Cleaner Production in Glass Sector

A strategy for Pollution Prevention

Prepared by:

Gujarat Cleaner Production Centre
(Established by Industries & Mines Department, Government of Gujarat)

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OPTIMIZING COMBUSTION EFFICIENCY OF FURNACE

Firing is the most cost intensive part in any ceramic industry, whether it may be using oil or natural gas. Slightest deviation from the scientific technique may consume more fuel than theoretically required. It is crucially required to optimize the Combustion air – Fuel ratio. Deviation from stoichiometric combination of air and fuel may affect in two ways –

1. *Less air than required: It may lead to incomplete combustion of fuel and thereby generation of Carbon Monoxide (CO), a potentially harmful gas*

2. *More air than required: It may lead to over utilization of fuel, as more oxygen attracts more fuel in combustion chamber, increasing the fuel consumption.*

A few kilns were studied using a portable Flue Gas cum Combustion Efficiency Analyser and the results obtained were quite surprising, and after the analysis, the precautionary measures to be undertaken and expected results were even more surprising.

Combustion Efficiency Indicator:

1. As a rule, the most efficient and cost-effective use of fuel takes place when CO_2 concentration in the exhaust is maximized. Theoretically, this occurs when there is just enough O_2 in the supply air to react with all the carbon in the fuel.

2. The absence of any O_2 in the flue gas directly indicates deficient combustion air while presence indicates excess air. Ideally, the O_2 level shall be maintained 2 % to 6 %, CO_2 level shall be maintained 8 % to 11 %, CO level shall be maintained 80 ppm - 100 ppm and excess air shall be maintained 5 % to 7 % (high pressure burner) for natural gas.

3. Carbon monoxide (CO) is a sensitive indicator of incomplete combustion; its levels should range from 0 to 400 ppm by volume. The presence of a large amount of CO in flue gas is a certain indicator of deficient air.

The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyser or by installing O_2 sensor at the furnace exhaust for flue gases and a modulating motorized damper or RPM of combustion air blower through VFD for combustion air control. The sensor will provide constant feedback of O_2% to the damper / VFD which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 - 90% (Achievable combustion efficiency).

<table>
<tr><th>Intervening Technique</th><th>Optimization of Combustion Efficiency of Melting Furnace in Container Glass Manufacturing Industries (Fuel : Natural Gas)</th></tr>
<tr><td>Before CP</td><td>

Flue gas exhaust at the Furnace was monitored. The flue gas analysis for the Furnace was carried out at the exhaust of individual furnaces. Two furnaces were subjected to the exercise. The measured parameters are shown in tables below:

- % O2 in flue gas varies from 12 % to 13 %.
- Flue gas temperature also varies from 518 ^{o}C to 525 ^{o}C. % O2 in flue gases should be between 3– 4%.

Flue Gas Monitoring Parameters at 95 TPD Furnace

<table>
<tr><th>Parameters</th><th>Reading 1</th><th>Reading 2</th><th>Reading 3</th></tr>
<tr><td>Oxygen (%)</td><td>12.4</td><td>12.6</td><td>12.8</td></tr>
<tr><td>Carbon Monoxide (ppm)</td><td>821</td><td>408</td><td>146</td></tr>
<tr><td>Combustion Efficiency (%)</td><td>44</td><td>42</td><td>42</td></tr>
<tr><td>Carbon Dioxide (%)</td><td>4.8</td><td>4.6</td><td>4.6</td></tr>
</table>

</td></tr>
</table>

Flue Gas Temperature (^0C)	518	522	525
Access Air (%)	148	144.8	151.8
Pressure (mBar)	0.18	0.20	0.21

Flue Gas Monitoring Parameters at 55 TPD Furnace

Parameters	Reading 1	Reading 2
Oxygen (%)	13	12.1
Carbon Monoxide (ppm)	0.0	0.0
Combustion Efficiency (%)	42.8	46
Carbon Dioxide (%)	4.6	4.9
Flue Gas Temperature (^oC)	525	525
Access Air (%)	151	140
Pressure (mBar)	0.17	0.21

Recommendation:

- The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O2 sensor at the furnace exhaust for flue gases and a modulating motorized damper for combustion air control.
- The sensor will provide constant feedback of O2% to the damper which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 - 90% (Achievable combustion efficiency).

	• Thus, it is recommended to operate the furnaces at optimum efficiency by controlling (manual/auto) air fuel ratio so that to get maximum combustion efficiency, the fluidised bed furnaces are known for generating maximum combustion efficiency in principal more than 80 %, thus plant should target to achieve the same initially manual adjustment through frequency adjustment and monitoring oxygen percentage in flue gases and then putting the drives in auto with online O2 sensor in exhaust and feedback to supply air, although caution need to be considered with setting of minimum air requirement for pressure & draft control within furnace. • By maintaining optimum combustion efficiency even upto 75 % from existing (average 45 %) in these two furnaces, plant can save approximately 280524 SCM per annum.
Benefit	
Environmental	• Per Day reduction in the gas consumption: 779 SCM. • Per Year reduction in gas consumption: 280524 SCM. • Per Day reduction in Greenhouse Gas (CO_2) emission: 1.46 MT of CO_2 • Per Year Reduction in Greenhouse Gas (CO_2) emission: 525 MT of CO_2
Economical	Investment: Rs. 30,00,000/-for 2 nos. of Furnace

	Annual Savings: Rs. 50,49,000/- per annum Payback Period: 8 months

Intervening Technique	Optimization of Combustion Efficiency of Melting Furnace in Figure Glass Manufacturing Industry (Fuel: Natural Gas, Furnace Oil & Pet coke)
Before CP	Flue gas exhaust at the Furnace was monitored. Plant is operating 2 nos. furnaces for melting the glass with natural gas as fuel. Thus, the flue gas analysis for the furnaces was carried out, at the exhaust of individual furnaces, the measured parameters are shown in table below:

Table: Flue Gas Monitoring Parameters at Unit 2 Furnace

Parameters	Right Side Firing	Left Side Firing
Oxygen (%)	3.0	6.8
Carbon Monoxide (ppm)	0	78
Carbon Dioxide (%)	10.3	7.9
Access Air (%)	15.4	47.1
Pressure (mBar)	0.46	0.23

Table: Flue Gas Monitoring Parameters at Unit 1 Furnace

Parameters	Right Side	Left Side Firing

	Firing	
Oxygen (%)	4.0	10.4
Carbon Monoxide (ppm)	0	0
Carbon Dioxide (%)	9.6	6.0
Access Air (%)	26.6	95.3
Pressure (mBar)	-0.04	-0.10

It can be observed that the combustion parameters are maintained properly with oxygen percentage in flue gases 3 to 4 % while right side firing and 6 to 12 % while left side firing. Thus, there is loss of combustion efficiency during left side firing and need to be optimized by following combustion efficiency indicators.

