PROMOTING CLEANER PRODUCTION THROUGH INNOVATIVE UNIVERSITY RESEARCH METHODS

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Outline

- Introduction
- UNO's Approach to Promote Cleaner Production
- UNO's Research Methodology – Abrasive Blasting Case Study
- Preliminary Results
- Summary and Conclusions

Introduction

- UNO's Location
- Gulf Coast and the Shipbuilding and Ship Repair Sector
- UNO's Departments and Centers
  - SNAME
  - Department of Civil & Environmental Engineering
  - GCRMTC / MERIC
- Synergy for Cleaner Production Research

UNO's Approach to Promote Cleaner Production

- Understanding shipbuilding and ship repair processes
  - Integrated Environmental Management Plan for SF (Broad based research)
  - Specific projects to address more focused issues

- Major processes
  - Surface preparation
  - Metal cutting
  - Painting
  - Welding
  - Assembly

UNO's Approach to Promote Cleaner Production

- Need for simulating shipyard processes on UNO's research site to monitor:
  - Process conditions
  - Multimedia environmental performance
  - Product quality
  - Energy consumption
  - Productivity or efficiency
- Need for Emissions Test Facility (ETF)
- Need for Weld Fume Chamber

Abrasive Blasting – Case Study

- Dry Abrasive Blasting
  - Abrasive materials are propelled against a surface with the aid of compressed air
  - Used to
    - remove surface contamination (rust, paint, oil/grease)
    - create anchor pattern (rough profile) for coating to improve its performance
- Waste Streams
  - Air Emissions
  - Spent Abrasive
- Air Emissions Include
  - Abrasive material: upon bombarding with base plate, abrasive material breaks down into smaller particles
  - Contaminants removed such as paint, rust and others
  - Base metal eroded due to abrasion
  - Metals such as As, Cd, Cr, Cr^{+6}, Pb, Mn, Ni, Ti, and others which may be toxic

Abrasive Blasting – Case Study

- Air emissions from dry abrasive blasting are influenced by
  - Abrasive type
  - Abrasive particle size gradation (medium, coarse, fine)
  - Surface contamination type and level
  - Blast pressure
  - Abrasive feed rate
  - Blast nozzle size
  - Angle of abrasive jet stream to the surface being cleaned
  - Wind velocity (in case of outdoor blasting)
  - Exhaust fan capacity and room size (in case of indoor blasting)
  - Worker training.

Abrasive Blasting – Case Study

- Emission Factors (EF): amount pollutant emitted per unit output work done or amount of pollutant emitted per unit mass of raw material consumed

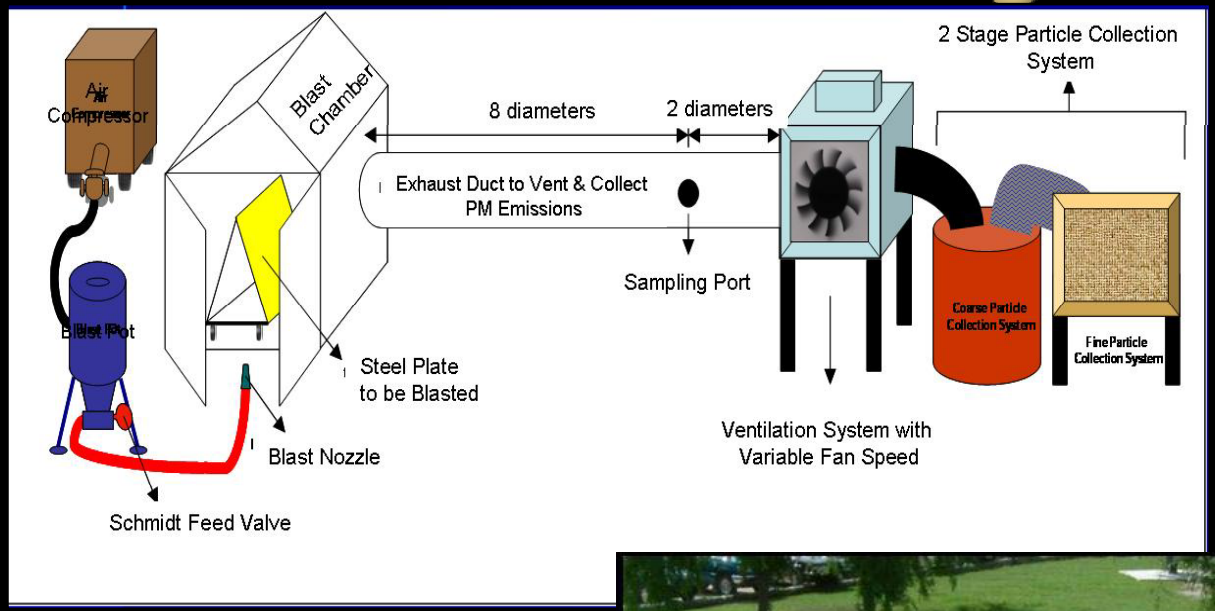
- EFs are used in
  - Estimating emissions
  - Environmental compliance
  - Determining impact on ambient air quality
  - Making environmentally preferable purchases
  - Design and selection of best management processes
  - Health risk impact assessments

