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 Firing	Left Side 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.