

CEMENT, ENERGY AND ENVIRONMENT



**ACHIEVING CIRCULARITY THROUGH
WASTE TO WEALTH**



CEMENT
MANUFACTURERS
ASSOCIATION

CEMENT, ENERGY and ENVIRONMENT

EDITORIAL



I am happy to present to you the January–June 2019 issue of the *CMA Cement, Energy and Environment Journal*.

With the return of the Government at the Centre for a second time in succession this May, the Cement industry has all the reasons to be hopeful for stability and seamless progress towards the committed agenda of growth. The Industry strongly supports Government's transformative initiatives to raise GDP and foster manufacturing and job growth amongst others that should have a cascading effect on cement demand and contribute to the growth of the Cement Industry positively.

The CMA CEE Journal as a prime objective has long been providing for a broader system of scholarly communication, which includes both formal and informal elements, and plays different roles at different stages of the innovation and research cycle in the Cement industry in a fast shifting technology paradigm to drive businesses sustainably. In continuation of our belief in this principle and its importance fundamentally, this issue of the journal has endeavoured to cover articles building upon the facets of Cement sustainability, business and environment. I hope the information provided in the journal by different authors with proven expertise in their respective professional fields assists you in meeting your information needs on the emerging issues and to draw learnings from them to face the challenges before the Cement Industry with a more positive outlook. It will be our pleasure to receive your valued feedback on this issue and also your contribution by way of enlightening articles for the CMA journal on the highly dynamic Indian Cement Industry and its future.

Lastly as I informed in the December issue of CEE, CMA is organising the 4th CMA Conference on Alternative Fuels & Raw Materials in Cement Industry on September 30 to October 1, 2019, at Hotel Hyatt Regency, New Delhi . The Conference over two days of discussions involving decision makers, industry and several organisations associated with waste management and sustainability will seek technical, regulatory and financial solutions for an effective and efficient utilisation of AFR usage in the Cement Industry, including agricultural, municipal and industrial wastes generated in the Country. The moderated panel discussions would also address growing concerns of the Government relating to environment protection, reducing the use of fossil fuels by encouraging more usage of AFR and nurturing increased downstream employment opportunities. On the sidelines of the Conference, an Exhibition would also be held that offers an opportunity to our Member Companies as well as machinery and equipment manufacturers to showcase their products and achievements at the Event. I invite you to actively participate in the Conference and be part of the discussions on various important issues that impact the Cement Industry in India. We would be releasing a special publication on success stories and case studies on Alternative Fuel usage in Cement Plants at the Conference and we would welcome your contributions for the same.

(Aparna Dutt Sharma)
Secretary General

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ENERGY SAVINGS BY REDUCTION OF THERMAL LOSSES FROM KILN SHELL

K K Sharma
INVOTECH SOLUTIONS & SYSTEMS

ABSTRACT

The cement industry is reckoned the most energy consumed industry in terms of consumption. The energy cost forms about 35 to 45 % of the total cost of production. Out of this, thermal energy constitutes around 70 %, where as electrical energy about 30 %, which may vary from plant to plant. Owing to this, efficient energy utilization has always been a focus point in the cement industry. If we improve energy efficiency, we may be able to reduce the cost of production of cement. In the product like cement, which is primarily a low value product, with high incidence of taxes and duties, high energy costs, the avenues available to a plant for reducing the costs are limited. In the present environment due to the energy crisis and steep increase in the cost of energy and other input materials, it has become imperative to give a serious thought on how to make operations and equipment efficient towards use of energy and adoption of latest technology equipments to retain the requisite competitive edge in the market.

INTRODUCTION

India was the second-largest cement producer in the world in terms of cement capacity during 2018. The industrial sector accounts to 30-70% of the total global energy consumption of which cement industry is one of most energy intensive industries in the world. Energy consumption by a cement industry is estimated at about 2% of the global primary energy consumption (or) which is almost 5% of total global industrial energy consumption. Cement production, which is highly dependent on the availability of natural resources, will face severe scarcity of resources in the future. Cement manufacturing has regarded as an intensive consumer of natural raw materials, fossil fuels, energy and is a major source of multiple pollutants. Because of the dominant use of carbon-intensive fuels such as coal, the cement industry is also a major source of carbon dioxide. The cement industry contributes 5% of total carbon dioxide emissions.

