

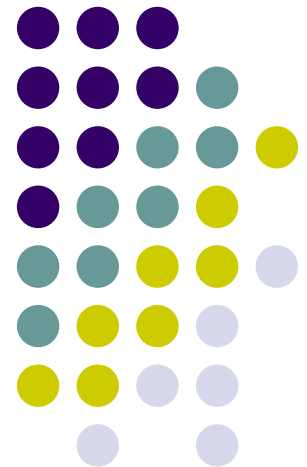
37TH Annual Hand Glass Symposium

Energy Conservation Survey from
Fenton Glass
and
Energy Savings Opportunities in Glass
Manufacturing Industries

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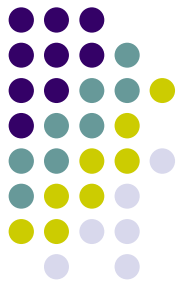
05/11/2006



Presentation Outline



- Fenton Glass - Energy Conservation Survey (2006)
 - Boilers
 - Portable Tanks
 - Electric Motors
 - Plant Lighting
 - Compressed Air Usage
- Energy Savings Opportunities in Glass Manufacturing Industries



1. Natural Gas Fired Boilers

| Description | Input (Btu/hr) | Output (Btu/hr) |
|--------------------|---------------------------|----------------------------|
| Boiler # 1 | 1,980,000 | 1,584,000 |
| Boiler # 2 | 1,740,000 | 1,392,000 |
| Boiler # 3 | 600,000 | 480,000 |
| Boiler # 4 | 675,000 | 540,000 |
| Boiler # 5 | 3,000,000 | 2,400,000 |

Stack Gas Analysis



- Equipment Needed - Combustion Analyzer



- Measures O₂ from 0.1 to 20.9%
- Measures Flue Gas Temp from 0 to 2192° F
- Measures ambient temp 0 to 999° F
- Fuel Type - NG, Oil #2, Oil #4, Oil #6, Kerosene, Propane, and Coal

Equipment Cost - \$1,000

Stack Gas Analysis - Results

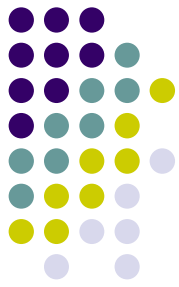


| Boiler # | MMBtu / hr | O₂ (%) | CO₂ (%) | T_{Stack} (°F) | T_{comb. air} (°F) | Current Efficiency (%) |
|-------------------|-------------------|--------------------------|---------------------------|-------------------------------|-----------------------------------|-------------------------------|
| Boiler # 1 | 1.58 | 16.5 | 2 | 175 | 74 | 81 |
| Boiler # 2 | 1.39 | 14.0 | 3.9 | 241 | 76.5 | 82 |

Optimal Percentages of O₂, CO₂, and Excess Air in the Exhaust Gases are:

| Fuel | O₂ (%) | CO₂ (%) | Excess Air (%) |
|-----------------------|--------------------------|---------------------------|-----------------------|
| Natural Gas | 2.2 | 10.5 | 10 |
| Liquid Petroleum Fuel | 4.0 | 12.5 | 20 |
| Coal | 4.5 | 14.5 | 25 |
| Wood | 5.0 | 15.5 | 30 |

Adjust Air-Fuel Ratio



O_2 - 2.2 %

(3% - 4% is Acceptable)

| Boiler # | MMBtu / hr | O_2 (%) | CO_2 (%) | T_{Stack} (°F) | $T_{comb. air}$ (°F) | Proposed Efficiency (%) |
|-------------------|-------------------|-----------------------------|------------------------------|------------------------------------|--|--------------------------------|
| Boiler # 1 | 1.58 | 3.5 | 9.8 | 175 | 74 | 83.1 |
| Boiler # 2 | 1.39 | 3.5 | 9.8 | 241 | 76.5 | 83.9 |

Adjust Air-Fuel Ratio (Contd.)



