Case Experience on WIN WIN Approach Towards Industrial Pollution Control-Economic and Environmental Efficacy of Cleaner Technology in Select Cement Industry in Tamil Nadu

X. Agnello J. Naveen, S. Boopathi, and A. Arivoli

Abstract The cement industry pollutes air, water and soil to control pollution using different types of advanced pollution control technologies to reduce the pollution levels and achieve permissible limits. But still, Cement industry manages to recycle and reuse its (Co-processing) by-products based on the "concept of industrial ecology" on its own production premises in a holistic positive environmental management approach. Due to the production totally based on mining products from "fossil fuels" like calcium carbonate, Gypsum. Co-generation (energy conservation, variable frequency drives (VFD), Cement industry cost variables Economic and environmental variables, older (Conventional) and newer (Cleaner) technology and their negative and positive advantages were compared. Variables like capital cost, variable cost, viability period of the equipment, depreciation cost, buy back cost, benefit cost and environmental benefits like energy in kWh per year, water in liters per year and other recycling process like "Add-on" and "Process change" technologies are taken in consideration. The main objective is to focus on the cost aspects between the two technologies, conventional and cleaner technology in pollution control. This was carried out by comparing cost benefit analysis and Return on Investment (ROI) for the old and clean technologies. There are nine technologies used in this industry that has been analyzed.

Keywords Conventional technology · Cleaner technology · Industrial ecology · Return on investment · Recycling

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X. Agnello J. Naveen (✉)
Department of Environmental Management, Bharathidasan University, Tiruchirappalli, India
e-mail: agnello.naveen18@gmail.com

S. Boopathi
Department of Economics, Bharathiar University, Coimbatore, India

A. Arivoli
Department of Environmental Science, Government Arts and Science College, Ariyalur, India

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1 Introduction

The cement Industrial process is a very complex high-energy consumption to run, which leads to environmental issues by using non-renewable energy resources, heavy electricity depended industries like Aluminum smelter, copper smelter, iron and steel, cement, paper and pulp, fertilizer industries (Gupta 2013; Sengupta 2016). And it is clear that steel, aluminum, cement are the largest consumers of commercial energy compared to other industrial sectors. Energy Reduction for (Perform-Achieve-Trade) PAT (Ministry of power 2012) Indian Cement industry comprises of 210 large cement plants (BEE 2018), and that accounts for 10.3% of total fuel consumption in the manufacturing sector (Khurana et al. 2002). Cement industry depends upon combusted energy level (specific heat capacity) which is used for operation can be conducted smooth by the operators Green rating project (GRP) has focused to implement the directives of European union best available technology (BAT). Which is very essential in finding the carbon emission reduction and carbon foot printing for a year or a decade? So to update technology regulatory systems are enhancing system based support like monitoring and have prior responsible for the energy audit ISO 50001, the main focus in the cement industry is on air pollution control, adsorption and energy conservation.

2 Study Area

The select Cement industry taken for the study situated in Ariyalur is an "Ultra red" category industry as the pollution load is very high. The production of cement is 3 MT per day.

2.1 Materials and Methods

Economic Parameters

Cost variables: In this cost analysis basic cost parameters like capital expenditures, variable cost, Buy back cost and viability of the mechanism (Life time of the mechanism in years) of the two treatment process are Elicited by the environmental engineer has a secondary data this are necessary cost to find (Benefit cost per liter).

VC = Variable cost, FC = Fixed cost, BB = BuyBack cost, Viability Period of the mechanism

Steps involved

1. **The total Buyback cost** is equal to capital investment in Rupees. Multiply with buyback cost in %, is divide by 100 is equal to Rupees (Total Buyback cost).
2. **Actual capital Investment** equals to capital Investment in Rupees minus Total buyback cost in Rupees is equal to fixed cost per year in Rupees,

3. **The Fixed cost** is given fixed cost equals Actual capital investment in rupees divided by viability period of the mechanism in years, it is given in Rupees,
4. **Total cost (TC)** equal to fixed cost in Rupees per year plus variable cost in Rupees, gives Rupees minus Depreciation cost per year.
5. **For Return on Investment (ROI)** Profit is equal to benefited amount– Total cost + Depreciation cost per year.

2.2 Cost Variables for Return on Investment (R.O.I)

In This Cost Analysis Basic Cost Parameters like Capital Investment, Variable Cost, Buy Back Cost and Viability of the Mechanism (Life Time of the Mechanism in Years) of the Two Technology Are Elicited from the Environmental Engineer and Energy Auditor Has a Secondary Data This Are Necessary for Cost Variables to Find Return on Investment (R.O.I) (Phillips and Philips 2006).

$$\text{Profit} = \text{Total Revenue} - \text{Total operational cost} \tag{1}$$

$$\text{Return on Investment(R.O.I)} = \text{Profit/Total cost}^{*}100 \tag{2}$$

Cost variable for Cost Benefit Ratio is (Total Revenue) and Total cost (Fixed cost + Variable cost + Depreciation cost + Pollution and operational cost (Siva 2016).