For clinker production, a cement industry requires the substantial energy consumption. About 70%

of energy consumption lies on the unit of rotary kiln system. The higher amount of energy consumption is due to the lack of work efficiencies tools leading to the wastage of heat. **It is found that about 40% of the total input energy was lost through kiln shell, cooler stacks and hot flue gas.** Therefore, it is important to pay attention to reduce energy consumption by reducing 'THERMAL LOSSES' and energy related environmental emissions in both local and global scales.

THERMAL LOSSES = LOSSES DUE TO RADIATION+ LOSSES DUE TO CONVECTION

WHAT IS RADIATION

Radiation is transfer of heat through electromagnetic waves through space. Unlike convection or conduction, where energy from gases, liquids, and solids is transferred by the molecules with or without their physical movement, radiation does not need any medium (molecules or atoms). Energy can be transferred by radiation even in a vacuum.

Example, sunlight travels to the earth through space, where there are no gases, solids, or liquids.

Heat transfer through radiation takes place in form of electromagnetic waves mainly in the infrared region. Radiation emitted by a body is a

consequence of thermal agitation of its composing molecules. Radiation heat transfer can be described by reference to the '**black body**'.

A black body is a hypothetical body that completely absorbs all wavelengths of thermal radiation incident on it. Such bodies do not reflect light, and therefore appear black if their temperatures are low enough so as not to be self-luminous. All black bodies heated to a given temperature emit thermal radiation.

The radiation energy per unit time from a **black body** is proportional to the fourth power of the absolute temperature and can be expressed with **Stefan-Boltzmann Law** as

$$q = \sigma T^4 A \quad (1)$$

Where

q = heat transfer per unit time (W)

$\sigma = 5.6703 \cdot 10^{-8} \text{ (W/m}^2\text{K}^4\text{)}$ - **The Stefan-Boltzmann Constant**

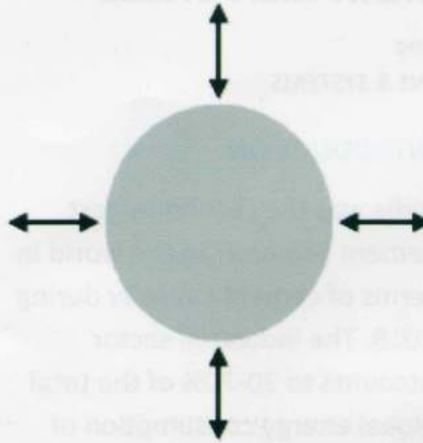
T = absolute temperature in Kelvin's (K)

A = area of the emitting body (m^2)

The Stefan-Boltzmann Constant in Imperial Units

$$\begin{aligned} \sigma &= 5.6703 \cdot 10^{-8} \text{ (W/m}^2\text{K}^4\text{)} \\ &= 1.714 \cdot 10^{-9} \text{ (Btu/ (h ft}^2\text{ }^\circ\text{R}^4\text{))} \\ &= 1.19 \cdot 10^{-11} \text{ (Btu/ (h in}^2\text{ }^\circ\text{R}^4\text{))} \end{aligned}$$

Gray Bodies and Emissivity Coefficients



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For objects other than ideal black bodies ('gray bodies') the **Stefan-Boltzmann Law** can be expressed as

$$q = \epsilon \sigma T^4 A \quad (2)$$

where

ϵ = emissivity coefficient of the object (one - 1 - for a black body)

For the gray body the incident radiation (also called irradiation)

is partly reflected, absorbed or transmitted.

The emissivity coefficient is in the range $0 < \epsilon < 1$, depending on the type of material and the temperature of the surface.