Combustion Efficiency Indicator:

1. As a rule, the most efficient and cost-effective use of fuel takes place when CO2 concentration in the exhaust is maximized. Theoretically, this occurs when there is just enough O2 in the supply air to react with all the carbon in the fuel.
2. The absence of any O2 in the flue gas directly indicates deficient combustion air while presence indicates excess air. Ideally, the O2 level shall be maintained 2 % to 6 %, CO2 level shall be maintained 8 % to 11 %, CO level shall be maintained 80 ppm - 100 ppm and excess air shall be maintained 5 % to 7 % (high pressure burner) for gas.

3. Carbon monoxide (CO) is a sensitive indicator of incomplete combustion; its levels should range from 0 to 400 ppm by volume. The presence of a large amount of CO in flue gas is a certain indicator of deficient air.

Excessive draft allows increased volume of air into the furnace. The large amount of flue gas moves quickly through the furnace, allowing less time for heat transfer to the material side. The result is that the exit temperature decreases with increase in heat quantity along with larger volume of flue gas leaving the stack contributes to higher heat loss.

Recommendation:

The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O2 sensor at the furnace exhaust for flue gases and a modulating motorized damper or RPM of combustion air blower through VFD for combustion air control. The sensor will provide constant feedback of O2 % to the damper / VFD which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 - 90% (Achievable combustion efficiency).

Thus, it is recommended to operate the furnaces at optimum efficiency by controlling (manual/auto) air fuel ratio so that to get maximum combustion efficiency, the fluidised bed furnaces are known for generating maximum combustion efficiency in principal

	more than 80 %, thus plant should target to achieve the same initially manual adjustment through frequency adjustment and monitoring oxygen percentage in flue gases and then putting the drives in auto with online O2 sensor in exhaust and feedback to supply air, although caution need to be considered with setting of minimum air requirement for pressure & draft control within furnace. By maintaining optimum combustion efficiency even up to 75 % for left side firing of particularly unit 1 furnace from existing (average 40 % as per oxygen percentage in flue gases) in these two furnaces, plant can save approximately 346149 SCM per annum.
Benefit	
Environmental	• Per Day reduction in the gas consumption: 961 SCM. • Per Year reduction in gas consumption: 346149 SCM. • Per Day reduction in Greenhouse Gas (CO2) emission: 1.80 MT of CO_2 • Per Year Reduction in Greenhouse Gas (CO2) emission: 648.34 MT of CO_2
Economical	Investment: Rs. 20,00,000 /- (for complete automation of furnace) Annual Savings: Rs. 51,92,000 /- per annum Payback Period: 5 months

Intervening Technique	Optimization of Combustion Efficiency of Melting Furnace in Figure Glass Manufacturing Industry (Fuel: Natural Gas)

Before CP

Plant is operating one furnace for melting the glass with natural gas and furnace oil as fuel. Thus, the flue gas analysis for the furnaces was carried out, at the exhaust of furnace, the measured parameters are shown in table below:

Table: Flue Gas Monitoring Parameters at Furnace

Parameters	Right Side Firing	Left Side Firing
Oxygen (%)	0.2	0.6
Carbon Monoxide (ppm)	O/R	O/R
Carbon Dioxide (%)	11.5	11.4
Access Air (%)	0.4	3.4
Pressure (mBar)	0.02	0.06

It can be observed that the combustion parameters are not maintained properly with carbon monoxide level in flue gases over 10,000 ppm, indicating air deficient combustion. Thus, there is loss of combustion efficiency during firing and need to be optimized by following combustion efficiency indicators.

- As a rule, the most efficient and cost-effective use of fuel takes place when CO_2 concentration in the exhaust is maximized. Theoretically, this occurs when there is just enough O_2 in the supply air to react with all the carbon in the fuel.

- The absence of any O_2 in the flue gas directly indicates deficient combustion air while presence indicates excess air. Ideally, the O_2 level shall be maintained 2 % to 6 %, CO2 level shall be maintained 8 % to 11 %, CO level shall be maintained 80 ppm - 100 ppm and excess air shall be maintained 5 % to 7 % (high pressure burner) for gas.
- Carbon monoxide (CO) is a sensitive indicator of incomplete combustion; its levels should range from 0 to 400 ppm by volume. The presence of a large amount of CO in flue gas is a certain indicator of deficient air.

Reduced combustion air resulted in incomplete combustion and thus unburnt carbon, leading to carbon monoxide generation resulting in lower combustion efficiency and loss of fuel.

Recommendation:

The same can be maintained by regular monitoring of flue gas sample with the help of a portable flue gas analyzer or by installing O_2 sensor at the furnace exhaust for flue gases and a modulating motorized damper or RPM of combustion air blower through VFD for combustion air control. The sensor will provide constant feedback of O_2% to the damper / VFD which will in turn regulate the flow of combustion air to maintain the combustion efficiency at optimum level of 80 - 90% (Achievable combustion efficiency).

