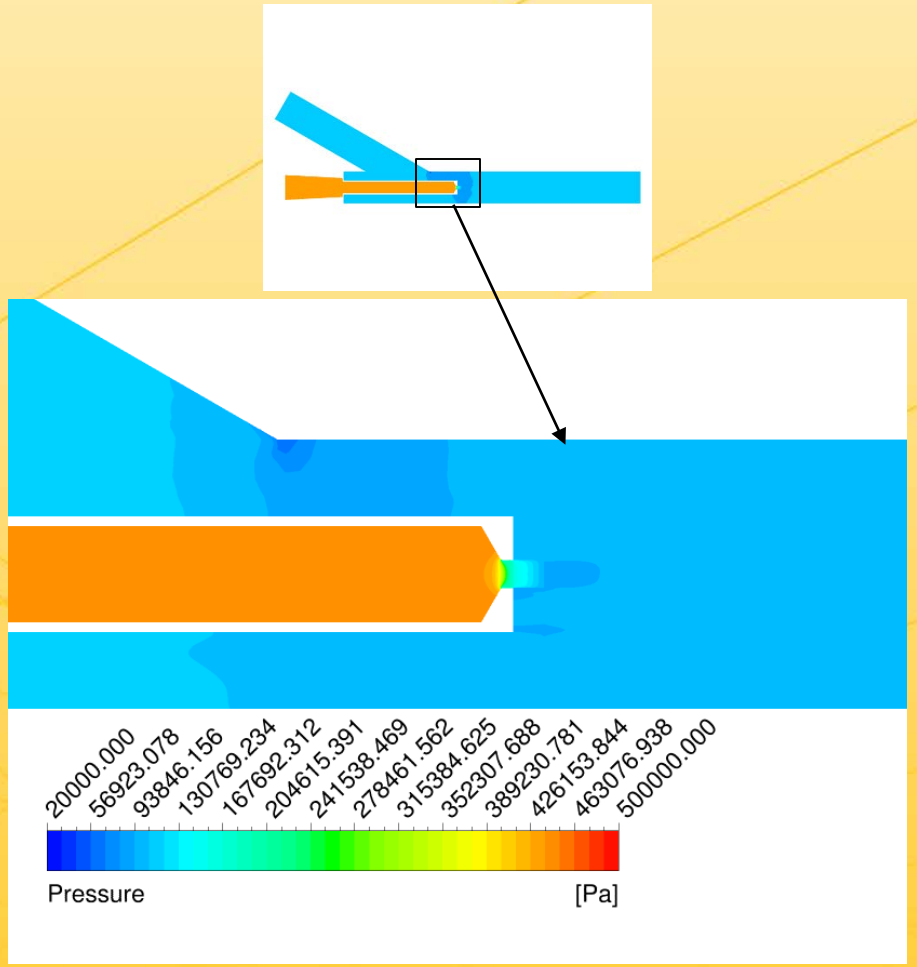


ISO heavy-duty dust injector

Contours of Pressure

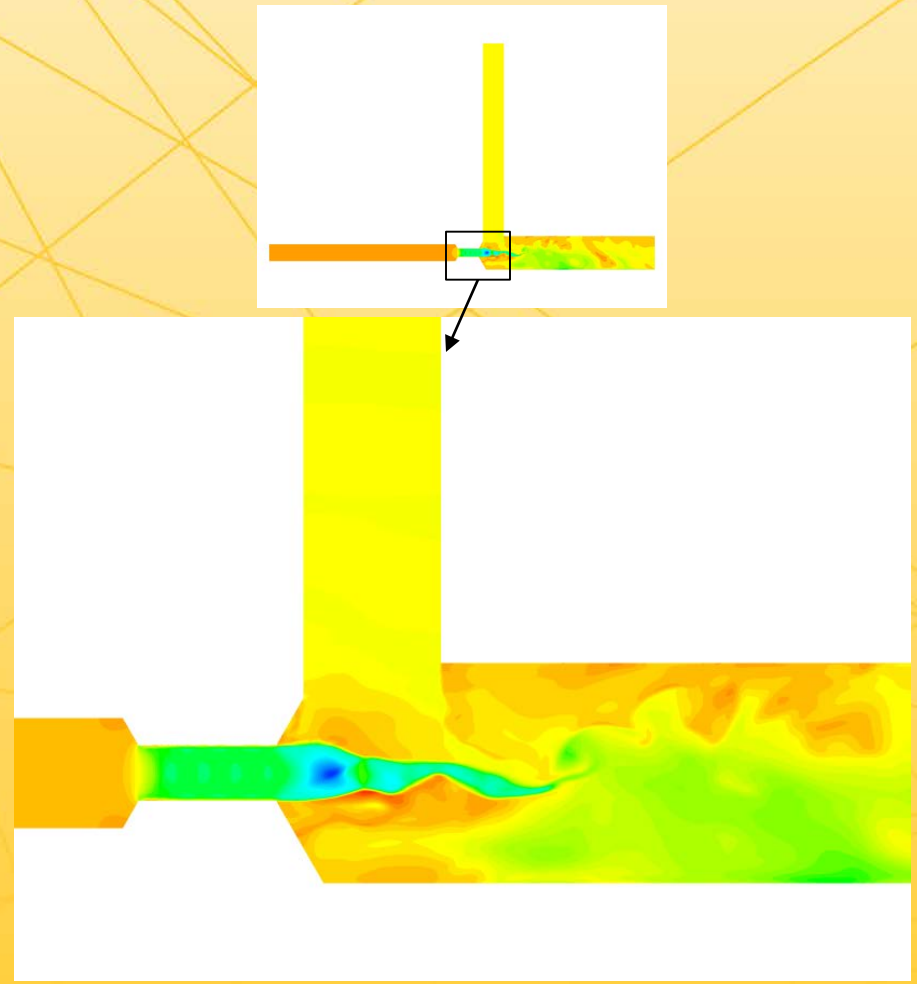


ISO dust injector