- **Boiler # 1**

- Output Rating 1.58 MMBtu/hr
- Operation Hours 2,678 hours/yr (7 / 12 * 4,590)
- Exhaust Temperature 175 °F
- Current % O₂ in Stack 16.5 %
- Current Efficiency 81 %

- Proposed % O₂ in Stack 3.5 %
- Proposed Efficiency 83.1 %

- Energy Consumption (Current) = **4,179** MMBtu/yr
- Energy Consumption (Proposed) = **4,073** MMBtu/yr
- Recommended Energy Savings = 4,179 - 4,073 MMBtu/yr
= **106** MMBtu/yr

- Natural Gas Cost = \$10/MMBtu
- **Energy Cost Savings \$1,060/yr**

Adjust Air-Fuel Ratio (Contd.)



- **Boiler # 2**

Energy Cost Savings \$800/yr

- **Total Energy Cost Savings = \$1,860/yr**
- **Implementation Cost = \$1,000**
- **Simple Payback = 7 Months**

2. Natural Gas Fired – Portable Tanks



Stack Gas Analysis Results

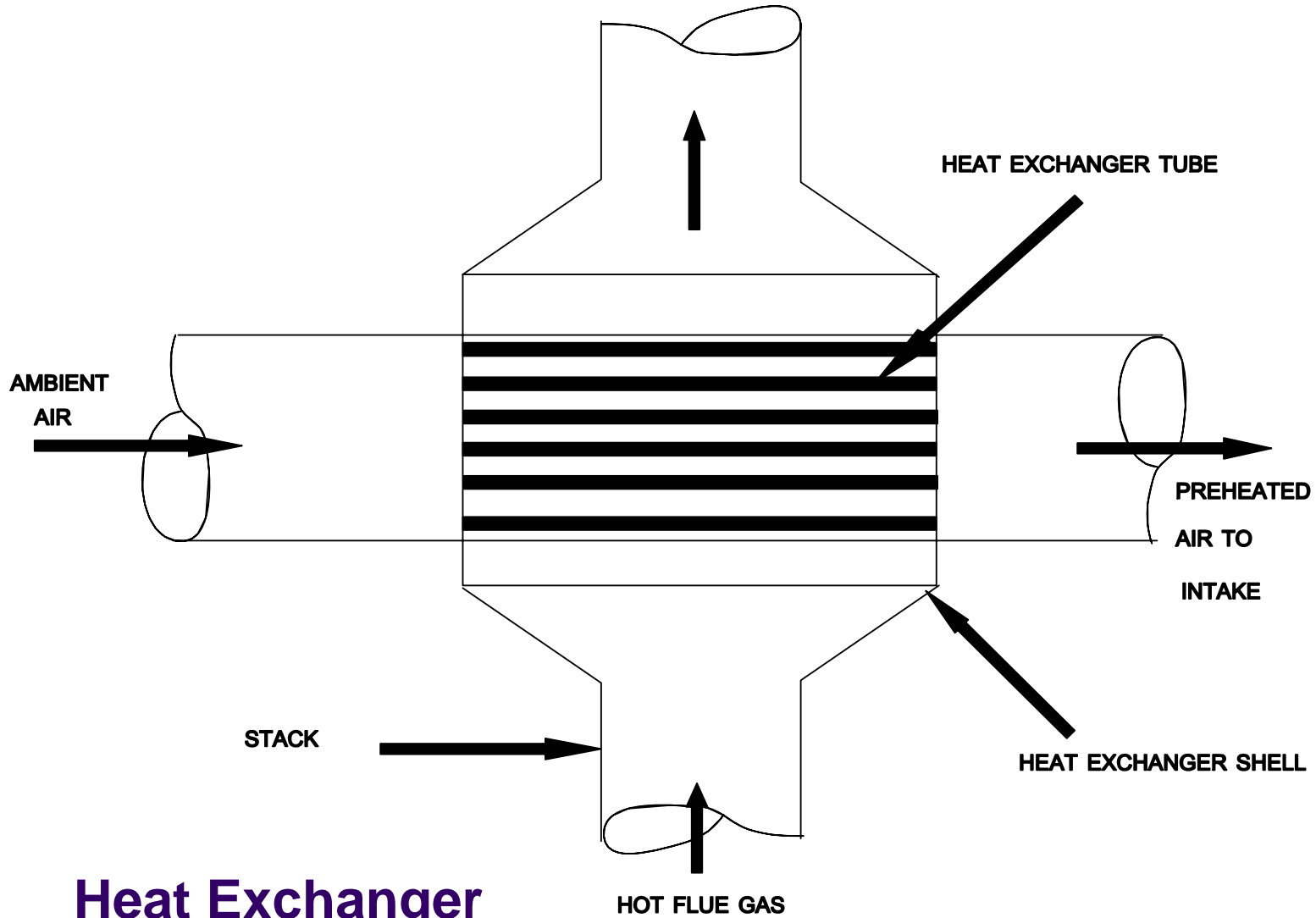
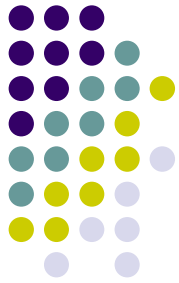
| Portable Tank # | Capacity (MMBtu/hr) | T _{comb. air} (°F) | T _{Stack} (°F) | Current Efficiency (%) |
|-----------------|---------------------|-----------------------------|-------------------------|------------------------|
| 20 - 26 | 0.32 | 74 °F | 850 °F | 64.3% |