Thus, it is recommended to operate the furnaces at optimum

	efficiency by controlling (manual/auto) air fuel ratio so that to get maximum combustion efficiency, the fluidised bed furnaces are known for generating maximum combustion efficiency in principal more than 80 %, thus plant should target to achieve the same initially manual adjustment through frequency adjustment and monitoring oxygen percentage in flue gases and then putting the drives in auto with online O_2 sensor in exhaust and feedback to supply air, although caution need to be considered with setting of minimum air requirement for pressure & draft control within furnace. By maintaining optimum combustion efficiency even upto 75 % from existing (average 65 % as per oxygen percentage in flue gases) in the furnace, plant can save approximately 573588 SCM of gas as well as 105813 litre of furnace oil per annum
Benefit	
Environmental	• Per Day reduction in the gas consumption: 1593 SCM. • Per Year reduction in gas consumption: 573588 SCM. • Per Year reduction in Oil consumption: 294 Litre • Per Year reduction in Oil consumption: 105813 Litre • Per Day reduction in Greenhouse Gas (CO_2) emission: 3.00 MT of CO_2 • Per Year Reduction in Greenhouse Gas (CO_2) emission: 1187.55 MT of CO_2

Economical	Investment: Rs. 25,00,000 /- (for complete automation of furnace) Annual Savings: Rs. 1,10,00,000 /- per annum Payback Period: 3 months

Options for Saving Electricity

Intervening Technique	Installation of Variable Frequency Drive (VFD) In Furnace Blower Motor in Container Glass Manufacturing Industry
Before CP	Plant is operating 6 nos. Of furnace with common connection to 30 HP to 60 Hp motor. The motor load test conducted while operating all 4 nos. blower simultaneously is shown in table below:

Table: Electrical Parameters Measured at Ball Mill Motor (4 nos. Motor)

Parameter	75 TPD Furnace		55 TPD Furnace	100 TPD Furnace
	BT-11 Throat Cooling Blower (30 HP)	BD-12 Distribution Blower (30 Hp)	BB-3 Block Cooling Blower (50 HP)	BB-663 Block Cooling Blower (60 HP)
Voltage (V)	412	418	420	420
Ampere (A)	16	5.66	26.7	34.1
Power (kW)	3.46	1.15	7.98	11.0
Power Factor (Cos Ø)	0.30	0.28	0.51	0.44

	The load survey conducted on the blower shows that the maximum loading on blower motor are between 15 to 50 %. The load variation recorded during normal operation of blower motor is • kW for BT-11 Throat Cooling Blower, while the rated capacity of motor is 22.2 kW • 1.15 kW for BD-12 Distribution Blower, while the rated capacity of motor is 22.2 kW • 7.98 kW for BB-3 Block Cooling Blower, while the rated capacity of motor is 37 kW • 11.0 kW for BB-663 Block Cooling Blower, while the rated capacity of motor is 44.4 kW. The load survey during all blower operation is shown in table above: • It could be observed that all the motors are running below 50% of the rated load; however, this does not consume less electricity than required at full load, on the contrary, the motor efficiency decreases dramatically. • Cooling blowers are critical equipments for glass industries and they keep on running for 24 hours all the day, hence there is a huge scope of saving the electricity.
After CP	• The speed of the motor can be reduced by installing variable frequency drive on Blower motor and operating

	speed can be programmed accordingly. • This will result in reduction in electricity consumption to the tune of 15% saving in electricity consumption in blowers. This concept is applicable to all the motors in the plant above 5 HP. • Approximate total one time investment will be Rs.2, 45,000 for all four VFD.
Benefit	
Economical	Investment: Rs. 2,45,000/-for 4 nos. of VFD Annual Savings: Rs. 2,80,000/- per annum Payback Period: 10 months

Intervening Technique	Installation of VFD on Throat Cooling Blower Motor in figure glass industry
Before CP	Most electric **motors** are designed to run at 50% to 100% of rated load. Maximum efficiency is usually near 75% of rated load. Thus, a 10-horsepower (hp) motor has an acceptable load range of 5 to 10 hp; peak efficiency is at 7.5 hp. A motor's efficiency tends to decrease dramatically below about 50% load. However, the range of good efficiency varies with individual motors and tends to extend over a broader range for larger motors.

A motor is considered under loaded when it is in the range where efficiency drops significantly with decreasing load. Figure shows that power factor tends to drop off sooner, but less steeply than efficiency, as load decreases.

Electrical load survey was conducted on major motors in the plant, the parameters measured are shown in following table:

Motor Name	Voltage (V)	Current (A)	Power Factor	Power (kW)	Rated Power (kW)	Loading (%)
Unit No. 2 (75 TPD Furnace Area)						
Throat Cooling Blower	412	8.57	0.64	3.94	9.32	42
Unit No. 1 (84 TPD Furnace)						
Throat Cooling Blower	416	6.32	0.78	3.55	9.32	38

Loading on both the motors is less than 50 %, thus they are running at lower efficiency of around 75 %,

Recommendation:

It is recommended to replace these motors with appropriate size on next failure, the motor need to be selected so that the loading

	on motor is more than 80 % to have more than 90 % efficiency. Replacement of these motors with energy efficient motors will save approximately 9450 kWh per annum.
Benefits	
Environmental	• Per Day reduction in the Electricity consumption: 26.25 KWh • Per Year reduction in Electricity consumption: 9450 KWh • Per Day reduction in Greenhouse Gas (CO2) emission: 0.02 MT of CO2 • Per Year Reduction in Greenhouse Gas (CO_2) emission: 8.13 MT of CO_2
Economical	Investment: Rs. 50,000/- (for 2 nos. of Furnace) Annual Savings: Rs. 71,253/- per annum Payback Period: 9 months

Intervening Technique	Installation of VFD on Cooling Blower Motor in figure Glass industry
Before CP	Most electric motors are designed to run at 50% to 100% of rated load. Maximum efficiency is usually near 75% of rated load. Thus, a 10-horsepower (hp) motor has an acceptable load range of 5 to 10 hp; peak efficiency is at 7.5 hp. A motor's efficiency tends to decrease dramatically below about 50% load. However, the range

of good efficiency varies with individual motors and tends to extend over a broader range for larger motors.

A motor is considered under loaded when it is in the range where efficiency drops significantly with decreasing load. Power factor tends to drop off sooner, but less steeply than efficiency, as load decreases.