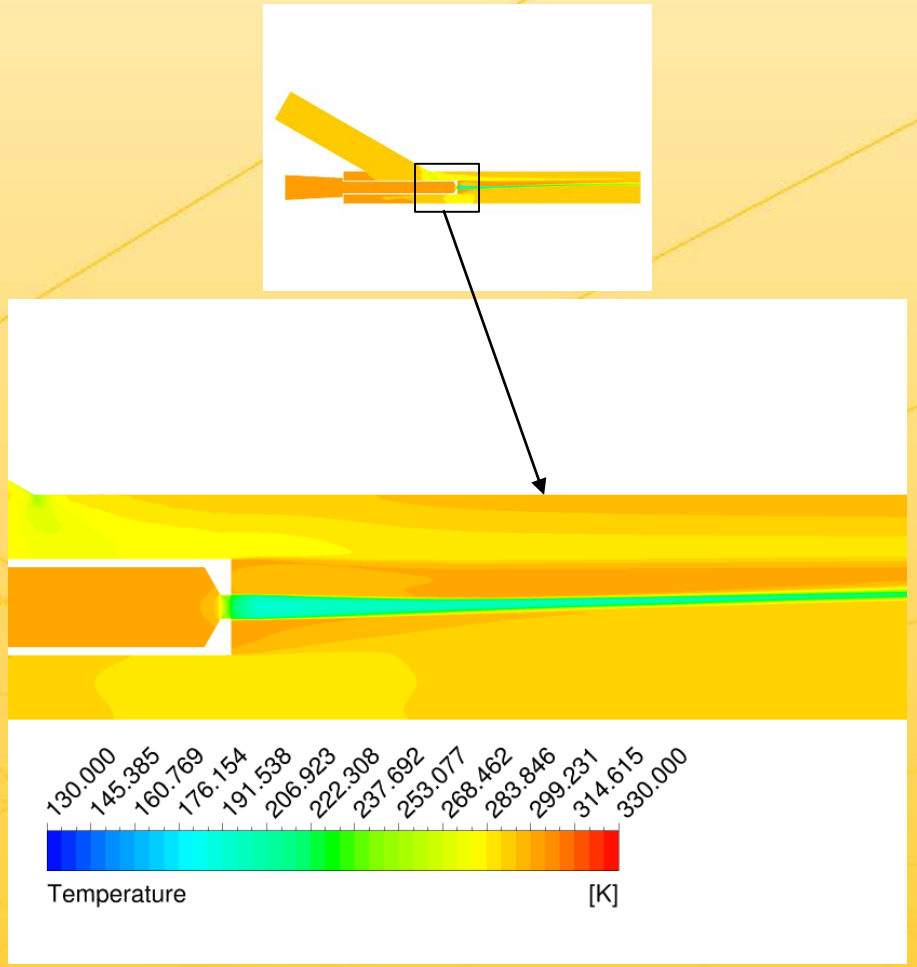


ISO heavy-duty dust injector

Contours of Temperature

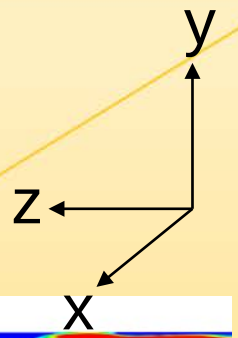


ISO dust injector

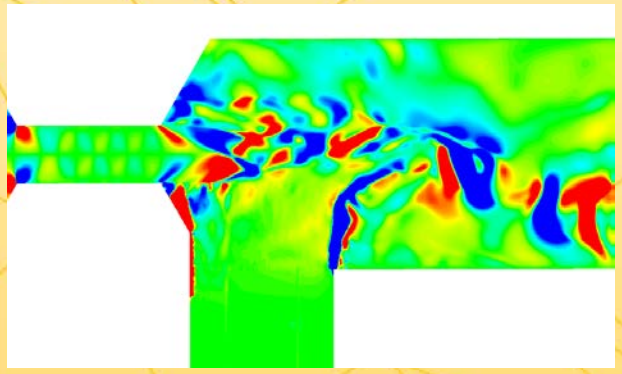