Preheat the Combustion Air by Recovering the Heat in the Stack Gas by Installing a Heat Exchanger

An Increase in Efficiency of Approximately 1% is Possible for Every 60°F Increase in Combustion Air Temperature

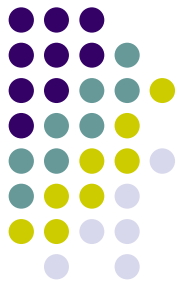
$$Q_T = \text{EFF} \times M_h c_{ph} (T_{h,\text{ins}} - T_{h,\text{out}}) = M_c c_{pc} (T_{c,\text{out}} - T_{c,\text{ins}})$$

Preheat Portable Tank Combustion Air



Heat Exchanger

Preheat Portable Tank Combustion Air (Contd.)



- $T_{c,out} = 540 \text{ }^\circ\text{F}$

- Proposed Efficiency (EFF_p)

$$\begin{aligned}\text{EFF}_p &= \text{EFF}_c + [(TD)/60] \\ &= 64.3\% + 7.7\% \\ &= 72 \%\end{aligned}$$

- Recommended Energy Savings (ES)

$$\text{ES} = \text{Energy Usage} \times [(1/\text{EFF}_c) - (1/\text{EFF}_p)]$$

$$\text{Energy Usage} = 6,142 \text{ MMBtu/yr}$$

$$\begin{aligned}\text{ES} &= 6,142 \text{ MMBtu/yr} \times [(1/0.643) - (1/0.72)] \\ &= 1,020 \text{ MMBtu/yr}\end{aligned}$$

Preheat Portable Tank Combustion Air (Contd.)

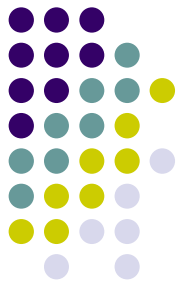


- Natural Gas Cost = \$10/MMBtu
- Energy Cost Savings = 1,020 MMBtu/yr x \$10/MMBtu
= \$10,200/yr
- Implementation Cost / Tank

| | |
|--|----------------|
| Cost of the Galvanized Sheet /Tank | \$150 |
| 12" Fan Cost / Tank | \$300 |
| Cost of 1" fiber glass insulation / Tank | \$50 |
| Heat Exchanger Cost / Tank | \$1,000 |
| Labor Cost / Tank (\$20/hr x 5 hrs) | \$100 |
| Total Cost / Tank | \$1,600 |

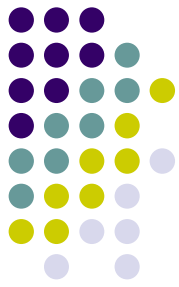
- Total Implementation Cost = 7 Tanks x \$1,600 / Tank
= \$11,200
- Simple Payback = \$11,200 / \$10,200 * 12
= 13 Months

3. Electric Motors



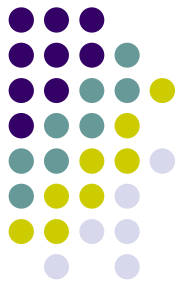
- Motors Use Around 20% of Energy Used in the United States
- Electric Motors, if Not Maintained:
 - Burn Out
 - Cause Bearing Failures
- Significant Drop in Motor Efficiency, Before a Complete Failure Occurs

Electric Motors (Contd.)