Electrical load survey was conducted on major motors in the plant, the parameters measured are shown in following table:

Motor Name	Voltage (V)	Current (A)	Power Factor	Power (kW)	Rated Power (kW)	Loading (%)
100 TPD Furnace Area						
Glass Cooling Lower Blower	412	5.27	0.64	2.40	5.5	43
Throat Cooling Blower (with VFD)	411	9.02	0.78	5.02	11.2	45

- Loading on both the motors is less than 50 %, although throat cooling blower motor is driven through VFD still

	showing low power factor, indicating the opportunity to reduce the frequency of the VFD and optimize the power consumption. • The Glass cooling lower blower motor is running at lower efficiency of around 75 %, thus it is recommended to replace motor with appropriate size on next failure, the motor need to be selected so that the loading on motor is more than 80 % to have more than 90 % efficiency. Recommendation: • It is recommended to reduce the frequency of the throat cooling blower motor frequency and replacement of the glass cooling lower blower motor with energy efficient motor will save approximately 5208 kWh per annum.
Benefits	
Environmental	• Per Day reduction in the Electricity consumption: 14.47 KWh • Per Year reduction in Electricity consumption: 5208 KWh • Per Day reduction in Greenhouse Gas (CO2) emission: 0.01 MT of CO2 • Per Year Reduction in Greenhouse Gas (CO_2) emission: 4.48 MT of CO_2
Economical	Investment: Rs. 50,000/- (for 2 nos. of Furnace) Annual Savings: Rs. 71,253/- per annum

	Payback Period: 9 months

Intervening Technique	Optimise the Power Consumption at Cooling Water Pump in figure Glass Industry
Before CP	Cold Water Pump • Plant is operating cold water pump of 9.32 kW rated power with rated discharge of 151 m^3/hr, with rated head of 15 m. Cooling water is being used for different cooling application, the suction head of the cooling water was found 3 m. The discharge line has flow control valve which was only 30 % open, indicates that the pump installed is over capacity. • The pump is not operating at the optimum efficiency due to shift in flow rate from design parameter. The pump is consuming 9.5 kW power while the hydraulic power required for pumping water (@ 60 m^3/hr flow as per valve position) at total head of 20 m (assumed) is only 4.5 kW. Hot Water Pump • Plant is operating hot water pump of 15 kW rated power with rated discharge of 120 m^3/hr, with rated head of 28 m. Water is being pumped to the cooling tower, the suction

	head of the cooling water was found 1.5 m. The discharge line has flow control valve which was only 50 % open, indicates that the pump installed is over capacity. The pump is not operating at the optimum efficiency due to shift in flow rate from design parameter. The pump is consuming 15 kW power while the hydraulic power required for pumping water (@ 72 m^3/hr flow as per valve position) at total head of 30 m (assumed) is only 7.8 kW. Recommendation: Hot Water Pump • It is recommended to install a Variable Frequency Drive with pressure feedback on this pump to optimize the power consumption without replacing the pump as well as keeping option of load increment in future; the VFD will save approximately 21000 kWh per annum. Cold Water Pump • Thus it is recommended to install a Variable Frequency Drive with pressure feedback on this pump to optimise the power consumption without replacing the pump as well as keeping option of load increment in future; the VFD will save approximately 29400 kWh per annum. Total save Approximately 50400 KWh per annum.
Benefit	

Environmental	• Per Day reduction in the Electricity consumption: 140 KWh • Per Year reduction in Electricity consumption: 50400 KWh • Per Day reduction in Greenhouse Gas (CO2) emission: 0.12 MT of CO2 Per Year Reduction in Greenhouse Gas (CO_2) emission: 43.34 MT of CO_2
Economical	Investment: Rs. 55,000 /-(for 2 VFD) Annual Savings: Rs. 3,80,016/- per annum Payback Period:2 Months

Intervening Technique	Optimise the Power Consumption at Cooling Water Pump in figure Glass Industry
Before CP	Plant is operating cold water pump of 19.70 kW rated power with rated discharge of 150 m3/hr, with rated head of 35 m. Cooling water is being used for different cooling application, the suction head of the cooling water was found 2 m. The discharge line has flow control valve which was only 50 % open, indicates that the pump installed is over capacity. The pump is not operating at the optimum efficiency due to shift in flow rate from design parameter. The pump is consuming 20 kW power while the hydraulic power required for pumping water

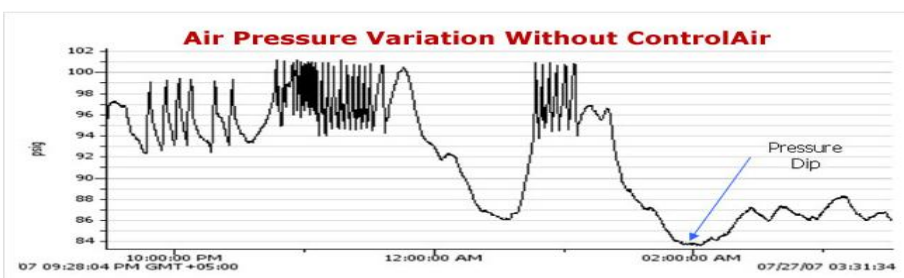
	(@ 90 m3/hr flow as per valve position) at total head of 40 m (assumed) is only 13.5 kW.
After CP	Thus it is recommended to install a Variable Frequency Drive with pressure feedback on this pump to optimise the power consumption without replacing the pump as well as keeping option of load increment in future; the VFD will save approximately 27300 kWh per annum. Plant is operating hot water pump of 8.12 kW rated power with rated discharge of 150 m^3/hr, with rated head of 15 m. Water is being pumped to the cooling tower, the suction head of the cooling water was found 2 m. The discharge line has flow control valve which was only 70 % open, indicates that the pump installed is over capacity. The pump is not operating at the optimum efficiency due to shift in flow rate from design parameter. The pump is consuming 8.2 kW power while the hydraulic power required for pumping water (@ 120 m3/hr flow as per valve position) at total head of 15 m (assumed) is only 6.6 kW. Thus it is recommended to install a Variable Frequency Drive with pressure feedback on this pump to optimise the power consumption without replacing the pump as well as keeping option of load increment in future; the VFD will save approximately 6300 kWh per annum.