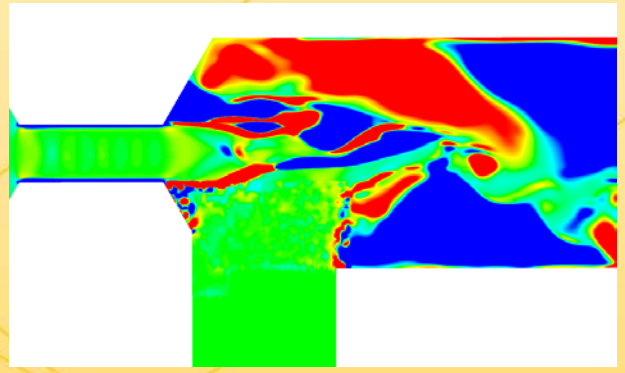
ISO heavy-duty dust injector

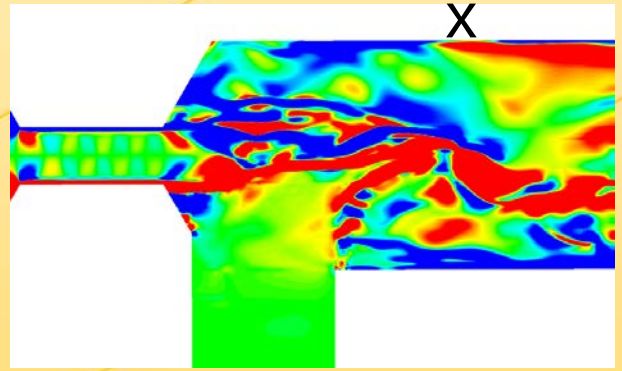
Contours of velocity gradients



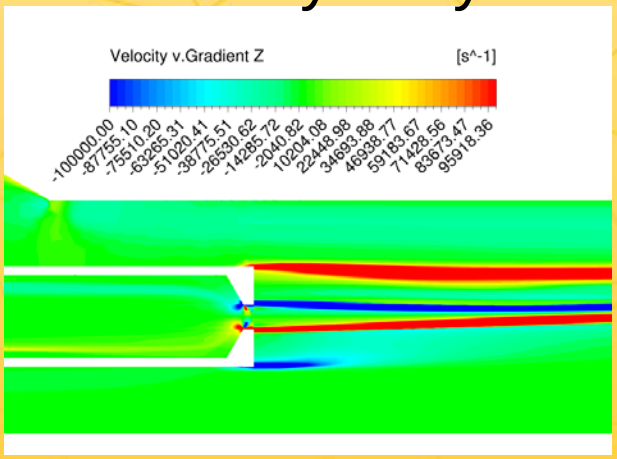