WHAT ARE RADIATION LOSSES

If a hot object is radiating energy to its cooler surroundings the net radiation heat loss rate can be expressed as

$$q = \epsilon \sigma (T_h^4 - T_c^4) A_h \quad (3)$$

Where

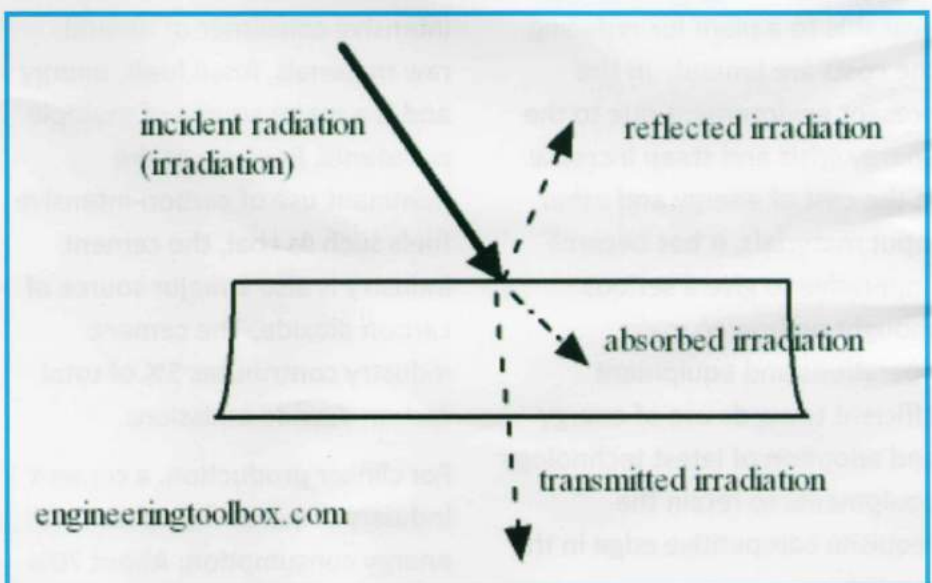
T_h = hot body absolute temperature (K)

T_c = cold surroundings absolute temperature (K)

A_h = area of the hot object (m^2)

CONVECTION

Heat transfer through convection arises when a moving fluid absorbs heat from some surface



and transports this heat to some other location such that the fluid acts as a carrier. Two forms of convection are distinguished. In the first place convection may arise naturally. If for example a hot object at temperature T_1 is in contact with a cooler fluid of temperature T_2 , heat is transported from the object to the boundary layer through conduction. This leads to density changes in the boundary layer and as a result the fluid in the boundary layer will rise and be replaced by cooler fluid that is heated again etc. This phenomenon is called free convection.

The second form of convection arises if the flow is brought about by for example a pump or a fan. In principle this form of convection, known as forced convection, is generally more efficient since the period of contact between the hot object and the fluid is shortened. This effectively comes down to an increase of the temperature difference between the solid and the fluid and with that an increase of the heat transfer to the boundary layer through conduction.

The heat transfer per unit surface through convection was first described by Newton and the relation is known as Newton's law

of cooling. According to this law the heat exchange is, under normal atmospheric conditions, proportional to the temperature difference at the interface.

$$q'' = h(T_1 - T_\infty)$$

Here the heat exchange q'' is measured in $[W m^{-2}]$. The temperature of the surface and the fluid are indicated by T_1 and T_∞ respectively, where it is implied that the fluid is present in such large quantities that its temperature may be taken to be constant. The constant of proportionality h is called the convection heat transfer coefficient in $[W m^{-2} K^{-1}]$. The total power removed from an object with surface although convection then is:

$$P_{conv} = Aq'' = hA(T_1 - T_\infty)$$

Note that this expression accounts for the heat that is transferred from the object at hand to the 'infinite' body of surrounding fluid.

$$P_{tot} = P_{rad} + P_{conv} = \epsilon\sigma A(T_1^4 - T_2^4) + hA(T_1 - T_\infty)$$

IMPACT OF THERMAL LOSSES IN CEMENT PLANT

1. Increase of Power Consumption
2. Increase of Fuel Consumption
3. Increase in Production Cost.
4. Decrease in Efficiency of System.