- EFs by USEPA, NSRP, and State Agencies
  - Very general, limited, discontinuous and incomplete
  - Diverse test conditions
  - Procedures not standardized

Abrasive Blasting – Case Study

- Shipbuilding survey to understand most commonly used abrasive
- Six abrasives were tested at the UNO emissions test facility for emission factors, consumption, and productivity:
  - Coal Slag (mixture of metallic oxides)
  - Garnet (ferrous, magnesium, aluminum silicate complex)
  - Copper Slag (metallic abrasive containing a mixture of copper and metallic oxides)
  - Bar shot (metallic abrasive, also called hematite, primarily containing ferrous oxide)
  - Steel Grit (metallic abrasive with iron as the primary constituent and trace quantities of metallic and non-metallic oxides)
  - Sand / Specialty Sand

Abrasive Blasting – Case Study



Abrasive Blasting – Case Study

- Exhaust Duct
  - An average exhaust velocity of 3500 – 4000 fpm was maintained comply with the recommended transport velocities for abrasive particles
  - An exhaust fan with a maximum capacity of 5000 cfm was used to vent emissions from the test chamber
  - Designed to comply with the EPA guidelines for source testing
    - Diameter of duct: 12 inches
    - Location of sampling port: 8 diameters (downstream) from the air intake (flow disturbance) and was positioned at 2 diameters upstream from the variable speed fan (flow disturbance)