ISO Dust Injector

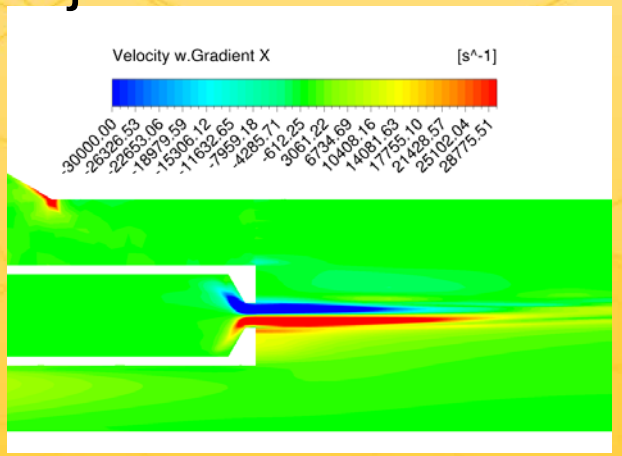


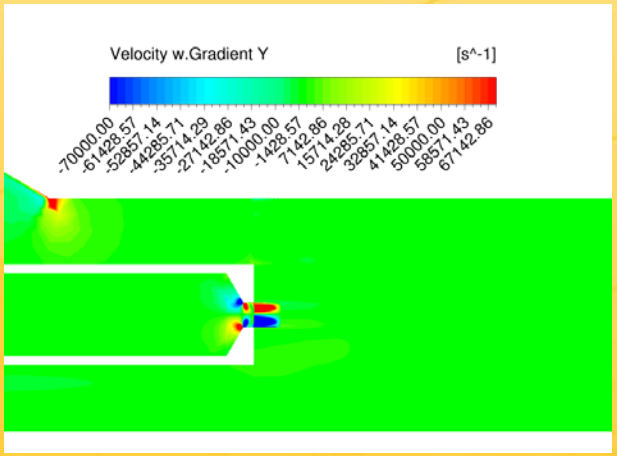




ISO Heavy-Duty Dust Injector

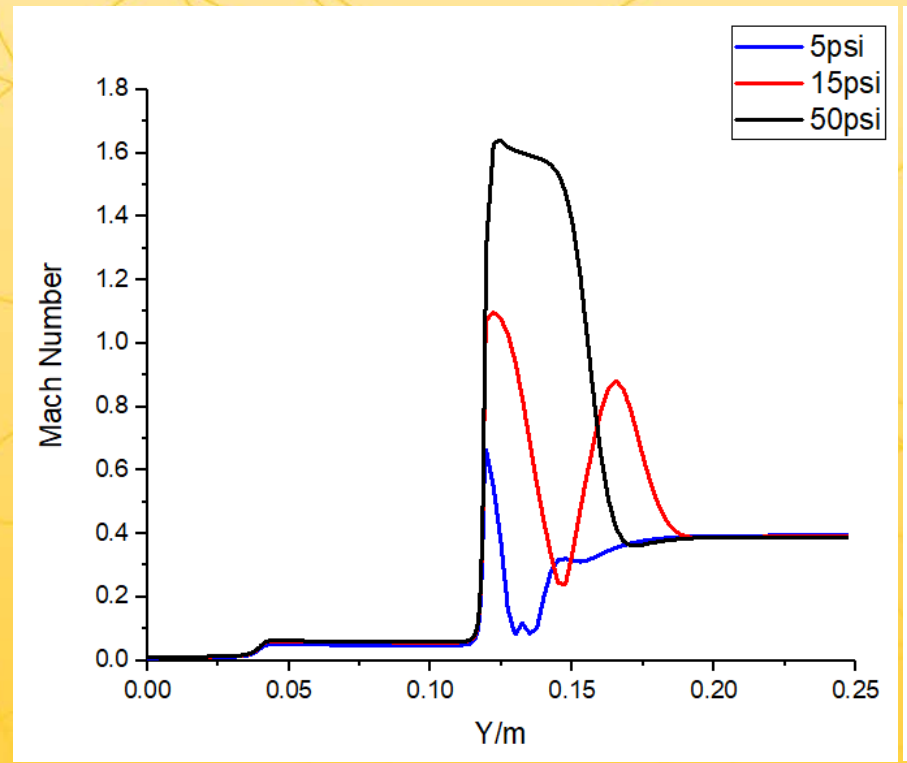


