

Acid Spray Scrubbers for Recovering Ammonia Emissions from Animal Facilities

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Acid Spray Scrubbers for Recovering NH_3 Emissions from Animal Facilities

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Introduction

- What are Spray Scrubbers?
- Spray versus Packed Scrubbers
- Why Spray Scrubbers are Best for AFOs?

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Development of a NH_3 Spray Scrubber

- Lab Simulation Apparatus
- Factors Affecting Spray Scrubber Performance
- Optimization of Scrubbing performance
- Lab Spray Scrubber Performance

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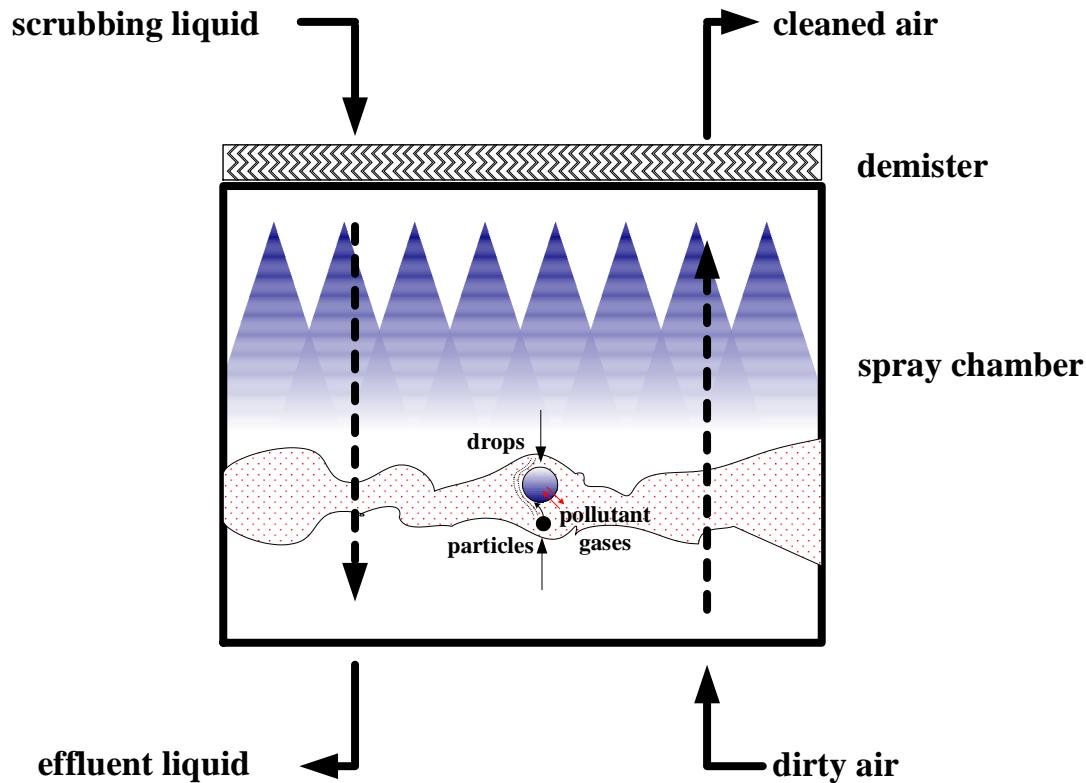
Full-Scale Scrubbers

- Actual Full-Scale Scrubbers
- Research Challenges

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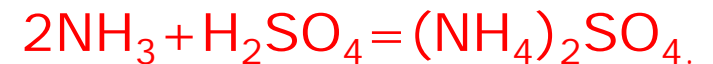
Conclusions