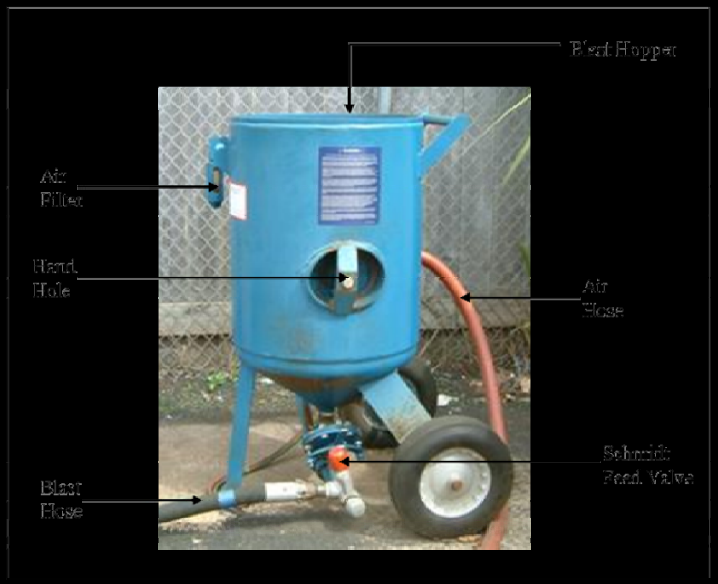
Abrasive Blasting – Case Study

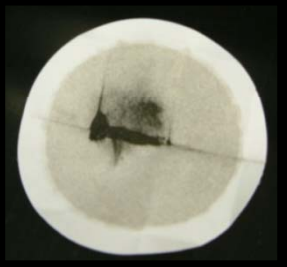
- Abrasive Blasting
  - A measured amount of abrasive material was added to blast pot and blasting was carried out until the blast pot was empty
- Stack Sampling Equipment
  - Designed as per EPA Methods 1- 5
  - Sampling train was used to draw samples from exhaust duct
  - EPA Method 4 was used to measure stack gas velocity and volumetric flow rate
  - Particles were collected on a filter paper
  - Moisture was collected using a series of 4 glass impingers to determine moisture content

Abrasive Blasting – Case Study

- Particle Collection
  - Two-stage particle collection system placed at downstream of exhaust fan
    - The first stage collected the coarse particles by changing the direction of the gas flow
    - The second stage collected fine particles by using a fabric filter
  - Particle samples were collected upstream of exhaust fan
  - Emission factors represent “uncontrolled” emission factors

