Computational Fluid Dynamics Study Investigating the Effect of Ventilation Rate and Exhaust Geometry on Airflow Patterns and Particle Dispersion in a Swine Barn

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Background

Decreased animal productivity and adverse health effects among pig producers associated with inhalation of large concentrations of particles within swine barns

Poor mixing within swine barns can cause particle concentrations to vary spatially

Increasing ventilation proposed as a method of decreasing dust concentrations, however there is a potential to re-suspend dust

No standardized design criteria or ventilation standards

Objectives

Determine the optimal exhaust geometry and ventilation rate to reduce concentrations within a swine barn

Methods

Two barn geometries:
- Continuous slot running the length of the barn
- Two discrete fans (48 in^2)

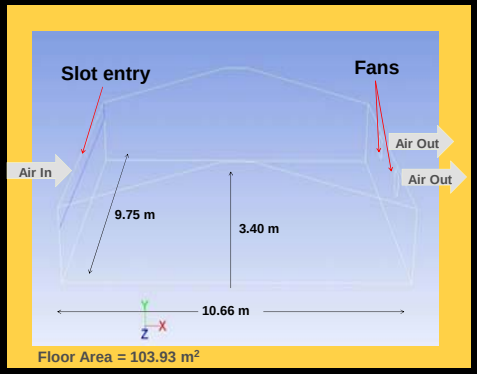
Two exhaust flow rates:
- High: 4.2 m^3/s
- Low: 1.1 m^3/s.

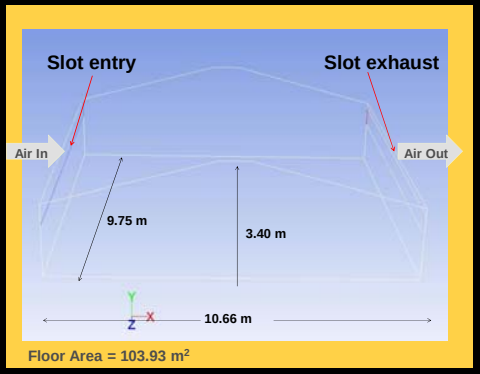
Settings:
- 20° C air temperature – isothermal
- No barriers in barn (empty)
- Standard kε turbulence (TI = 8%, Ru= 10)

Solution Methods
- Pressure-based decoupled segregated solver
- SIMPLE algorithm with second order upwinding
- Standard wall functions
- Full buoyancy effects

Solutions at 1E-5 global solution error tolerances were (1) converging and (2) independent of mesh

Geometries

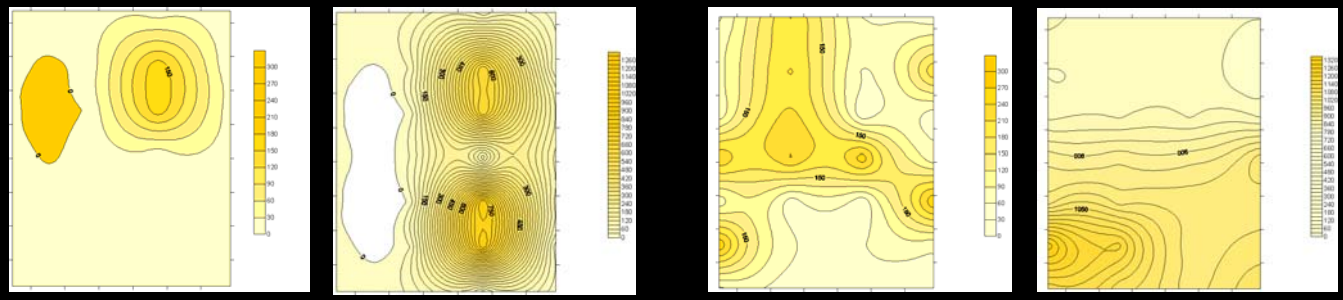




Results

Particle Residence Time

Fan, High Flowrate | Fan, Low Flowrate | Slot, High Flowrate | Slot, Low Flowrate



Conclusions

Strong recirculation patterns in center of barns

Two *exhaust fans* yielded better exhaust near barn walls

Longest residence times in center of barn

Approximately 82.5 min (474%) longer residence times with slot geometry for high flowrate

Approximately 466 min (338%) longer residence times with slot geometry for low flowrate

Future Research

To be more realistic, future simulations should incorporate:

- **Heat generation of animals/heat sources**
- **Indoor/outdoor temperature gradients**
- **Different slot geometries and locations**
- **Different fan exhaust rates and locations**

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