5. Environmental Pollution.

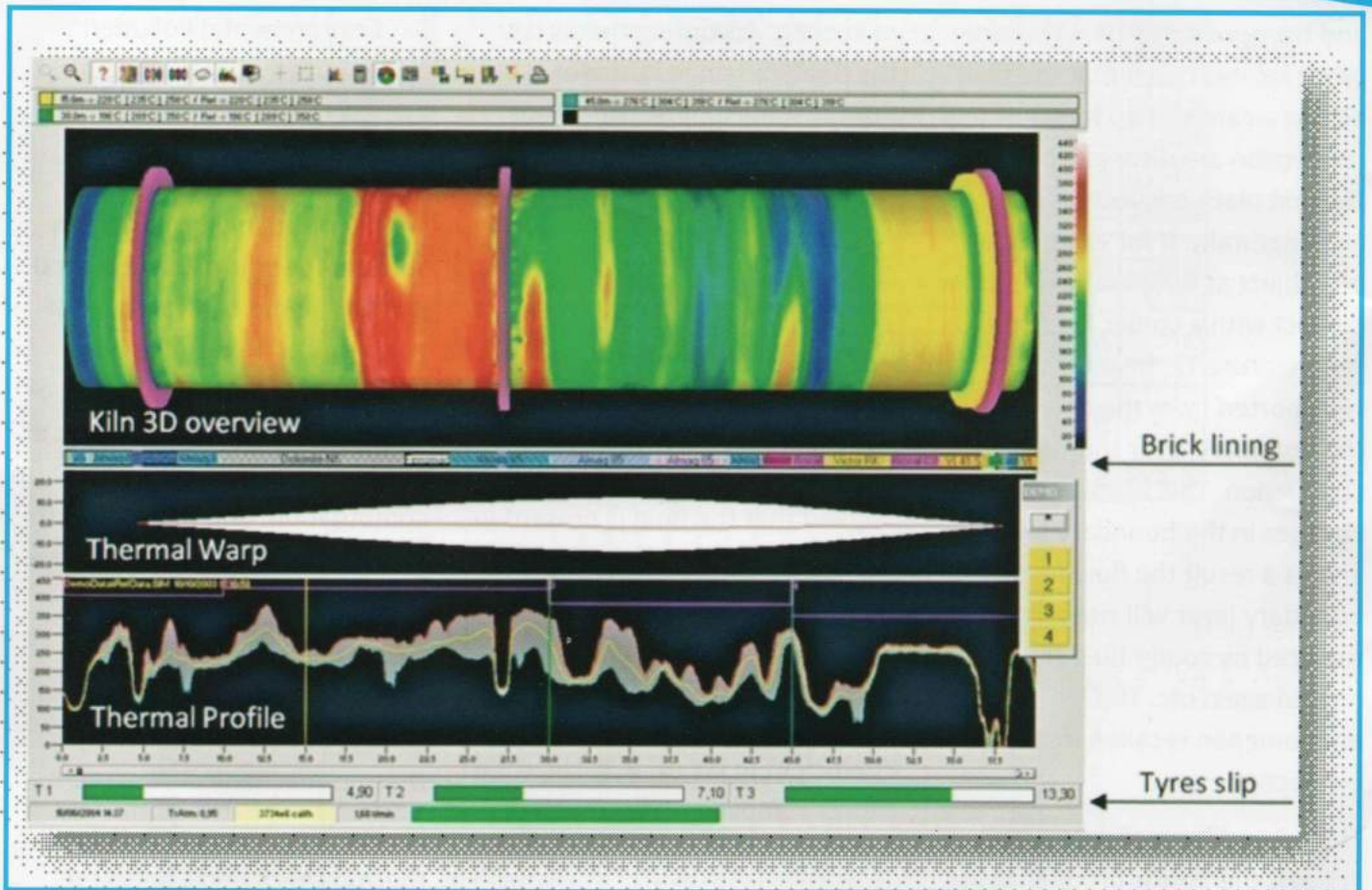
SHELL SCANNER/THERMAL SCANNER

Thermal scanner, enables continuous surveillance of kiln shell temperature, has a central position in the control room of hundreds of modern cement plants around the world. One of the unique advanced features of Shell Scanner is the thermal warp computation. The thermal warp analysis is made available to the operator for

- Protecting the kiln and its equipment through a better control of mechanical and thermo-mechanical stresses.
- Keeping trace of the kiln thermo-mechanical behavior when operating conditions are altered (flame, meal flow rate, kiln rotation speed, gas draught).

The system works from the real-time synchronous acquisition of the following measurements-

- Kiln shell temperature, by the infrared scanner,
 - Synchronization by kiln rotation contact switch,
 - Tyre slippage.
- From the screen menu, the operator can display:
- The shell thermal chart and



thermal profile from the most recent temperature measurement.