Abrasive Blasting – Case Study

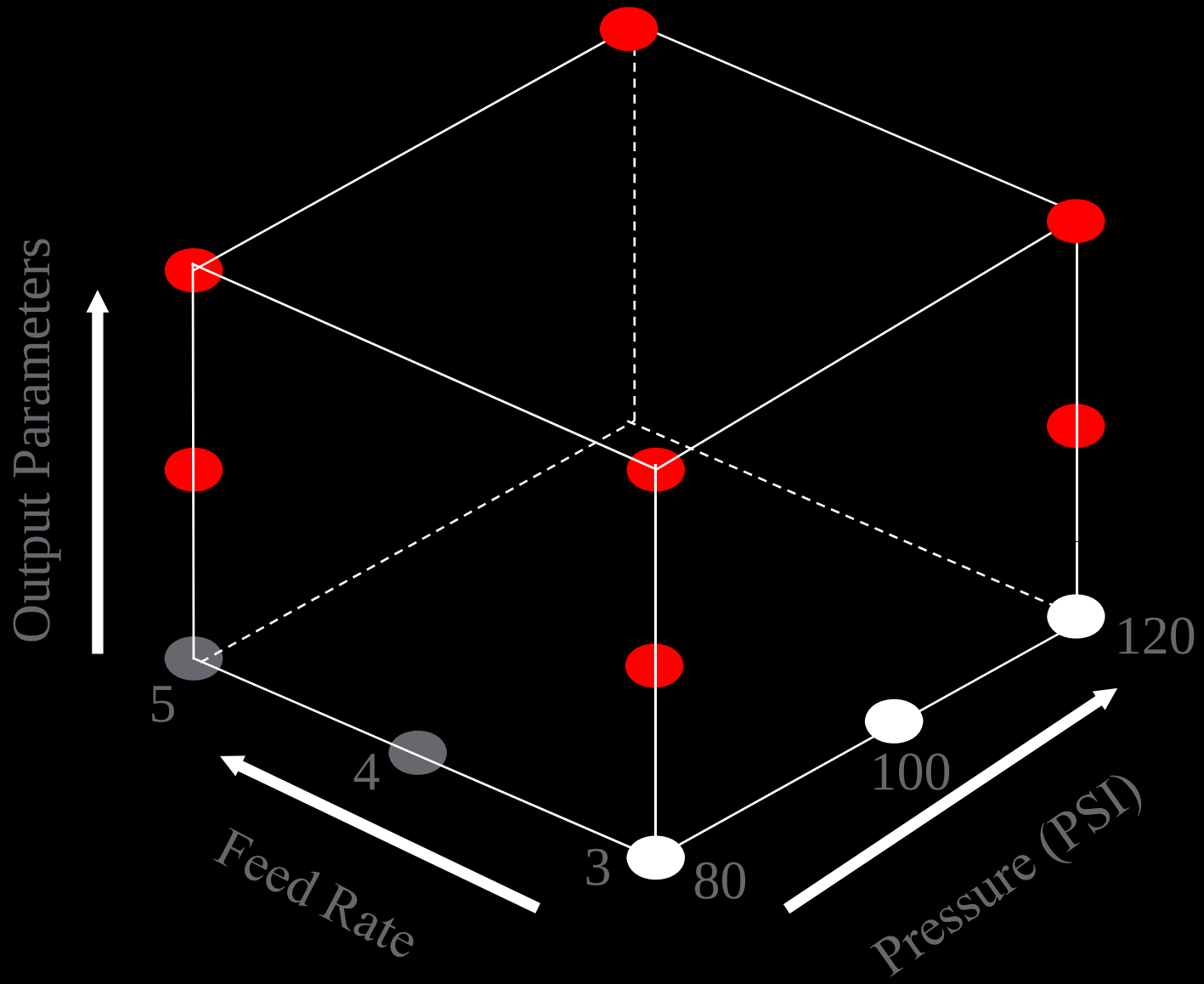




Abrasive Blasting – Case Study

- **Variable Parameters**
  - ***Abrasive Material***: 6 abrasives
  - ***Blast Pressure:*** 80 PSI, 100 PSI, and 120 PSI
  - ***Feed Rate:*** 3, 4, and 5 turns of opening of Schmidt feed valve
  - ***Initial Surface Conditions:*** Flash rust and paint
- **Constant Parameters**
  - ***Abrasive Grade:*** Medium grade
  - ***Blast Nozzle:*** Bazooka No.6 nozzle with 9.5 mm diameter (venturi nozzle)
  - ***Angle of Deflection:*** 90^0 (Nozzle held perpendicular to surface)
  - ***Stand-off Distance:*** 12" was maintained between the test plate and the blast nozzle
  - ***Exhaust Flow Rate:*** 3000 cfm (average volumetric flow rate)
  - ***Surface Finish:*** Near-white finish (SP-10)
- **27 runs for each material and each surface type (3 pressures X 3 feed rates X 3 runs)**

Abrasive Blasting – Case Study



Abrasive Blasting – Case Study

- Area Cleaned: The blasted area was measured using a measuring tape
- Blasting Time: The total blasting time was measured for each run using a stop watch
- Productivity: Area Cleaned (m^2) / Total Blasting Time (hr)
- Consumption: Quantity of Abrasive Used (kg) / Area Cleaned (m^2)
- Emission Factors: Emission factors for various tests were computed as follows:
  - Mass of pollutant emitted (g) / Area Cleaned (m^2)
  - Mass of pollutant emitted (g) / Quantity of abrasive used (kg)
  - Mass of pollutant emitted (kg) / Quantity of abrasive used (kg)
  - Mass of pollutant emitted (kg) / Quantity of abrasive used (ton)

Preliminary Results

- Productivity:

$$Y = a + (b/P) + (c/F) + (d/P^2) + (e/F^2) + f/(P*F)$$

- Abrasive Consumption:

$$Z = a + (b/P) + (c/F) + (d/P^2) + (e/F^2) + f/(P*F)$$

- Emission Factors:

$$EF = a + (b*P) + (c*F) + (d*P^2) + (e*F^2) + (f*P*F)$$

Where:

Y = productivity in m^2/hr,
Z = abrasive consumption in kg/m2
EF = emission factor in g/m2 or g/kg,
P = blast pressure (PSI), applicable range: 80 – 120 PSI,
F = feed rate, applicable range: 3 - 5 turns of Schmidt valve, and
a, b, c, d, e, and f are coefficients that depend on type of abrasive used

Summary and Conclusions

- UNO's approach promotes:
  - Cleaner production
  - Resource conservation (energy and materials)
  - Cost optimization
  - Improved productivity
- Similar approach is being used for other maritime processes
- Concepts are scalable to other industry sectors and other production processes