NH₃ Acid Spray Scrubber Technology



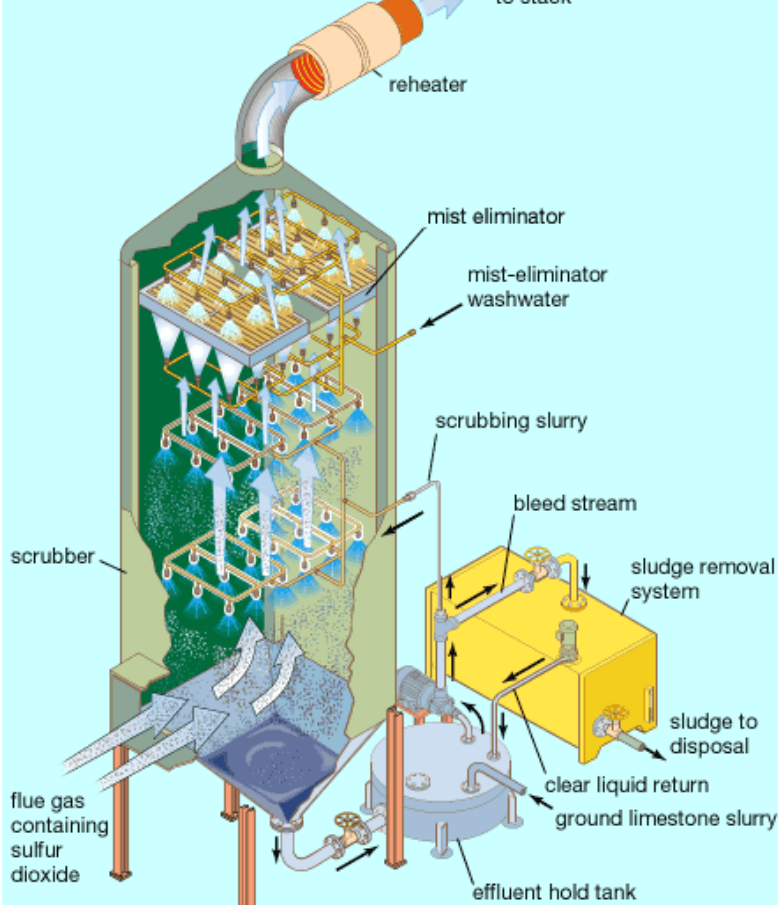
NH₃ acid spray scrubber

- gas scrubbing device to absorb ammonia (NH₃) from the air,
- use small droplets to enhance air and liquid mass transfer contact,
- use dilute sulfuric acid (H₂SO₄) as scrubbing liquid:



Why use Spray Scrubbers for AFOs? Spray vs. Packed

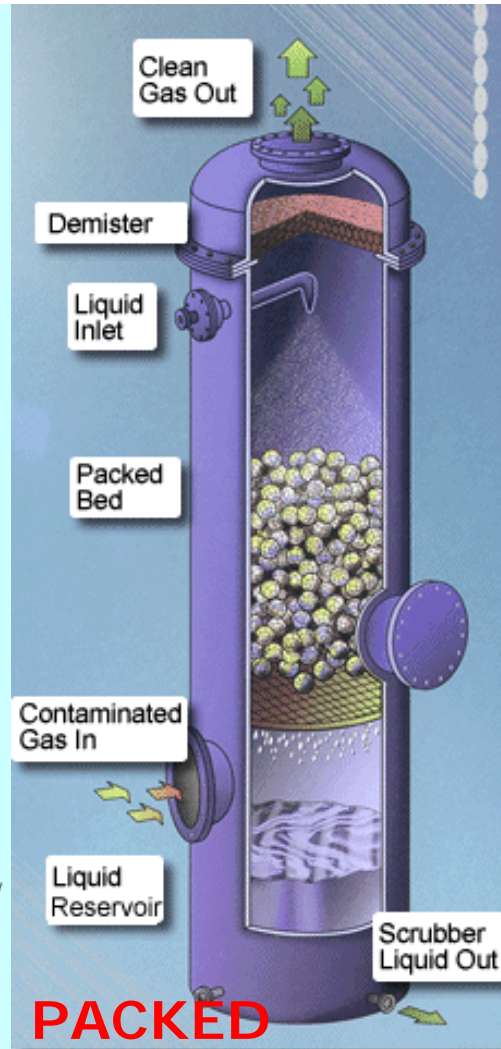
Flue gas desulfurization (FGD)
limestone wet scrubber



SPRAY

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<http://www.sugarudyog.com>



PACKED

<http://www.triplemfiberglass.com>

Spray scrubbers have:

- ❖ lower back pressure,
- ❖ lesser airflow restriction,
- ❖ needs bigger volume

compared to packed scrubbers.