- The configuration of thermal warp analysis.

At a pre-selected period (for example 30 minutes), the system displays automatically:

- The shell temperature fluctuations along the kiln.
- The thermal non-axisymmetrical distortion of the kiln.
- The clearance between tyres and shell.

ADVANTAGE of Shell Scanner is to evaluate the risks of mechanical failures such as-

- Risk of hot spots under the tyres.
- Risk of excessive shell out-of-roundness under the tyres.
- Risk of tyre constriction on the shell.
- Risk of breakage of the tyres according to the fatigue criteria,
- Risk of rollers slackening on the shaft.

- Risk of rollers and scaling off.
- Risk of bearing bushes seizing.

DETECTION PRINCIPLE

The system consists of calculating the kiln distortion induced by temperature changes over the shell in order to infer the cyclical overloads and associated stresses suffered by the shell, tyres and roller stations. The kiln thermo-mechanical distortion is calculated in real time from the shell thermal map drawn up by the shell infrared scanner.

CASE STUDY

In this study, heat loss from rotary kiln was examined. Analysis of energy balance was used to determine the sources of heat loss from kiln system. The major heat loss is Heat losses by the kiln exhaust gas (19.15%) Hot air from cooler stack (5.61%), Radiation from kiln surfaces (10.47%). Results indicate the presence of waste heat, which is 51% of the overall heat of the process. Some possible ways to recover the heat losses are introduced and discussed.

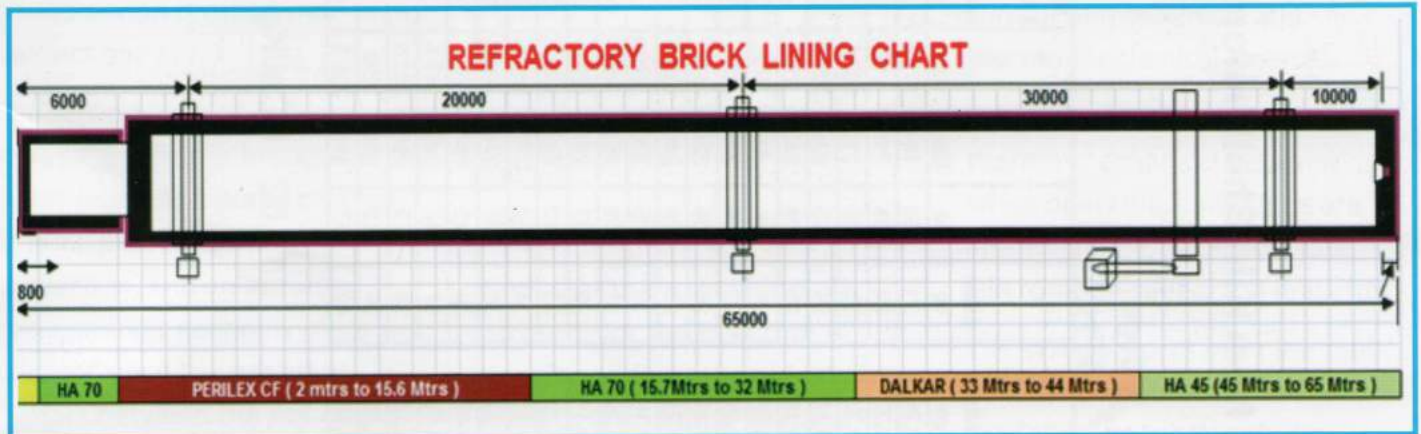
SOLUTION- ARREST MASTER 3001

By coating the outer surface of kiln with a coating (Arrest Master 3001) to partially block the radiation coming out of Kiln surface, significant savings can be achieved. Here the kiln parameters were examined & refractory brick lining chart is studied to analyze the savings which can be achieved. Generally savings ranges in range of 5-20% depending upon the operating parameters like area of kiln surface, Temperature Profile of

kiln, Type of Fuel used, Calorific Value of fuel, Capacity of kiln, condition of kiln shell, e.t.c.

Significant properties of Arrest Master 3001:-

1. Unaffected by UV rays.
2. The paint can be applied in plant running condition.
3. Contains no volatile solvents.
4. Contains no hazardous fiber.
5. Does not require special equipment and handling.
6. Requires no solvents, ready to use.