Note: Cost benefit Ratio is equal to Total Benefit value divided by Total cost.

Figure 1. Shows the operational of select cement industrial unit production process the flow chart describes a classification of pollution control technologies in waste recycling technology (Co-processing), Air pollution and Energy conserve technology, this industry adopted conventional (older), cleaner (newer) technologies which describes detail given below in Table 1 with detail explanation of concepts.

$$\text{Cost benefit Ratio} = \text{Total Benefited Value or Total Revenue/Total Cost}$$

2.3 Primary Data

Vertical roller mill inlet duct Modification

Older technology

The conventional process of gas flow in mill grinding system are generally consists of vertical roller mill like separator, cyclone, mill circulation fan, and electrostatic precipitator (EP) and EP fan is used to pulverize final products, called has kiln feed raw meal, are collected at the cyclone and EP. For a high pressure loss at the cyclone there is a process change in the control mill attached to gas flow, mill circulation fan

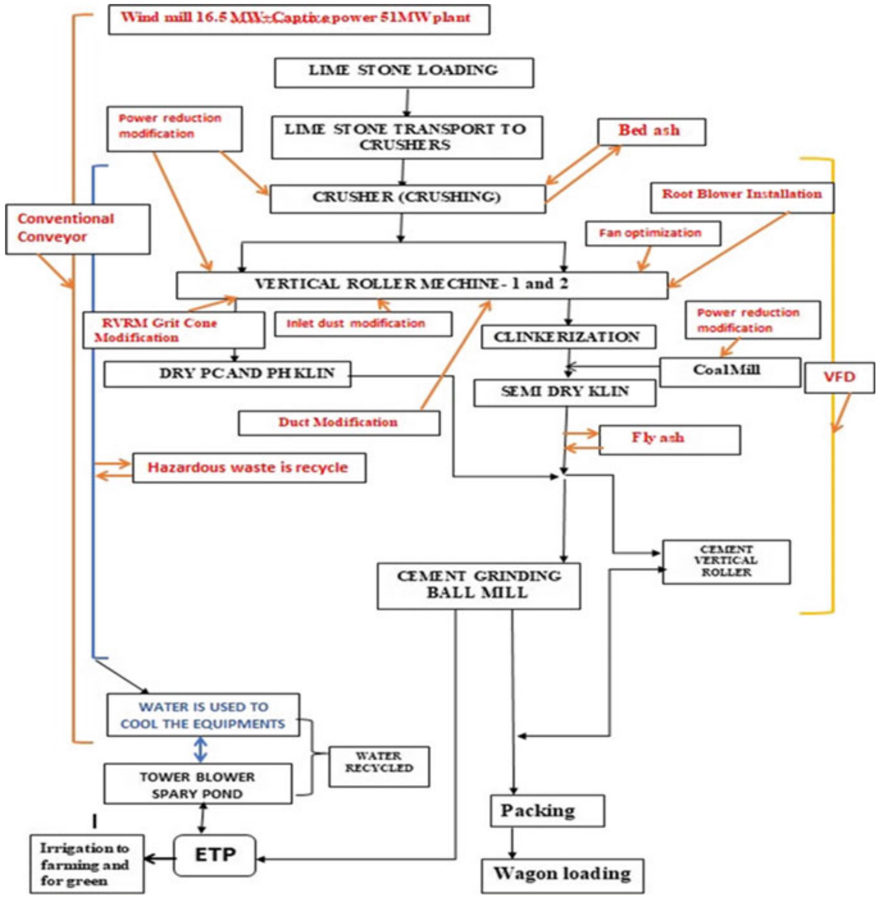

Fig. 1 Operational process of Cement industry with Cleaner technology

and EP fan are provided after the cyclone and EP respectively. Power consumption is high and energy conservation is less in this process (Bapat 2001).

2.4 *Cleaner Technology Working Process of Inlet Duct Modification*

In the direct inlet dust collection system flow is simple. The raw materials are dried and ground by the mill step by step process in one-pass kiln exit gas and then done to fine product after separation is sent to EP directly, Cyclone is not installed, and system pressure loss reduces. And as the mill fan has de-dusted gas only, it's less power consumption (Jankovic et al. 2004; Chinkal et al. 2013).