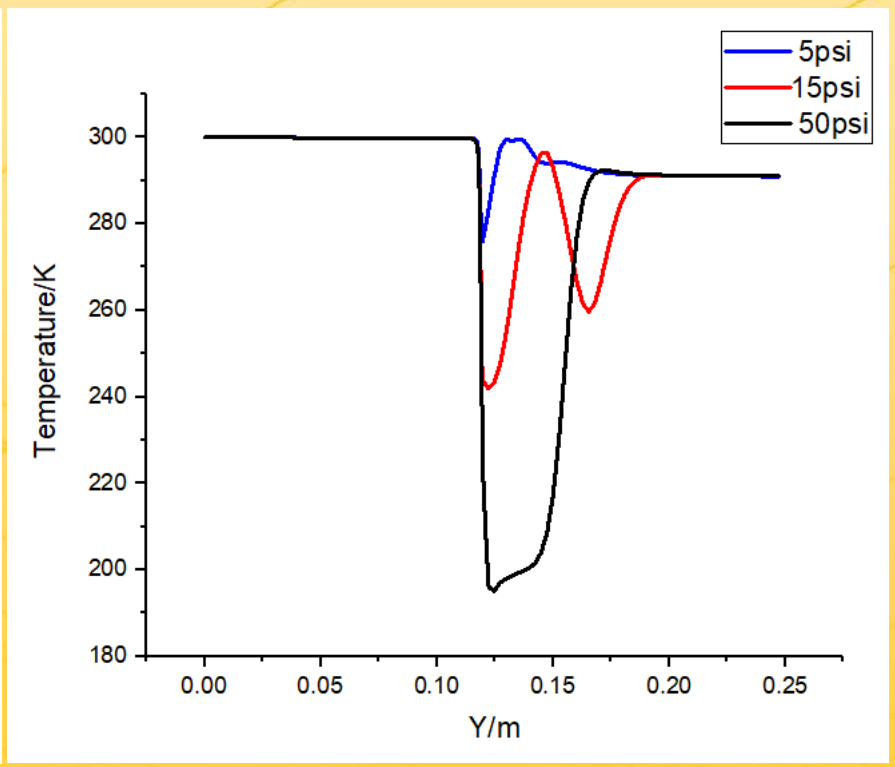




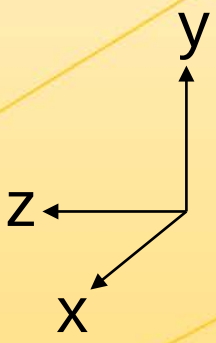
$\partial v/\partial z$ $\partial w/\partial x$ $\partial w/\partial y$