Benefit	
Environmental	• Per Day reduction in the Electricity consumption: 93 KWh • Per Year reduction in Electricity consumption: 33600 KWh • Per Day reduction in Greenhouse Gas (CO2) emission: 0.08 MT of CO2 • Per Year Reduction in Greenhouse Gas (CO_2) emission: 28.90 MT of CO_2
Economical	Investment: Rs. 75,000 /- (for complete automation of furnace) Annual Savings: Rs. 2,43,000 /- per annum Payback Period: 4 months

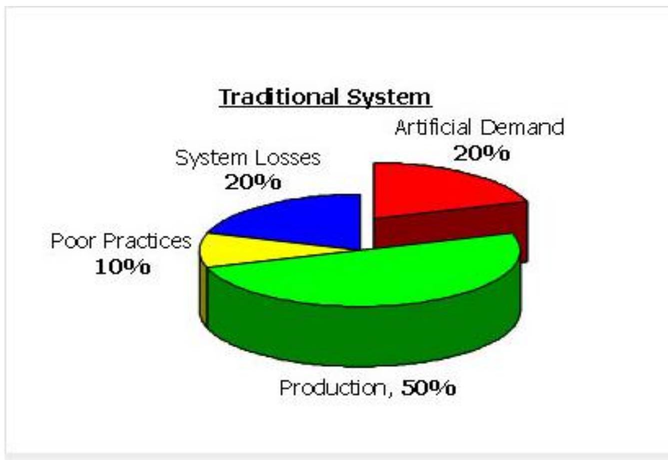
Intervening Technique	Avoid Compressed air usage for cleaning purposes
Before CP	During the visit it was observed that compressed air is used for cleaning purposes at some workstations to clean the components with open hose of 5 mm diameter and at 6 kg/cm²g pressure.
After CP	Usually, cleaning can be done at lower pressure (around 2-3 kg/cm²g). So, the first step would be to reduce the pressure and energy saving would be around 8% at drop of each bar for that hose if generated separately. From our past experience the company can save Rs. 21,000 per year (from one workplace) by installing compressed air saving gun.

	The compressed air is a costly utility and the less critical purposes like cleaning can be achieved by installing air saver nozzles at the tip of these cleaning devices or shall be replaced with new one. The special design of these improved cleaning nozzles allows ambient air to get entrained in the path due to vacuum created by compressed air and delivers the air with similar velocity and thrust giving to desired cleaning effect. However, the amount of compressed air uses is only 20-25% which reduces the compressed air requirement and thus resulting in energy savings. In addition, these nozzles also reduce the noise level.  
Environmental	Reduction in the electricity consumption to generate the compressed air, with that, also reducing Noise Pollution of the surrounding, making the site easy to work.
Economical	Investment: Rs. 3,000/- per gun

	Annual Savings: Rs. 21,000/- per station Payback Period: 3 months

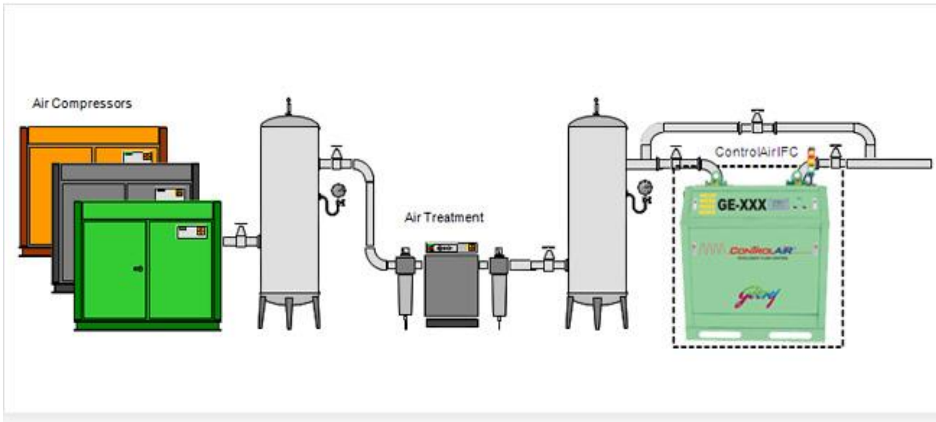
Intervening Technique	Reducing Fluctuating Compressed Air Demand
Description	Plant is operating various air compressors for process application, while 2 nos, air compressors of 75 kW rated power and 484 CFM free air delivery capacity each were operating for instrumentation air purpose. Industry usually have problem of fluctuating air pressure. This is caused by intermittent use of several pneumatic equipments. It begins with sudden air demand pulling down pressure at the point of use. The only way for the Air Compressors to know about it, is when it travels to upstream through distribution network. The capacity control mechanism of the Air Compressor in the form of Load/Unload or VSD then starts delivering compressed air in the system. Practically it takes a while for the entire air system to fill up to the required pressure. 

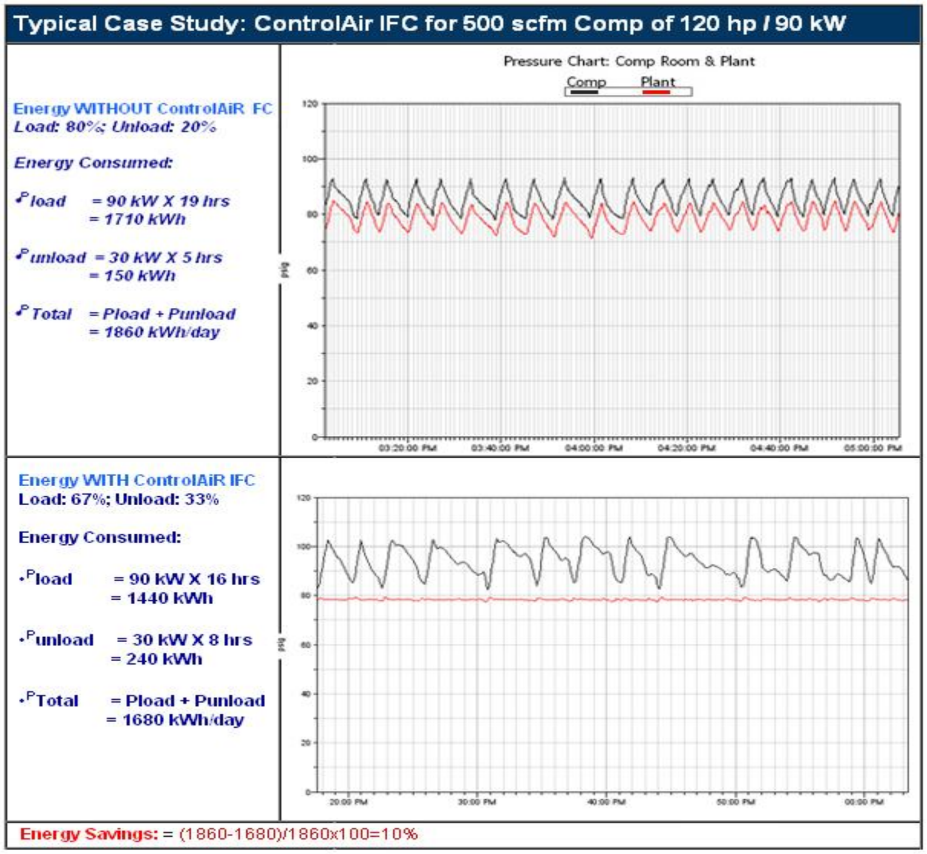
- This lag in response time between demand & supply, force the Compressor operators to maintain higher level of pressure in the air system to sustain a sudden demand. Thus more Compressors are needed to meet the artificial demand along with real air demand. This causes wastage of compressed air & leads to an energy inefficient system. This translates into high energy bills. Isn't it time, you controlled the cost of energy for your Air Compressors?



