Optimization of Combustion Efficiency: Kilns and Dryers

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).

Case Study – 1	Wall and Floor Tiles manufacturing industry with roller kilns and horizontal and vertical roller dryers (Fuel: Natural Gas)
Implementing the technology	Flue gas exhaust at the kilns & dryers was monitored. The flue gas analysis for the kilns & dryers were carried out at the exhaust of individual kilns.Four kilns and three dryers were subjected to the exercise. The measured parameters are shown in tables below:

Table 1: Floor Tiles Plant Kiln 1

Parameter	Unit	Initial	Reduced Combustion Air
Net Temperature	^{0}C	168	160
O_2	%	15	12.7
CO	Ppm	107	120
Combustion Efficiency	%	71.6	76.6
CO_2	%	3.5	4.7
Flue Gas Temperature	^{0}C	198	194
Ambient Temperature	^{0}C	30.2	33.8
Excess Air	%	231	164
Pressure	mbar	0.08	0.40

Table 2: Floor Tiles Plant Kiln 2

Parameter	Unit	Initial	Reduced Combustion Air
Net Temperature	^{0}C	226	204

O_2	%	17.2	14.5
CO	ppm	79	180
Combustion Efficiency	%	50.2	68.2
CO_2	%	2.0	3.6
Flue Gas Temperature	^0C	255	237
Ambient Temperature	^0C	29.5	33
Excess Air	%	480.5	221.5
Pressure	mbar	0.07	0.37

Table 3: Wall Tiles Plant Biscuit Kiln

Parameter	Unit	Initial	Dilution Blower Off
Net Temperature	^0C	246	260
O_2	%	17.1	16.7
CO	ppm	29	32
Combustion Efficiency	%	46.7	49.5
CO_2	%	2.1	2.4
Flue Gas Temperature	^0C	279	274
Ambient Temperature	^0C	32.6	32.6
Excess Air	%	464.8	397.6
Pressure	mbar	0.29	0.28

Table 4: Wall Tiles Plant Glost Kiln

Parameter	Unit	Initial
Net Temperature	^0C	150
O_2	%	15.3
CO	ppm	86
Combustion Efficiency	%	72.3
CO_2	%	3.2
Flue Gas Temperature	^0C	181
Ambient Temperature	^0C	82.4
Excess Air	%	273.2
Pressure	mbar	0.22

Table 5: Horizontal Dryer 1

Parameter	Unit	Initial	Reduced Combustion Air
Net Temperature	^0C	88	88
O_2	%	19.9	19.7
CO	ppm	22	24
Combustion Efficiency	%	37.9	44.7
CO_2	%	0.6	0.7
Flue Gas Temperature	^0C	119	120
Ambient Temperature	^0C	30.7	31
Excess Air	%	1990	1642
Pressure	mbar	0.04	0.05

Table 6: Horizontal Dryer 2

Parameter	Unit	Initial
Net Temperature	^0C	144
O_2	%	19.2
CO	ppm	1
Combustion Efficiency	%	38.4
CO_2	%	1.0
Flue Gas Temperature	^0C	177
Ambient Temperature	^0C	33.1
Excess Air	%	1061
Pressure	mbar	0.29

Table 7: Vertical Dryer

Parameter	Unit	Initial
Net Temperature	^0C	127
O_2	%	17.9
CO	ppm	37
Combustion Efficiency	%	62.7
CO_2	%	1.7
Flue Gas Temperature	^0C	161

Ambient Temperature	^{0}C	34.3
Excess Air	%	620.6
Pressure	mbar	0.06

Recommendations:

It was suggested to control the combustion air through reducing the RPM of combustion air blower by 1-2 Hertz at a time by monitoring required temperature within kiln and set the appropriate frequency and monitoring the required O_2 percentage in flue gas to optimize the air fuel ratio and thus combustion efficiency at the kiln.

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.

Benefits	
Environmental	• Per Day reduction in the gas consumption: 500 SCM. Per Year reduction in gas consumption: 1,82,500 SCM. • Per Day reduction in Greenhouse Gas (CO_2) emission: 0.94 MT Per Year Reduction in Greenhouse Gas (CO_2) emission: 341.82 MT
Economical	Investment: **NIL** Savings: **Rs. 53,50,000/-** per annum Payback period: **Immediate**