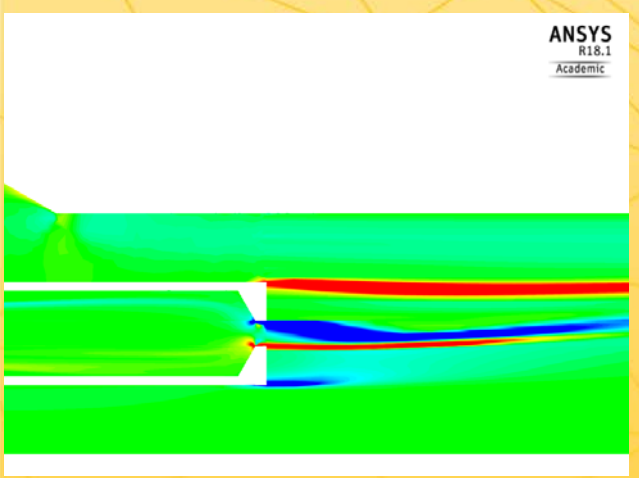
Graphs for Different Inlet Pressures – Mach Number and Temperature



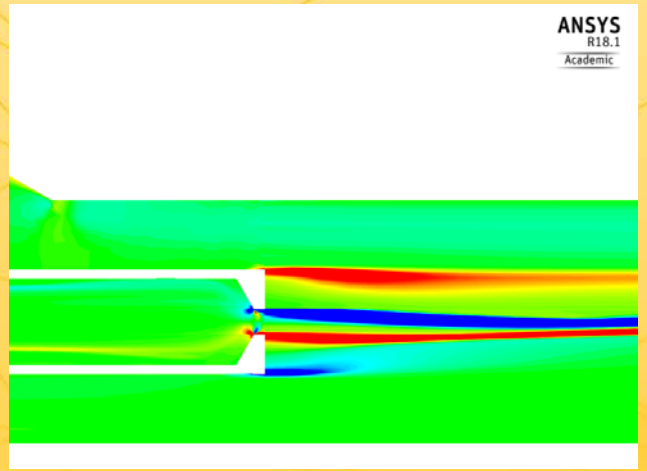


Contours for Different Inlet Pressures – Velocity v. Gradient of z

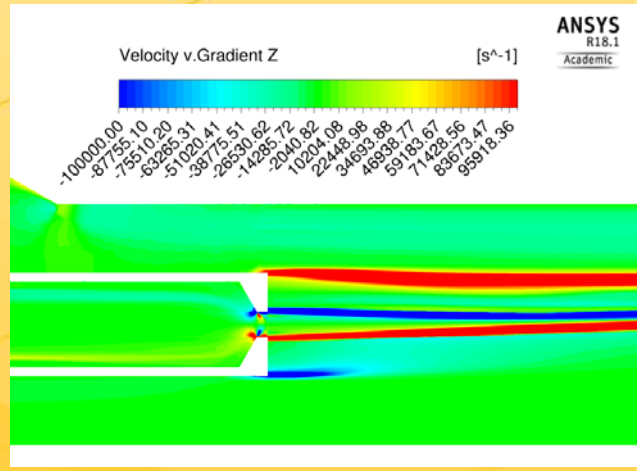




5psi



15psi



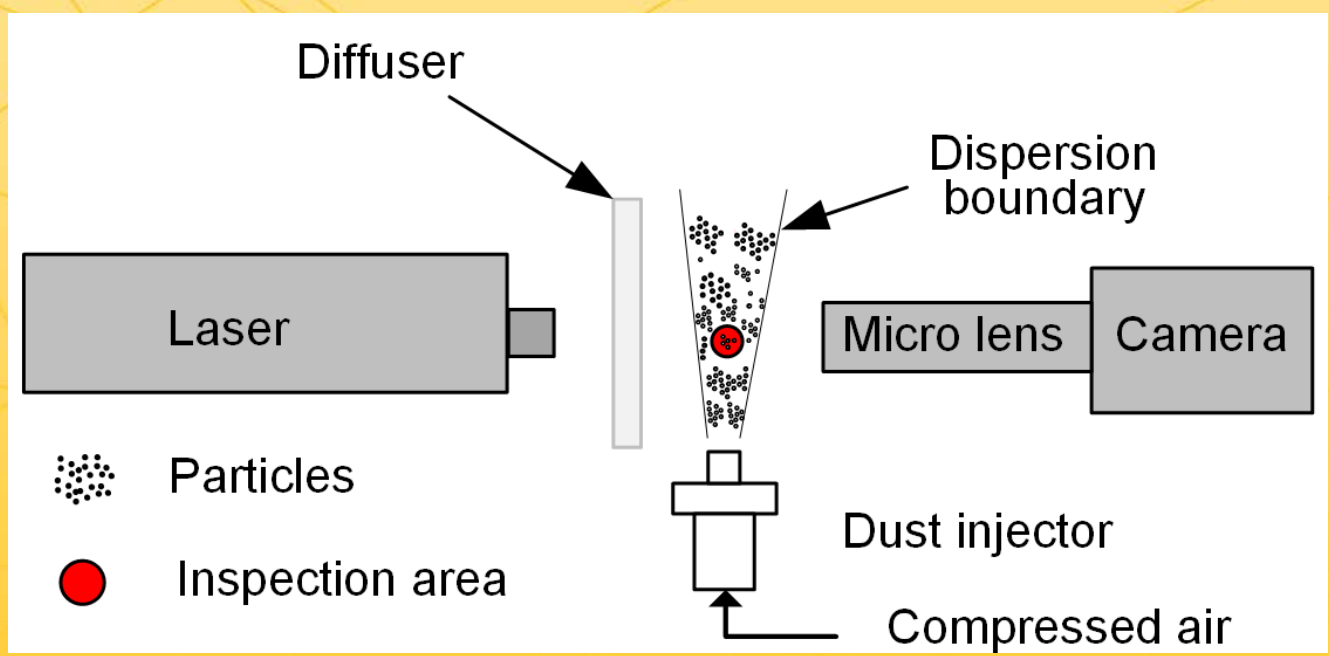
50psi

Conclusions- Numerical Simulation

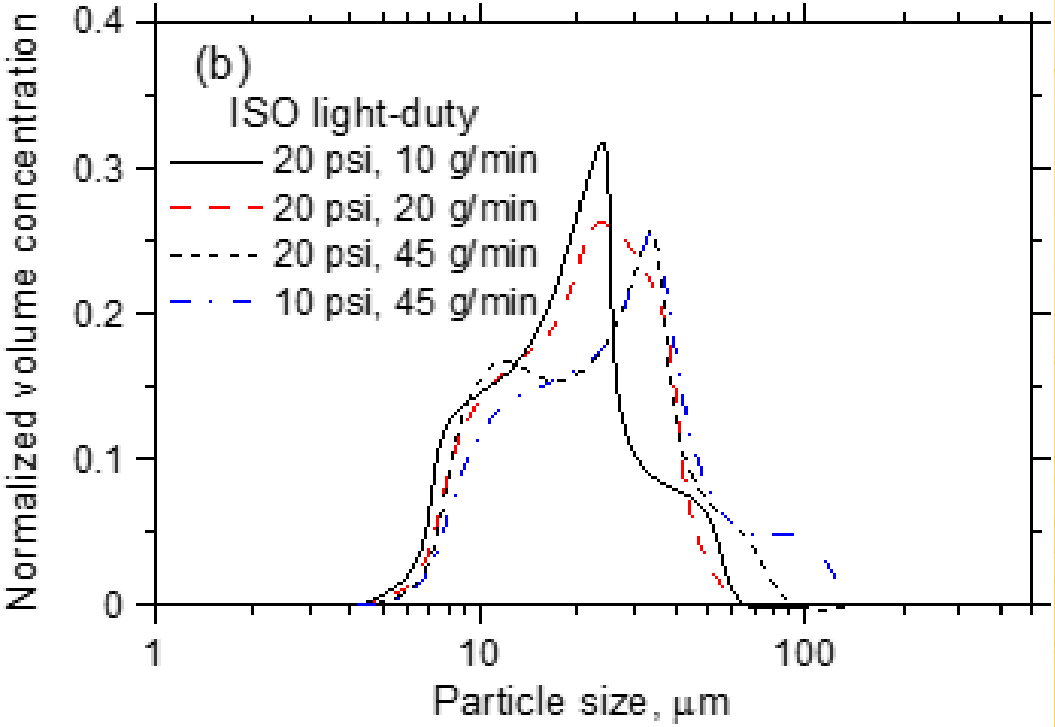
- The flow fields of two dust injectors are quite different
- The Mach Number becomes higher with increasing inlet air pressure