Benefits of Control Air IFC System:

- Constant Air Pressure throughout the plant
- Artificial Demand Reduction
- Reduced Compressed Air leaks
- Satisfy Peak Demand with Useful Storage
- Improved product quality
- Increased productivity
- Reduction in Comps operating & maintenance costs
- 80% depreciation under prevailing income tax laws in India

	• Payback between 7 to 22 months  • The Control Air IFC is designed to operate at the intermediate point of the compressed air system; i.e. on the downstream of Dryers / Receivers & upstream of the main piping distribution system. Control Air IFC creates useful storage which isolates Compressors from demand side peaks & troughs to provide a stable air supply at optimum pressure. It monitors demand side rate of change of pressure & releases only required amount of storage air to satisfy the peak demands instead of starting additional Compressors. Thus energy is saved through reduction in mass of air & reduction in load period of Compressors. 



- Thus, it is suggested to install the Control Air system for instrumentation air supply, this will save approximately 10 % of electricity consumption by air compressor.

Benefit	
Environmental	• Reduction in Greenhouse Gas (CO2) emission
Economical	Investment: Rs. 6,00,000/- Annual Savings: Rs. 4,97,000/- per annum Payback Period: 15 months

Oxy-Combustion in Furnaces

Intervening Technique	Optimisation of Gas Consumption through Oxygen Enhanced Combustion in Furnaces
Description	Glass manufacturing is a very energy intensive industrial process. Glass is produced by heating the raw materials like silica (Silicon dioxide), sand (Quartz), iron oxide, and other Materials to about 1500 to 2000 ^{0}C. Glass manufacturers who need to increase pull rate (pull rate is the velocity of the glass sheet) and improve quality, consistency, and thermal efficiency while decreasing NOx emissions can use Oxy-Fuel technology. Oxy-Fuel technology has proved to be one of the most energy efficient combustion processes for glass melting furnaces. Ideal burners for any furnace would have the following characteristics: • Flexibility with respect to flame length and heat transfer. • Continuity of operations, which can be adjusted during use. • Multiple fuel usage. • Robust and compact design. The Oxy-Fuel burners have most of the above characteristics. It has been observed by a major company in combustion technology that in Oxy-Fuel combustion the volume of the flue gases is approximately 20% of that in the Air-Fuel combustion resulting in a reduction of the amount of heat lost through flue gases. They have developed their own-patented burners and found it to be one

	of the most efficient ways of reducing NOxs, achieve maximum efficiency, and reduce particulate emissions from glass furnaces. Additional advantages of Oxy-Fuel Combustion in the glass industry are: • Better glass quality. • Very low NOx and particulate emissions. • No air preheating necessary. • Suitability at higher pull rate. • Better sequencing of the furnace. Thus with oxygen enrichment, more heat is transferred to the product, less heat is lost in the exiting combustion gases, and the combustion process becomes more efficient. With proper furnace design and burner selection, reduction of NOx by 50-70%, as compared to regenerator furnace is achievable. In addition, reduction of batch carry over is possible. Depending on the furnace operation and the efficiency of the operation, fuel savings can range from slightly over 50% to only 10%, so all the variables need to be reviewed prior to deciding if oxy combustion is a viable option. It is possible to convert specific zones of existing furnaces to oxy-fuel, or to add oxy-boosting burners as required at strategic locations in addition to air-fired burners. The conversion from an air-fuel combustions system to an oxy-

	fuel system will require a complete burner replacement. "Oxy-fuel burners are of a different design than air-fuel burners; it is not possible to simply insert an oxy-fuel element into an air-fuel burner. Oxy-fuel combustion is not the answer to all applications, so it is very important to determine if it is a viable alternative. That said, in some processes that cycle, where loads are taken from cold to hot and melted, going from air combustion to oxy combustion not only reduces fuel use but can reduce cycle and heat-up time. This is where the operator can see significant cost reductions. Add to this the potential for reduction in total NOx emissions and the ability to reduce the plant's carbon footprint by reduction in fuel use, and the benefits of oxy-fuel can be important. Before replacing or adding air-fuel combustion systems, it can be valuable to take a look at the oxy-fuel option. Depending on the furnace operation and the efficiency of the operation, fuel savings can range from slightly over 50% to only 10%, so all the variables need to be reviewed prior to deciding if oxy combustion is a viable option. It is possible to convert specific zones of existing furnaces to oxy-fuel, or to add oxy-boosting burners as required at strategic locations in addition to air-fired burners. Considering even 10 % fuel saving by converting air-fuel system into oxy-fuel system.