- Energy Losses Can Occur Due to
 - Bearing Failure
 - Inadequate Lubrication (Greasing)
 - Belt Tension
 - Misalignment and Unbalances in the Equipment
- These Losses Surface Out as Vibration, Heat and Noise

Perform Vibration Analysis



| Vibration Severity Per ISO 10816 | | | | |
|--|------------------------|--------------------------|----------------------------------|--------------------------------|
| Vibration Meter Reading, Velocity (Inches / Sec) | Class I Small Machines | Class II Medium Machines | Class III Large Rigid Foundation | Class IV Large Soft Foundation |
| 0.01 | | | | |
| 0.02 | | Good | | |
| 0.03 | | | | |
| 0.04 | | | | |
| 0.07 | | | | |
| 0.11 | | Satisfactory | | |
| 0.18 | | | | |
| 0.28 | | Unsatisfactory | | |
| 0.44 | | | | |
| 0.70 | | | | |
| 0.71 | | Unacceptable | | |
| 1.10 | | | | |

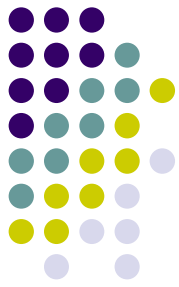
Perform Vibration Analysis (Contd.)



| Motor Description /Area | Total Motor (hp) |
|--------------------------------|-------------------------|
| Atlas Copco. Air Compressor | 150 |
| Ingersoll Rand Air Compressor | 75 |
| Red Max Air Compressor | 50 |
| Hot Metal Wind System | 40 |
| Inside Dope Scrubber | 15 |
| Outside Dope Scrubber | 7.5 |
| Mixing Elevator | 30 |
| Warehouse Elevator | 50 |
| Decorating Make Up Air | 7.5 |

| Vibration Reading (Inches/Sec) | Motor Description / Area | Motor Size (hp) |
|---------------------------------------|---------------------------------|------------------------|
| 0.16 | Hot Metal Wind System | 40 |
| 1.20 | Inside Dope Scrubber | 15 |

Perform Vibration Analysis (Contd.)



➤ Energy Usage (EU)

$$\begin{aligned} \text{EU}_{40\text{hp}} &= \frac{(40 \text{ hp}) \times 2,545 \text{ Btu/hp.hr} \times 0.80 \times 0.80 \times 2,295 \text{ hrs}}{0.904 \times 1,000,000 \text{ Btu/MMBtu}} \\ &= 166 \text{ MMBtu/yr} \end{aligned}$$

Total Energy Usage (EU) for the 9 Motors,
EU = 2,094 MMBtu/yr

➤ Recommended Energy Savings (ES) = 2% of EU

$$\begin{aligned} \text{ES} &= 42 \text{ MMBtu/yr} \\ &= 12,306 \text{ kWh/yr} \end{aligned}$$

$$\text{ECS} = \$380/\text{yr}$$

$$\text{Total Demand Savings} = 35 \text{ kW-month/yr}$$

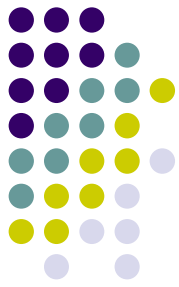
$$\text{Total Demand Cost Savings} = \$309/\text{yr} (@ \$8.82/\text{kW-month})$$

$$\text{Total Cost Savings} = \$689/\text{yr}$$

$$\text{Implementation Cost} = \$1,000$$

$$\text{Simple Payback} = 18 \text{ Months}$$

Replace Drive Belts (Flat or V) with Energy Efficient Cog Belts



- Power Available at the Drive Shaft of the Motor Cannot be Transmitted to a Machine Through a Belt Without Some Additional Energy Losses
 - Slippage
 - Flexion
 - Belt Stretching and Compression
- V-belts have a Maximum Efficiency of About 92%

Cog Belts (Contd.)