XYZ Cement Ltd.

Heat Loss from Kiln Shell before application of paint

Ambient temperature = 35 degc
 Clinker output rate = 162.5 TPH

Distance from kiln discharge	Heat transfer coefficient (Radiation)			distance	Heat transfer coefficient (Radiation)			Distance from kiln discharge	Heat transfer coefficient (Radiation)						
	Min.	Max.	Avg.		Min.	Max.	Avg.		Min.	Max.	Avg.				
1	212	264	238	21	160	187	173.5	21	160	187	173.5	41	241	244	242.5
2	209	273	241	22	205	219	212	22	205	219	212	42	204	229	216.5
3	234	291	262.5	23	199	216	207.5	23	199	216	207.5	43	217	234	225.5
4	154	207	180.5	24	205	236	220.5	24	205	236	220.5	44	219	236	227.5
5	165	201	183	25	219	243	231	25	219	243	231	45	214	225	219.5
6	75	92	83.5	26	87	88	87.5	26	87	88	87.5	46	215	234	224.5
7	177	220	198.5	27	215	247	231	27	215	247	231	47	225	238	231.5
8	175	225	200	28	206	224	215	28	206	224	215	48	217	222	219.5
9	197	224	210.5	29	220	245	232.5	29	220	245	232.5	49	210	226	218
10	170	198	184	30	205	235	220	30	205	235	220	50	216	229	222.5
11	180	208	194	31	219	251	235	31	219	251	235	51	226	237	231.5
12	146	170	158	32	237	267	252	32	237	267	252	52	112	117	114.5
13	189	220	204.5	33	240	261	250.5	33	240	261	250.5	53	214	243	228.5
14	236	262	249	34	250	273	261.5	34	250	273	261.5	54	238	245	241.5
15	244	253	248.5	35	248	278	263	35	248	278	263	55	249	253	251
16	119	132	125.5	36	243	287	265	36	243	287	265	56	234	250	242
17	116	125	120.5	37	248	247	247.5	37	248	247	247.5	57	228	242	235
18	136	171	153.5	38	250	255	252.5	38	250	255	252.5	58	217	228	222.5
19	168	194	181	39	252	260	256	39	252	260	256	59	215	224	219.5
20	156	206	181	40	247	266	256.5	40	247	266	256.5	60	214	226	220
												61	213	225	219
												62	218	226	222
												63	219	223	221
												64	205	213	209
												65	146	178	162

Total shell radiation loss =

15.52 KCal/Kg-Clk

Heat Loss from Kiln Shell after application of paint

Ambient temperature = 35 degc
 Clinker output rate = 162.5 TPH

Distance from kiln discharge	Heat transfer coefficient			Distance	Heat transfer coefficient			Distance	Heat transfer coefficient			Distance		
	Min.	Avg.	Max.		Min.	Avg.	Max.		Min.	Avg.	Max.			
1	191	214.5	238	21	144	156	168	41	217	220	218.5	13.7	6.54	0.24
2	188	246	217	22	185	197	191	42	184	206	195	12.4	6.56	0.20
3	211	262	236.5	23	179	194	185.5	43	195	211	203	12.9	6.55	0.21
4	139	186	162.5	24	185	212	198.5	44	197	212	204.5	12.9	6.55	0.22
5	149	181	165	25	197	219	208	45	193	203	198	12.6	6.56	0.20
6	68	83	75.5	26	78	79	78.5	46	194	211	202.5	12.8	6.55	0.21
7	159	198	178.5	27	194	222	208	47	203	214	208.5	13.2	6.55	0.22
8	158	203	180.5	28	185	202	193.5	48	195	200	197.5	12.6	6.56	0.20
9	177	202	189.5	29	198	221	209.5	49	189	203	196	12.5	6.56	0.20
10	153	178	165.5	30	185	212	198.5	50	194	206	200	12.7	6.56	0.21
11	162	187	174.5	31	197	226	211.5	51	203	213	208	13.1	6.55	0.22
12	131	153	142	32	213	240	226.5	52	101	105	103	8.2	6.14	0.06
13	170	198	184	33	216	235	225.5	53	193	219	206	13.0	6.55	0.22
14	212	236	224	34	225	246	235.5	54	214	221	217.5	13.7	6.54	0.24
15	220	228	224	35	223	250	236.5	55	224	228	226	14.2	6.53	0.26
16	107	119	113	36	219	258	238.5	56	211	225	218	13.7	6.54	0.24
17	104	113	108.5	37	223	222	222.5	57	205	218	212	13.3	6.5	0.2
18	122	154	138	38	225	230	227.5	58	195	205	200	12.7	6.6	0.2
19	151	175	163	39	227	234	230.5	59	194	202	198	12.6	6.6	0.2
20	140	185	162.5	40	222	239	230.5	60	193	203	198	12.6	6.6	0.2
								61	192	203	198	12.6	6.6	0.2
								62	196	203	200	12.7	6.6	0.2
								63	197	201	199	12.6	6.6	0.2
								64	185	192	189	12.1	6.6	0.2
								65	131	160	146	10.0	6.5	0.1