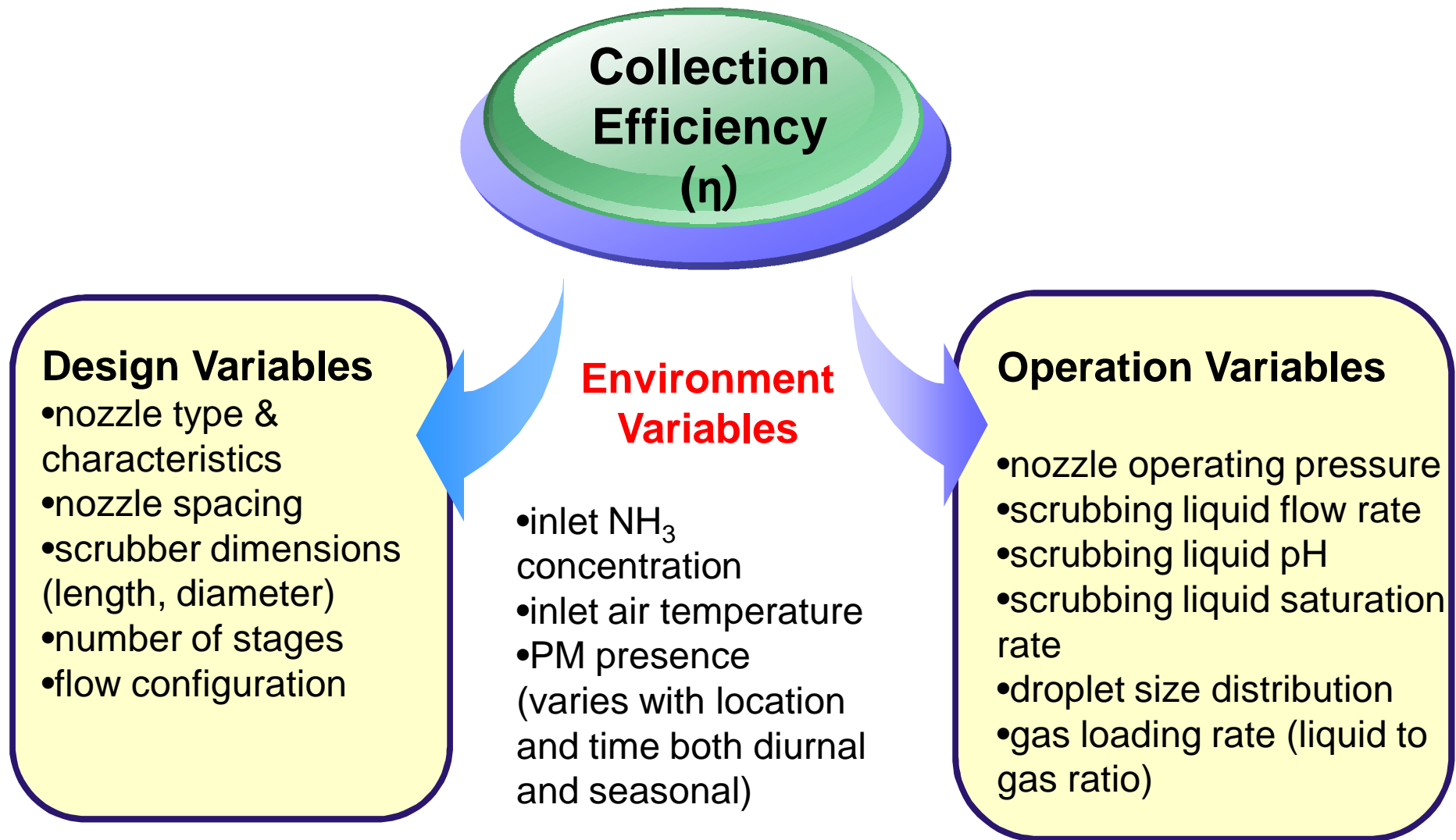
Why Use Spray Scrubber for AFOs?

- Spray scrubbers - very promising for AFOs:
 - Lower Air Flow Reduction
 - Easy to Retrofit in existing Animal Facilities
 - Proper design is needed for optimum NH_3 absorption in AFOs:
 - Increase efficiency
 - Lower footprint
 - Minimize pumping cost
 - Reduce/eliminate clogging
-

Optimization of NH₃ Spray Scrubbing



Factors Affecting Spray Absorption of NH_3



Scrubbing Chamber and Air-Mixer Simulator Apparatus

Measurements:

Inlet and outlet
ammonia concentration
Liquid pH &
Electrical Conductivity
Liquid Flow Rate
Fan Back Pressure