- Advantages of Cogged Belts
 - Reduced Friction Losses (Reduced Slippage)
 - Cogged Belts are 5% more Efficient than V Belts
 - Costs 30% More but Lasts 50% Longer than V Belts
 - Reduced Power Transmission Losses

Cog Belts (Contd.)

Recommended Energy Savings (ES)

$$ES = C \times N \times \Sigma H P / \eta \times L F \times U F \times H \times (1 / \eta_{old} - 1 / \eta_{new})$$



| Motor Description /Area | Total Motor (hp) |
|--------------------------------|-------------------------|
| Ingersoll Rand Air Compressor | 75 |
| Red Max Air Compressor | 50 |
| Hot Metal Wind System | 40 |
| Inside Dope Scrubber | 15 |
| Outside Dope Scrubber | 7.5 |
| Mixing Elevator | 30 |
| Warehouse Elevator | 50 |
| Decorating Make Up Air | 7.5 |

ES = 63 MMBtu/yr = 18,459 kWh/yr

ECS = \$555/yr

Total Demand Savings = 61 kW-month/yr

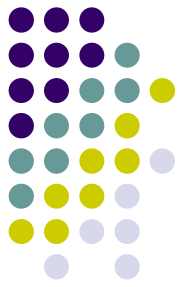
Total Demand Cost Savings = \$540/yr
(@ \$8.82/kW-month)

Total Cost Savings = \$1,095/yr

Implementation Cost = \$0

Simple Payback = Immediate

4. Lighting



- Low Occupancy in Some Areas:

| Location | | Qty. | Bulb Type | Occupancy (% Time) |
|--------------------|---------------------------------------|------|------------------------|-----------------------|
| Shipping Warehouse | Bldg. 45 F (1 st Floor) | 300 | T 12 (96") 60 Watts | ≈ 40% |
| Shipping Warehouse | Bldg. 45 S (2 nd Floor) | 196 | T 12 (96") 60 Watts | ≈ 40% |
| Storage | (2 nd Floor) | 68 | T 12 (96") 60 Watts | ≈ 30% |

Lighting (Contd.)



- Install Occupancy Sensors
 - Motion Sensing Devices
- Lighting Usage will Reduce during Unoccupied Periods



**Wall Switch
Sensors**

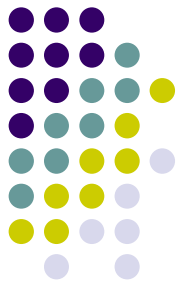


**Wall Mount
Sensors**



**Ceiling
Mount
Sensors**

Lighting (Contd.)



- Recommended Energy Savings (ES)

$$ES = NB \times W \times (1 + BF) \times H \times (1 - TO) / K$$

- For Example, Consider Bldg. 45 F (1st Floor);

$$ES = 300 \times 60 \text{ W} \times (1 + 0.15) \times 4,590 \text{ hrs/yr} \times (1 - 0.40) / 1,000 \text{ W/kW}$$

$$= 57,008 \text{ kWh/yr}$$

$$= 195 \text{ MMBtu/yr} \quad (\text{Note: } 1 \text{ MMBtu} \equiv 293 \text{ kWh})$$

| Area/Description | Recommended Energy Savings (kWh/yr) |
|------------------|-------------------------------------|
| Bldg 45 F | 57,008 |
| Bldg 45 S | 37,245 |
| Storage Area | 15,075 |
| Total | 109,328 |

Lighting (Contd.)

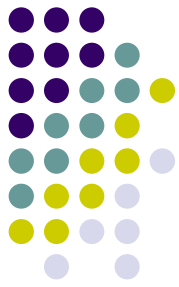


- Annual Energy Cost Savings, ECS,
ECS = ES x Electricity cost (\$/kWh)
= **\$3,386/yr**

- A Single Occupancy Sensor is Rated for Lights up to 1,200W at 120V

| Area/Description | No. of bulbs 60 W each | Total Wattage (W) | No. of Sensors Needed |
|------------------|---------------------------|----------------------|--------------------------|
| Bldg 45 F | 300 | 18,000 | 15 |
| Bldg 45 S | 196 | 11,760 | 10 |
| Storage area | 68 | 4,080 | 4 |
| Total | 564 | | 29 |

Lighting (Contd.)