Savings after Oxy - Combustion in Furnace:-

Industry	Investment in Rs.	Annual Saving per Annum in Rs.	Saving of Natural Gas & Oil	Payback in Months	Reduction in GHG
Container Glass	2,50,00,000 (for 2 Furnace)	1,29,50,000	718063 SCM	24	1344.93 MT of CO_2
Figure Glass	2,20,00,000 (for 2 Furnace)	86,17,695	574513 SCM	30	1076 MT of CO_2
Figure Glass	1,20,00,000	81,98,000	430191 SCM & 79360 Litre	18	890 MT of CO_2

BATCH AND CULLET PREHEATING

Intervening Technique	Optimisation of Gas Consumption through Batch & Cullet Preheating
Description	Batch and cullet is normally introduced cold into the furnace, but by using the residual heat ofthe waste gases to preheat the batch and cullet, significant energy savings can be possible. Preheating temperatures should preferably not be lower than 270 ^{0}C but should not exceed500 – 550 ^{0}C. In practice, most batch and cullet preheaters operate at batch preheat temperatures between 275 and 325 ^{0}C. The available systems are described below: • Direct preheating – this type of preheating involves direct contact between the flue-gas and the raw material (cullet and batch) in a cross-counter flow. The waste gases are supplied to the preheater from the waste gas duct behind the regenerator. They pass through the cavities in the preheater, thereby coming into direct contact with the raw material. The outlet temperature of the cullet and batch is about 300 ^{0}C and could go up to 400 ^{0}C. The system incorporates a bypass that allows furnace operations to continue when preheater use is either inappropriate or impossible. • Indirect preheating – the indirect preheater is, in principle, a cross-counter flow, plate heat exchanger, in which the

material is heated indirectly. It is designed in a modular form and consists of individual heat exchanger blocks situated above each other. These blocks are again divided into horizontal waste gas and vertical material funnels. In the material funnels, the material flows from the top to the bottom by gravity. Depending on the throughput, the material reaches a speed of 1 – 3 m/h and will normally be heated from ambient temperature up to approximately 300 0C. The flue-gases will be let into the bottom of the preheater and flow into the upper part by means of special detour funnels. The waste gases flow horizontally through the individual modules. Typically the flue gases will be cooled down by approximately 270 – 300 ^{0}C.

These techniques have a number of environmental effects, which can vary from case to case. In general, the benefits given below have been experienced.

- Specific energy savings of between 10 and 20 % with a consequent reduction of CO2 emissions.
- Reduction in NOX emissions (due to lower fuel requirements and lower furnace temperatures). However, in most cases the energy savings are used to increase the pull of the furnace.
- An increase of pull rate of up to 10 – 15 %, is possible for applications to existing glass furnaces, with preheating of the batch to 300 ^{0}C.

	By implementing the batch & cullet preheating plant can save Natural Gas and Furnace Oil.

Savings after Batch & Cullet Pre-heating:-

Industry	Investment	Annual Saving per Annum	Saving of Natural Gas	Payback in Month	Reduction in GHG
Container Glass	1,50,00,000 (for 2 Furnace)	53,87,000	1496616 SCM	34	2803 MT of CO2
Figure Glass	80,00,000	28,72,000	957522 SCM	30	1793 MT of CO2
Figure Glass	50,00,000	21,97,000	143397 SCM & 2126 Litre	28	271 MT of CO2

Options for Glass Processing Industries (Tempered Glass Units):-

Intervening Technique	Optimise the Electric Power at Washing Machine in Tempered Glass Industry (Fuel: Electricity)
Before CP	Plant is operating 3 nos. washing machine having air blower of 22 kW on 2 nos. machine while 7 kW on one machine. These blowers are running continuously even though the frequency of glass on conveyor is varying, also frequent ON/OFF of the blower motor is not practical as it will generate frequent and sudden load increment which is not advisable.
After CP	Thus it is advisable to install the Variable Frequency Drive (VFD) on these motors with speed variation feedback through material movement sensor on the conveyor. This intervention will save approximately 71400 kWh per annum.
Environmental	• Per Day reduction in the Natural Gas consumption: 198 KWh • Per Year reduction in the Natural Gas consumption: 71400 KWh • Per Day reduction in Greenhouse Gas (CO2) emission: 0.17 MT of CO2 • Per Year Reduction in Greenhouse Gas (CO_2) emission: 61.40 MT of CO_2

Economical	Investment: Rs. 1,00,000/- per Annum (for 3 nos. of VFD) Annual Savings: Rs. 5,35,000/- per Annum Payback Period: 3 months

Intervening Technique	Optimise the Plant Lighting Load in Tempered Glass Industry
Before CP	Plant is operating 15 nos. High Pressure Mercury Vapour Lamp (HPMV) of 250 watt each, for 8 hrs. Per day. Also, approximately 20 nos. CFL of 32 watt in admin department as well which also operated almost 8 hrs. Per day.
After CP	The comparison between different light types is shown in following table: **Table:** Comparison of Lights (LED/Fluorescent/Incandescent)

Energy Efficiency	Incandescent Light Bulbs	Fluorescent (CFL)	LED
Life Span (average)	1,200 hours	8,000 hours	50,000 hours
Watts of Electricity Used (equivalent to 60 watt bulb).LEDs use	60 watts	13-15 watt	6 - 8 watts

	less power (watts) per unit of light generated (lumens). LEDs help reduce greenhouse gas emissions from power plants and lower electric bills			
	Environmental	Incandescent Light Bulbs	Fluorescent (CFL)	LED
	Contains the TOXIC Mercury. A silvery-colored poisonous elemental metal that is liquid at room temperature.	No	Yes - Toxic for your health and the environment.	No
	RoHS Compliant (Reduction Of	Yes	No - contains 1mg-5mg of Mercury and is a	Yes

		Hazardous Substances).The maximum concentration limits on hazardous materials used in electrical and electronic equipment. Enforced by the European Union.		major risk to the environment	
		Important Facts	Incandescent Light Bulbs	Fluorescent (CFL)	LED
		Sensitivity to low temperatures	Some	Yes - may not work under negative 10 degrees Fahrenheit or over 120 degrees Fahrenheit	None
		Sensitive to humidity	Some	Yes – canhave a higher failure rate in more	No

		humid climates/weather.	
On/off Cycling. Switching a CFL on/off quickly, in a closet for instance, may decrease the lifespan of the bulb.	Some	Yes - can reduce lifespan drastically	No Effect
Turns on instantly	Yes	No - takes time to warm up the Mercury to achieve maximum light output.	Yes
Durability	Not Very Durable - glass or filament can break easily	Not Very Durable - glass can break easily	Very Durable - LEDs can handle jarring and bumping
Heat Emitted. Incandescent	85 btu's/hour	30 btu's/hour	3.4 btu's/hour

bulbs emit large amounts of heat which can increase air conditioning costs and energy consumption while using air conditioning.			
Possibility of Mechanical Failure	Some	Yes - may catch on fire, smoke, or omit an odor	Not typical
Minimum Light Output	Incandescent Light Bulbs	Fluorescent (CFL)	LED
Lumens Measures luminous flux or total packets of light produced by a light source	Watts The unit of power. The amount of energy transferred in one second		
250	25	4-9	3
450	40	9-13	4-5
800	60	13-15	6-8