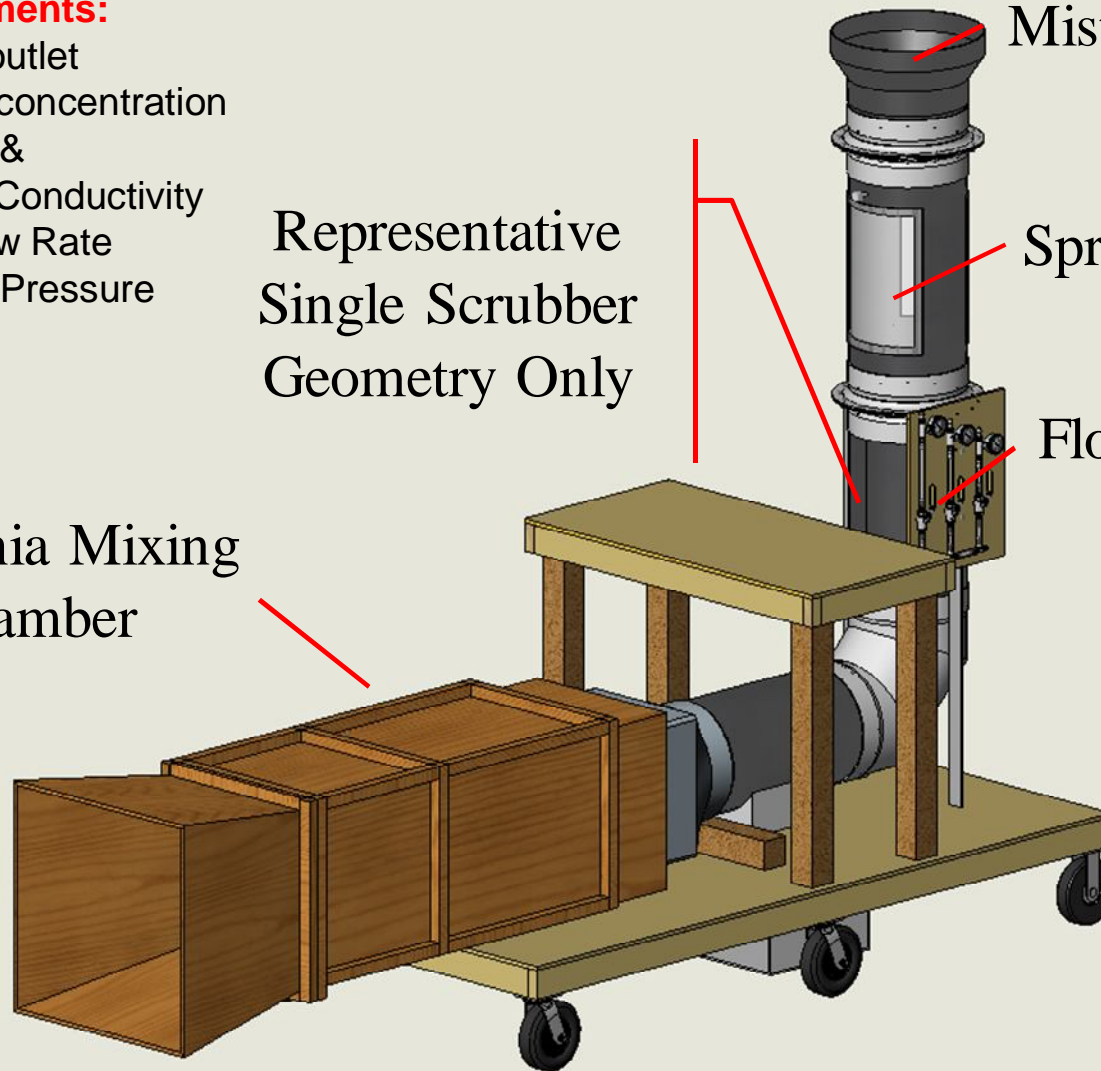
Representative
Single Scrubber
Geometry Only