- Implementation Cost

- Capital Cost

Occupancy Sensor Cost = \$50

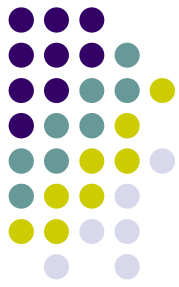
Total Cost for 29 Sensors = \$1,450

- Labor Cost = 0.5 hr/Sensor x 29 sensors x \$22/hr
= \$319

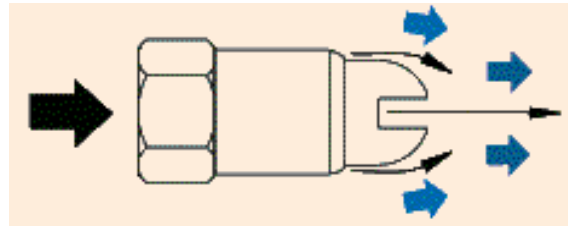
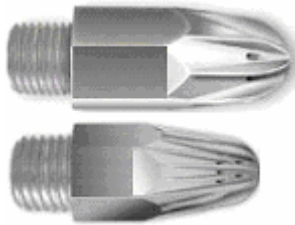
- Total Implementation Cost = **\$1,769**

- Simple Payback = $(\$1,769 / \$3,386/\text{yr}) \times 12$
= **7 Months**

5. Compressed Air – Vortex Nozzles



- Three air compressors in the facility of Size 150 hp, 75 hp, and 50 hp (Air Pressure – 80 psig)
- Twenty, 1/4" Compressed Air Hoses are Used for Cleaning Purposes
- Instead, Install Vortex Nozzles



- Releases a Small Amount of Compressed Air at Near-Sonic Velocity
- Creates a Strong Vacuum Along its Sides, Pulling a Much Larger Volume of Surrounding Air



Compressed Air – Vortex Nozzles

- Uses Less Compressed Air and Runs Quieter
- In Full Compliance with OSHA Regulations Regarding the Acceptable Noise Levels
- Generates Same Flow Rate as Existing 1/4” Nozzles – while Using Only 1 / 10th as much Compressed Air

$$\text{Power Consumed} = \frac{(\text{Measured SCFM} / 4.30 \text{ SCFM per HP}) * 0.746 \text{ kW/hp}}{\text{Motor Efficiency}}$$

$$\text{Power consumed 1/4” nozzle} = 16.41 \text{ kW/nozzle}$$

$$\text{Power consumed Vortex nozzle (1/10th)} = 1.641 \text{ kW/nozzle}$$

Compressed Air – Vortex Nozzles



- Recommended Energy Savings

$$\begin{aligned} \text{ES} &= (\text{PC}) * (\text{Hr}) * (\text{Days}) * (\text{Wks}) * (\text{NN}) \\ &= 87 \text{ MMBtu/yr} \\ &= \mathbf{25,491 \text{ kWh/yr}} \end{aligned}$$

- Energy Cost savings = **\$790/yr**

- Demand Savings = 64 kW-month /yr

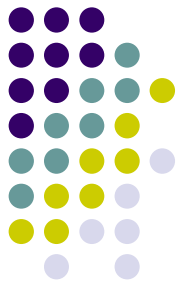
- Demand Cost Savings = **\$562/yr** (@ \$8.82/kW-month)