- Velocity Gradient increases with inlet air pressure, which contributes to the higher shear stress
- The performance of dust particle dispersion should be better with higher inlet air pressure

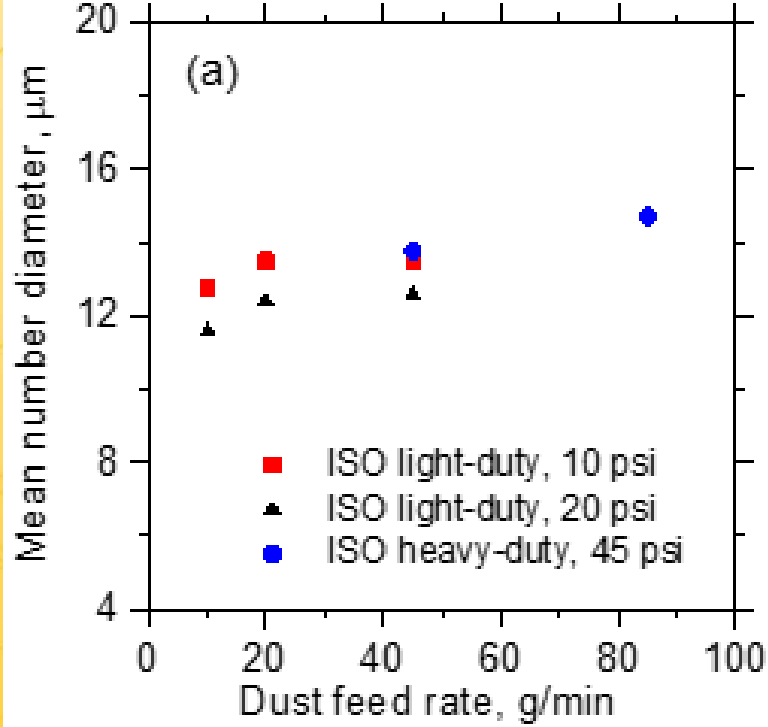
Measurement of Size Distributions of Dust Particles

- Applied shadowgraphy method to measure the particle size distributions from the two dust injectors under different inlet pressure conditions



Preliminary Results of Particle Size Distributions from Shadowgraphy Measurement





Future Work

- To solve the viscous Navier-Stokes equations for the dust injector flow fields
- To complete our experimental results under different inlet pressures and dust feed rate conditions for the two dust injector configurations.
- To validate our conclusions indicated from the numerical simulation against the experimental data.
- To design a new injector with better performance in dust particle dispersion based on the conclusions.

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Thank you

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