Ammonia Mixing
Chamber

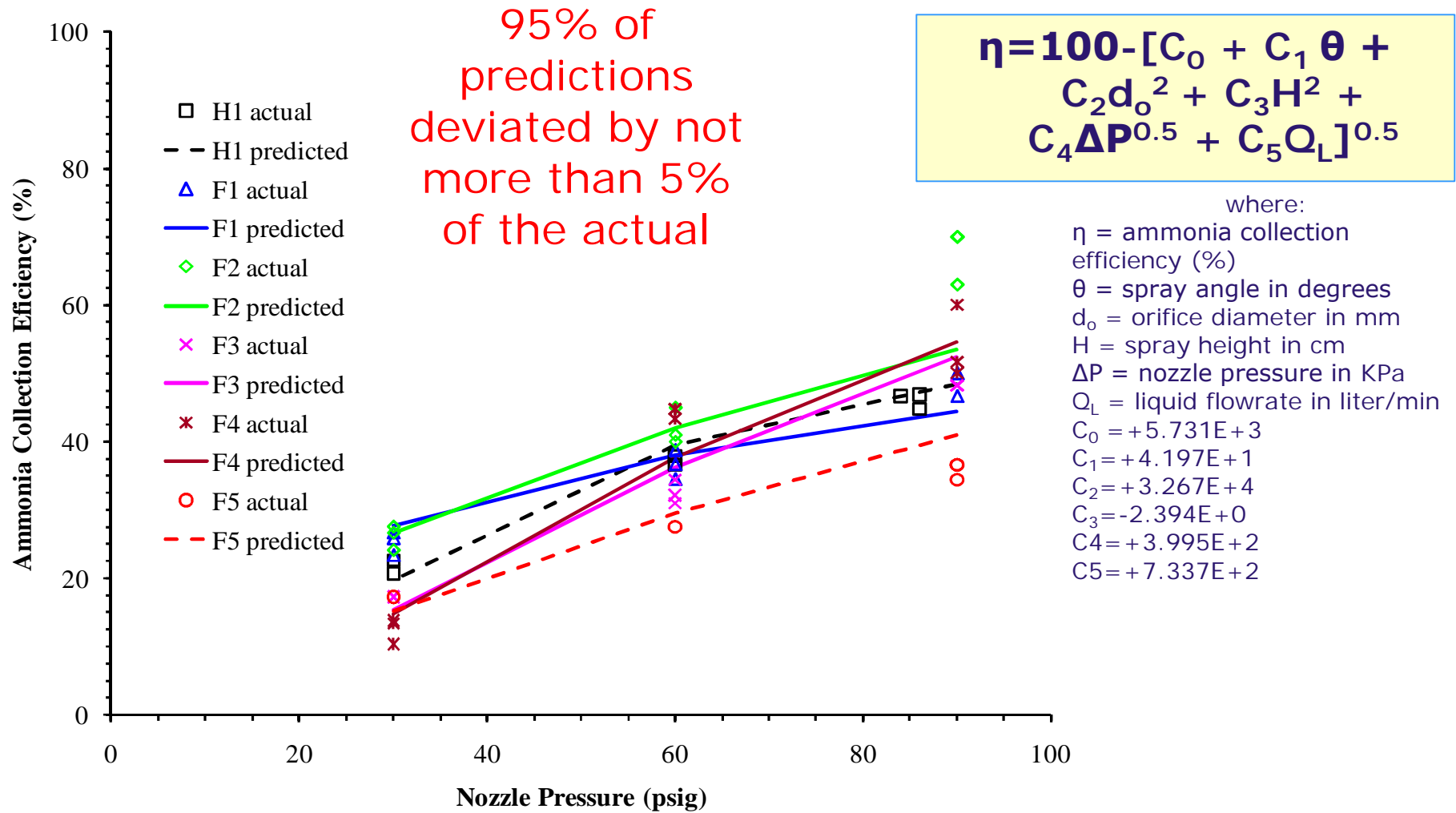
Mist Eliminator

Spray Chamber

Flow Controls



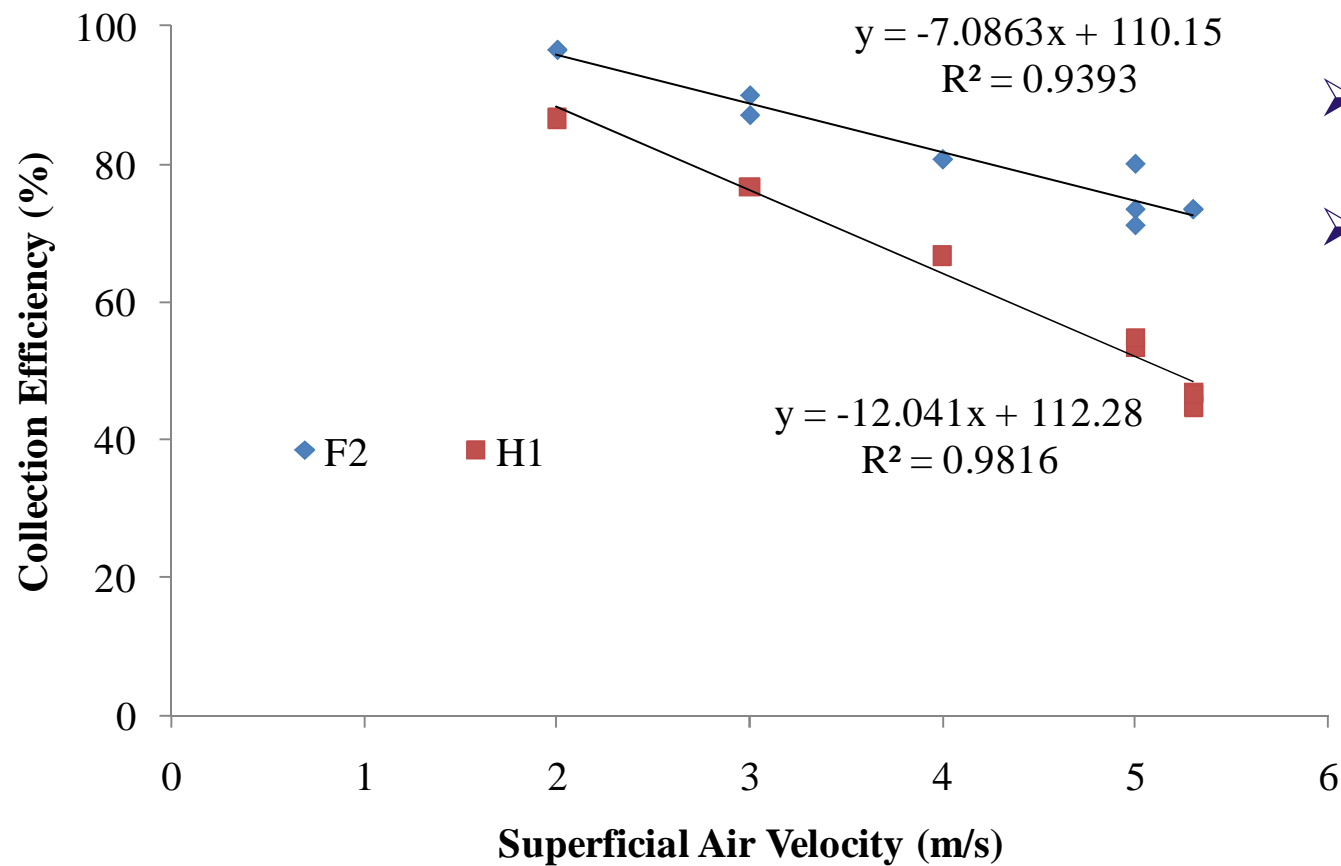
Effects of Nozzles on Efficiency



How to choose the right nozzle for NH_3 spray absorption?

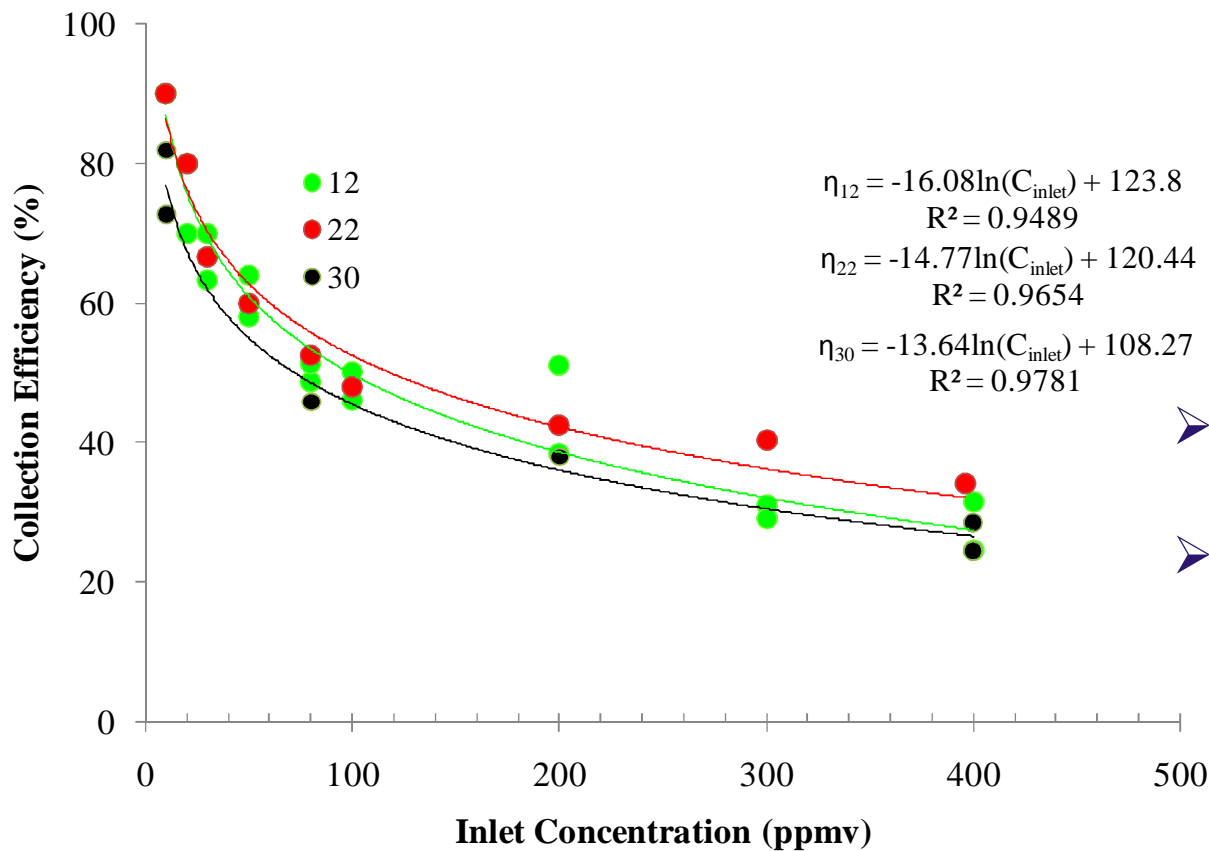
- ❖ Nozzle pressure - highly affects absorption performance
 - ❖ As nozzle pressure \uparrow
 NH_3 collection efficiency, spray angle \uparrow
 droplet size \downarrow
 (positive effect on scrubber performance)
 - ❖ Nozzle orifice diameter - independent of pressure
 - ❖ As orifice diameter \downarrow
 flow rate, droplet diameter \uparrow
 surface area increases \uparrow
 (positive effect on scrubbing performance and operation)
 - ❖ **Balance** between orifice size and nozzle pressure is needed to get the right flow and surface area that yields the maximum NH_3 collection efficiency.
 - ❖ Nozzle size must account for clogging during field actual operation.
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Effect of Superficial Air Velocity