1,100	75	18-25	9-13
1,600	100	23-30	16-20
2,000	125	28-40	20-25
2,600	150	30-55	25-28
Streetlight	90 LED	250W Mercury-vapour	
Light source	1W LED (90pcs)	(OSRAM)HQL 250W	
Central luminance	15-16Lux at 7m	15-16Lux at 7m	
Beam angle	120°	150°	
Life Span	100,000 hours	15,000 hours	
Energy consumption per year	442kWh /year	1068kWh /year	
Ultraviolet hazards	No ultraviolet emission	Emits ultraviolet	
LED Streetlight		Mercury-vapour Streetlight	
	Lumen	OSRAM HQL	Lumen
28 LEDs - 28W	2300	50W~80W	1800~3800
56 LEDs - 56W	5000	80W~125W	3800~6300
112 LEDs-112W	10000	125W~250W	6300~13000

	168 LEDs-168W / 14000 / 250W~400W / 13000~22000 Thus, by replacing the conventional light with LEDs (250 watt HPMV with 90 watt LED and 32 watt CFL with 18 watt LED) plant can save approximately 7504 kWh per annum.
Benefits	
Environmental	• Per Day reduction in the Natural Gas consumption: 20.84 KWh • Per Year reduction in the Natural Gas consumption: 7504KWh • Per Day reduction in Greenhouse Gas (CO2) emission: 0.02 MT of CO2 • Per Year Reduction in Greenhouse Gas (CO_2) emission: 6.45 MT of CO_2
Economical	Investment: Rs. 1,15,000/- for LED Annual Savings: Rs. 56,200 /- per Annum Payback Period: 25 months

Intervening Technique	Solar Roof-Top System for Plant Lighting Load in Tempered Glass Industry
Before CP	Plant is operating 15 nos. High Pressure Mercury Vapour Lamp (HPMV) of 250 watt each, for 8 hrs. per day. Also, approximately 20 nos. CFL of 32 watt in admin department as well which also operated almost 8 hrs. Per day.
After CP	After replacing conventional lighting system to LEDs plant lighting load will come down to 1.8 kW from 4.5 kW at present. Plant can install a battery assisted solar PV power generation

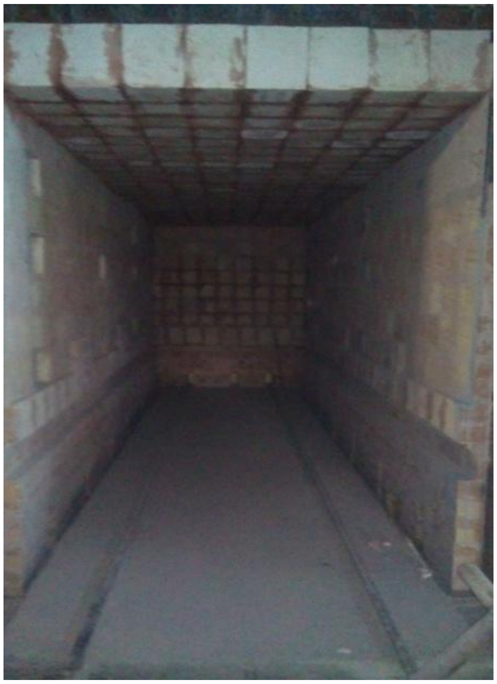
	system of 2 kW for the plant lighting load.
Economical	Investment: Rs.3, 00,000/- for solar PV system with battery. Annual Savings: Rs. 42,000/- per Annum Payback Period: 85 months

Improvement in Furnace Insulation using PCPF Wall Blocks

It is recommended to insulate the Furnace Walls using 'Pre-Cast Pre-Fired (PCPF) Hollow Wall Blocks. Its technical parameters are as follows.

As all the industries Steel, Cement, Non metal, petroleum, all engineering industries progressed in more and more sophisticated, their requirement for precision and durability increased. The need for better, stronger, stable at extreme conditions of pressure or temperature or abrasion material increased.

The conventional Pressed Refractory fired at high temperature were found wanting in such critical situation. Newer system of manufacturing, newer material stronger and fired at low temperature for the ease of Transportation and movement, far more stable were found. The unique ability to be formed in any shape you want, gave the designer a vastly improved area of working. These are pre cast, and pre fired to the precision required. The use of Hydraulic and Ceramic bonding simultaneous make these a unique material.

Historically, all the furnaces were lined by pressed, standard sized bricks in all the cases. So the wall thickness in all the furnaces was either 12-18 or 24 inches thick or even more, irrespective of its requirement. Anything less than 9" long was not available and hence they will use only this. Insulating materials like the Ceramic Fibre, the ULTRALITE, the Vermiculite got discovered in the last ten to twenty years.

Using this complete knowledge now the wall thickness can be made much lighter keeping the hot face of say 4.5" instead of 9" and design such blocks with cavity which will hold much superior insulating material like ULTRALITE within its hollow portion etc. Ultralite™ is a light weight refractory material used as a filling solution in hollow parts of thermally exposed materials. It has a density of just 75 kg/m^3.

This reduces the weight of the wall drastically. Keeping the solid part as required gave this wall a lasting life - Far more than a complete wall of ceramic fibre wall. Some pictures are shown in the attached email. The comparison between a solid brick wall, ceramic fibre wall and PCPF wall block is given here to highlight the energy efficiency of these wall blocks.

The fact remains that the new blocks will give far more stability at high temperature while keeping the fuel efficiency improved.

1 M³ Weight Comparison								
PCPF Block			**Fiber**			**HFK**		
Weight	1024 kg	(32 pcs)	Weight	250 kg	(11 pcs)	Weight	936 kg	(468 pcs)
Cost	80,000.00		Cost	8,800.00		Cost	32,760.00	
Per Kg Cost	78.125			35.20			35.00	

For More Details:

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