- Total Cost Savings = **\$1,352/yr**

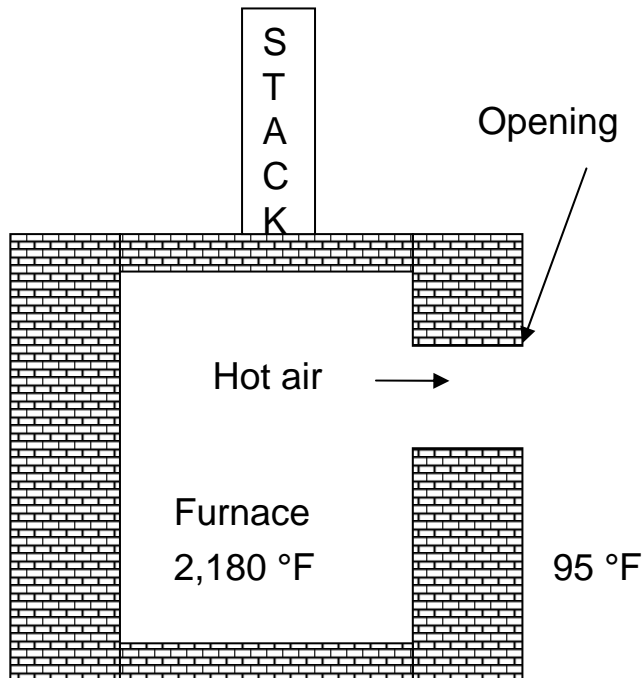
- Implementation Cost = 20 nozzles x \$10/nozzles = \$200

- Simple Payback = **2 Months**

Energy Savings Opportunities in Glass Manufacturing Industries



- Install Foot Operated Doors on Furnace Openings
- Heat Loss through the 11 Furnace Openings (Total Area of Opening = 42ft²), HL

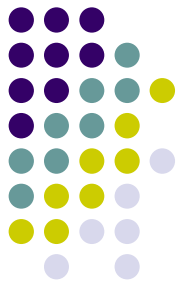


$$HL = h \times A \times (T_i - T_o) \times H \times LF / EFF \times 10^6$$

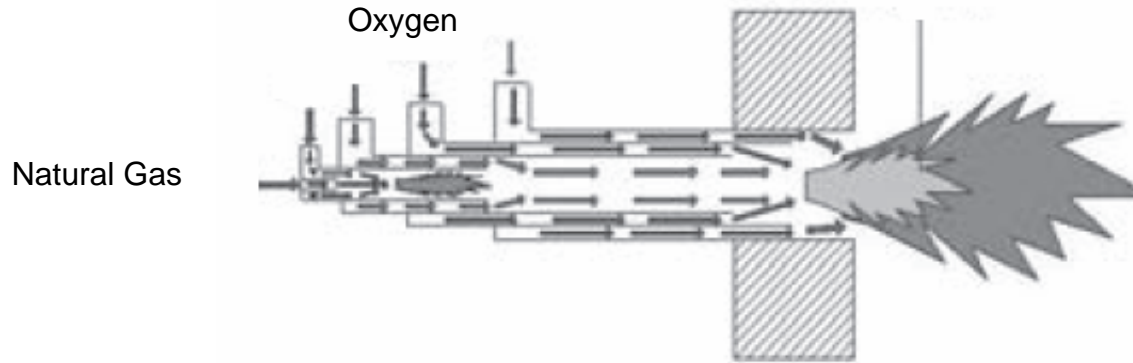
$$HL = 12,960 \text{ MMBtu/yr}$$

$$\begin{aligned} ECS &= HL \times (\text{Unit cost of Natural gas } \$/\text{MMBtu}) \\ &= 12,960 \text{ MMBtu/yr} \times \$5/\text{MMBtu} \\ &= \mathbf{\$65,189/\text{yr}} \end{aligned}$$

- Total Implementation Cost = Refractory Doors + Labor + Engineering = **\$33,000**
- Simple Payback = **6 Months**



● Use High Efficiency Oxy – Fuel Techniques



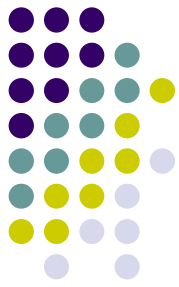
Radiation is the Dominant Mode of Heat Transfer, at Glass Melting Temperatures

Oxygen Increases the Flame Temperature which Greatly Increases Radiation Heat Transfer ($HT = \sigma \times \Delta T^4$)

Advantages of Using Oxy – Fuel Techniques:

- Improves Heat Transfer & Reduces Natural Gas Consumption
- Reduces CO₂/NO_x emissions

Use High Efficiency Oxy – Fuel Techniques (Contd.)