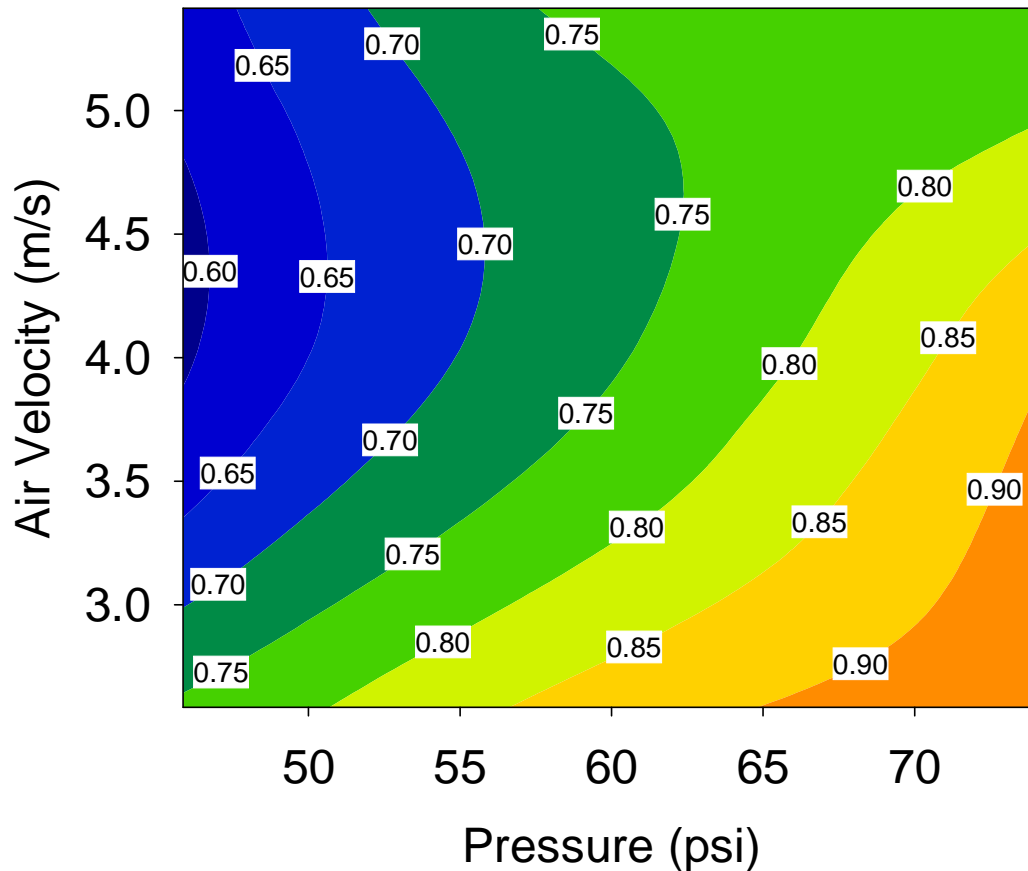
- Velocity ↑ - Efficiency ↓
- Change depends on nozzle (i.e. droplet size and air drag)