Total shell radiation loss =

12.85 KCal/Kg-Cik

XYZ Cement Ltd.

REDUCTION OF RADIATION LOSSES

The hot surface of the kiln is another source of waste heat recovery, in which heat loss

occurs by convection and radiation which is about 15.11% of the input energy. By using paint/coating to partially block radiation on kiln surface can

significantly reduce this loss which will reduce the fuel consumption and will increase the overall system efficiency by approximately 5-6%

Savings through reduction of heat loss from Kiln surface

S No	Parameters	Unit	Value
1	Kiln Shell radiation loss in present condition (Without Paint)	K Cal / Kg-Clk	15.52
2	Estimated saving	%	10
3	Kiln Shell radiation loss after application of AM 3001	K Cal / Kg-Clk	12.58
4	Reduction in radiation losses	K Cal / Kg-Clk	2.94
5	Clinker Production	Kg	3900000
6	Calorific value of firing coal	Kcal/kg coal	6257
7	Coal saving per day	Kg	1833
8	Firing Coal cost	Rs per Kg	8
9	Saving per day	Rs	14660
10	Annual saving (Consider 330 days running)	Lacs	48
11	Cost of Arrest Master 3001	Lacs	
12	Pay Back	Days	43

Other benefit :- After application of paint, outer surface of kiln shell will become free from rusting and atmospheric wear and tear.

XYZ Cement Ltd.

Invotech Solution & Systems keep itself abreast of latest development in Cement Industry so as to cater the need of the Industry using latest technology and quality systems. Also, with a view to retain the requisite competitive edge in the market, **Invotech Solution & Systems** participated in 15th NCB International seminar on cement, concrete & building materials 5th to 8th Dec, 2017 at Manekshaw Center, New Delhi. Subsequently, also participated in "National

workshop cum technology exhibition for promoting to promote energy efficient & cleaner production for sustainable industrial growth", 8th to 9th March, 2018, at India Habitat center, New Delhi, where presented a technical paper on "SIGNIFICANT SAVINGS IN ENERGY THROUGH FALSE AIR REDUCTION" & got award for "UPCOMING ENTREPRENEUR IN THE FIELD OF ENERGY EFFICIENCY". Also participated in 14th Green Cementech 2018 held

on 17th to 18th May, 2018 at Hyderabad International Convention Center, Hyderabad.

In the near future, **Invotech Solution & Systems** will also be participating in 16th NCB International seminar on cement, concrete & building materials Dec, 2019 at Manekshaw Center, New Delhi

CONCLUSION

Substantial potential for energy efficiency improvement exists in the cement industry and in

individual plants. Persistent efforts are also being made to continue to improve energy efficiency and reduce the energy cost for the cement industry for survival and growth. Our baby

step towards reducing “RADIATION LOSSES” can contribute immensely towards cost cutting of cement manufacturing and improving energy efficiency. It is needless to

mention that our efforts to improve energy efficiency will also indirectly minimize greenhouse gases and mitigate the environmental problems associated with cement production.

Year	No. of plants	Capacity (MW)	To be completed by 2025 or plants to be phased out			
			2018-21	2021	2022	2023
2018-21	414	1,61,223	179	172	2	61
2021						
2022						
2023						
2019	4					
2020	7					
2021	7					
2022	7					
2023	7					