- Literature Suggests around 30% Reduction in Natural Gas Consumption by Using Oxy –Fuel Burners
- Conservative Estimate = 25%

- Facility has 10 Furnaces, Total Rating = 15 MMBtu/hr
- Recommended Energy Savings = 0.25 x 15 x 8,736 Hours
= 32,760 MMBtu/yr

Energy Cost Savings = 32,760 MMBtu/yr x \$5/MMBtu
= \$163,800/yr

Additional Cost of Oxygen = \$110,000/yr

Net Energy Savings = \$163,800/yr - \$110,000/yr
= **\$53,800/yr**

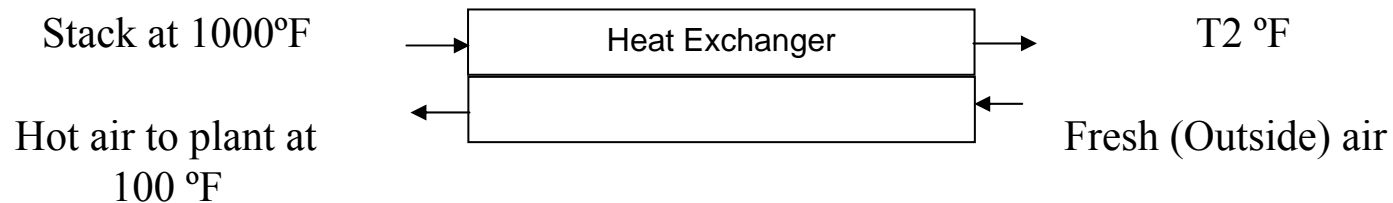
Implementation Cost = (\$10,000 / Burner) x 10 Burners
= \$100,000

Simple Payback < **2 Years**

Heat Recovery from Furnace Stack



| Equipment | Rating | Stack Temperature |
|---------------------------|-------------------|-------------------|
| Furnace | 4 MMBtu/hr | 1,000 °F |
| Natural Gas Space Heaters | 8 x 0.15 MMBtu/hr | - |



Recommended Heat Energy Savings

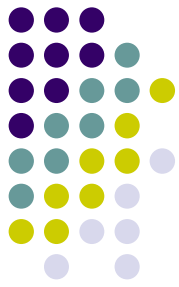
$$\text{HES} = [8 \times 0.15 \text{ MMBtu/hr} \times (16 \text{ weeks} \times 5 \text{ days/week} \times 17 \text{ hours /day})]$$

$$\text{HES} = 1,632 \text{ MMBtu/Winter months}$$

$$\begin{aligned} \text{ECS} &= [(1,632 \text{ MMBtu/yr} \times \$5/\text{MMBtu}) \\ &= \mathbf{\$8,160/\text{yr}} \end{aligned}$$

$$\begin{aligned} \text{Implementation Cost} &= \text{Cost of Heat Exchanger} + \text{Ductwork} + \text{Blowers} \\ &= \$5,700 \end{aligned}$$

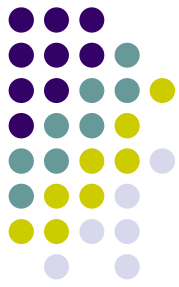
$$\text{Simple Payback} = \mathbf{9 \text{ Months}}$$



Glass Industries Visited

- Eagle Glass Specialties Inc., WV
- Blenko Glass Inc., Co., WV
- Jeannette Specialty Glass Co., PA
- Brooke Glass, WV
- Gentile Glass, WV
- West Virginia Glass Specialty Inc., WV
- Fenton Art Glass, WV
- Davis Lynch Glass Co., WV

Special Thanks



- **US Department of Energy**
Energy Efficiency and Renewable Energy
Industrial Technologies Program
Save Energy Now
(<http://www.eere.energy.gov/industry/saveenergynow/>)
- **West Virginia Development Office (WVDO)**
<http://www.wvdo.org/>