Effect of Inlet NH_3 Concentration and Temperature



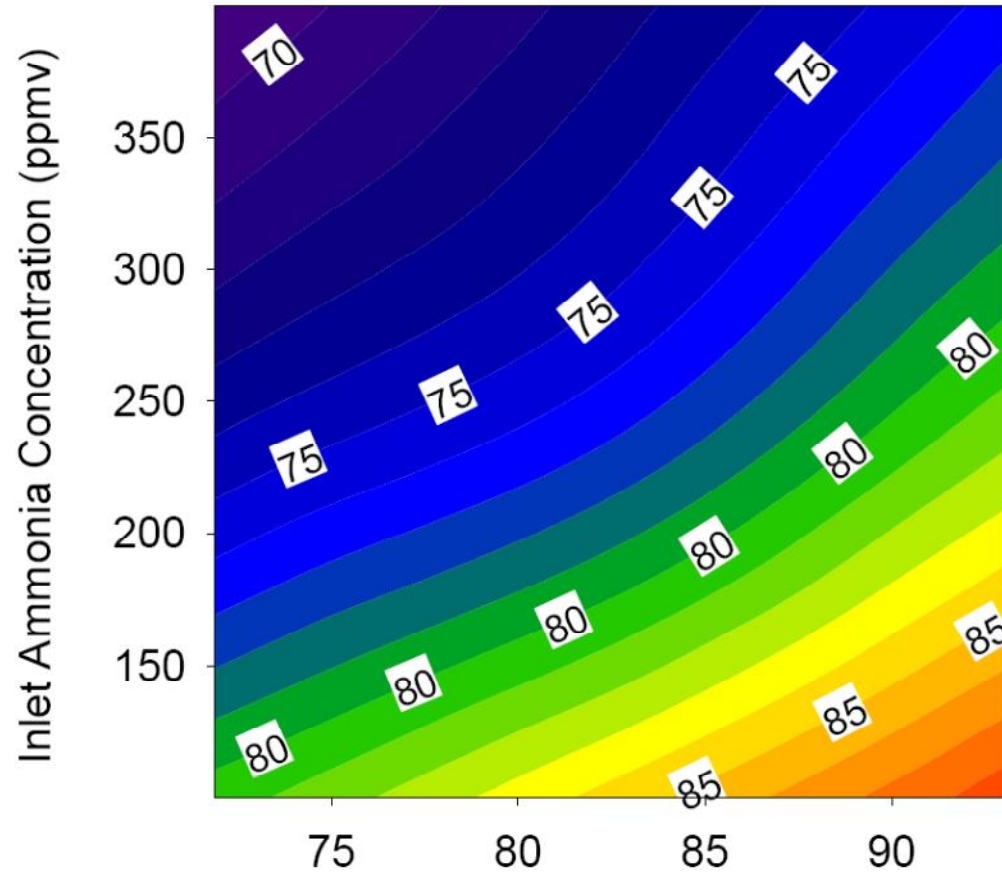
- $\ln(\text{Concentration}) \uparrow$ - Efficiency \downarrow
- Significant difference ($\alpha=0.05$) between performance at 22°C and 30°C

Performance of a Optimized Single Stage Spray Scrubber



Description	Value
nozzle type	pin jet with plain orifice
shape	full cone
spray angle	90°
orifice size	0.06096 mm
span	61 cm (24 in)
flow rate	1.82 l/min
duct size	36 cm (14 in)
air velocity	4 m/s (800 ft/min)
L/G	7E-5
efficiency	90% at 30 ppm

Spray Scrubber Performance Curve



Setting a pressure of 90 psi:

- 75% - min collection efficiency at 400 ppm
- 87% - max collection efficiency at 100 ppm

Nozzle Pressure (psi)

Air Velocity = 4 m/s,
N=20, $R^2=0.98$

Features of OSU Lab-Scale Spray Scrubber

- High Ammonia Removal Efficiency (70%-90%) at inlet NH_3 levels of 100-400 ppm
- Low Fan Back Pressure/Air Flow Reduction
- End product is Ammonium Sulfate (N+S), a fertilizer,
- Can Work with High Air Velocity AFO Exhaust Fans
- Low Footprint

Full-Scale NH_3 Acid Spray Scrubbers



Wet Scrubber Field Testing Sites

Field Testing Site	NH ₃ Concentration (ppmv)	Airflow (ft ³ /min)	Other Gases of interest
Poultry Manure Composting House	100-400	16,000	CO ₂ , N ₂ O
Deep-pit Swine Facility	4-25	450	CO ₂ , H ₂ S, CH ₄
Covered Swine Manure Storage	30-50	1	CO ₂ , H ₂ S, CH ₄

A Scrubber for a Poultry Manure Compost Facility



Scrubbers for Swine Facilities



Pit Fan Scrubber



Manure Storage Scrubber

Research Challenges Encountered

Problems	Solutions
High dust loading clogs line filters and nozzles	Proper sizing of line filters and installation of air filters
Corrosive liquid and high pressure makes pumping difficult	Replaced pump
Liquid line freezing during winter	Installed heat tapes and insulation on lines

Conclusions

- ❖ NH_3 Spray Scrubbing -optimized through Lab Simulations
 - Nozzles selection - balance between **orifice size** and **operating pressure** to optimize **scrubbing efficiency, scrubber size, pumping cost, and clogging**
 - Air velocity - lowered to obtain high collection efficiency and prevent droplet drift
 - Scrubber design - based on the expected variation in inlet NH_3 concentrations
 - ❖ An optimized lab-scale scrubber was developed with 70% to 90% collection efficiency (inlet NH_3 levels ranging from 100 to 400 ppm), low footprint, low pressure drop (0.05 to 0.1 in w.c.) and can work at high air speeds (less than 4 m/s).
 - ❖ Full-Scale scrubbers have been set up but still have challenges to overcome, such as nozzle clogging.
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Acknowledgements



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Thank You !