Table 1 Comparison between cleaner and conventional technology using return on investment and cost benefit ratio (ROI & CBR) in Cement Industry

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
1.	Vertical roller mill (inlet duct Modification)	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost 6. Profit 7. Benefit 8. TC	Rs. 9.5 lakh Rs. 1.7 lakh p.a. 2 years 5.5% Rs. 0.17 lakh p.a. **Rs. 1.449 lakh p.a.** **30,518 (kWh) p.a.** 6.1887 lakh p.a.	Rs. 204 lakh Rs. 1.5 lakh p.a. 4.5 years 7.8% Rs. 0.17 lakh p.a. **Rs. 2.774 lakh p.a.** **58,400 (kWh) p.a.** 43.297 lakh p.a.	**−79.03**	−93.3	**0.2341**	0.0640
2.	Vertical roller mill (Grit Cone Modification)	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost 6. Profit 7. Benefit 8. TC	Rs. 11.5 lakh Rs. 1.3 lakh p.a. 2 years 3.3% Rs. 0.23 lakh p.a. **2.1375 lakh p.a.** **45,000 (kWh) p.a.** 6.86 lakh p.a.	Rs. 16 lakh Rs. 3 lakh p.a. 5 years 6.7% Rs. 0.4 lakh p.a. **Rs. 4.561 lakh p.a.** **95,900 (kWh) p.a.** 5.98 lakh p.a.	−72.1	**−30.4**	0.3115	**0.762**

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
3.	Vertical roller mill (internal modification)	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost 6. Profit 7. Benefit 8. TC	Rs. 3.6 lakh Rs. 0.145 lakh p.a. 3 years 4.5% Rs. 0.04 lakh p.a. **Rs. 0.0285 lakh** **6000 (kWh) p.a.** 1.291 lakh p.a.	Rs. 30.7 lakh Rs. 0.32 lakh p.a. 4 years 6% Rs. 0.17 lakh p.a. **Rs. 5.7 lakh p.a.** **120 000 (kWh) p.a**. 7.5345 lakh p.a.	−100.89	**−26.5**	0.0220	**0.76**

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
4.	VRM cement girding CVRM Sp. Power Reduction in OPC	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 5 lakh Rs. 0.44 lakh p.a. 5 years 5% Rs. 0.3145 lakh p.a. **Rs. 0.0475 lakh** Rs. 1.39 lakh p.a.	Rs. 20 lakh Rs. 1.15 lakh p.a. 3 years 6% Rs. 0.12 lakh p.a. **Rs. 2.50 lakh p.a.** **52,600 (Kwh) p.a.** Rs. 3.4625 lakh p.a.	−119.19	**−67.8**	0.0341	**0.337**

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
5.	Variable frequency drive (VFD)	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 0.4 lakh Rs. 0.05 lakh p.a. 2 years 2% Rs. 0.02 lakh p.a. **Rs. 0.0285 lakh p.a.** **600 (kWh) p.a.** Rs. 0.246 lakh p.a.	Rs. 105 lakh Rs. 1.9 lakh p.a. 4 years 6% Rs. 0.8 lakh p.a. **Rs. 2.46 lakh p.a.** **80,000 (kWh) p.a.** Rs. 4.36 lakh p.a.	−96.54	−61.9	0.115	0.564

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
6.	False Air Reduction	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 0.8 lakh Rs. 0.08 lakh p.a. 2 years 3.5% Rs. 0.02 lakh p.a. **Rs. 0.003325 lakh p.a.** **700 (kWh) p.a.** Rs. 0.466 lakh p.a.	Rs. 2 lakh Rs. 0.18 lakh p.a. 4 years 7.7% Rs. 0.14 lakh p.a. **Rs. 0.076 lakh p.a.** **1600 (kWh) p.a.** Rs. 0.6415 lakh p.a.	**−103.59**	−109.97	0.00713	**0.1184**

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
7.	Compressor Power Reduction	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 15 lakh Rs. 0.11 lakh p.a. 2 years 6.7% Rs. 0.15 lakh p.a. **Rs. 0.2372 lakh p.a.** **5000 (kWh) p.a.** 7.106 lakh p.a.	Rs. 18.5 lakh Rs. 0.18 lakh p.a. 4 years 10% Rs. 0.139 lakh p.a. **Rs. 0.308 lakh p.a.** **6500 (kWh) p.a.** 4.342 lakh p.a.	−98	**−95.8**	0.033	**0.070**

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
8.	Reduction of specific power and fuel consumption in pyro section	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 22 lakh Rs. 7.55 lakh p.a. years % Rs. p.a.	Rs. 20.1 lakh Rs. 2.2 lakh p.a. 3. years 6% Rs. 0.66 lakh p.a. **Rs. 3.8 lakh p.a.** **80,000 (kWh) p.a.** Rs. 8.5 lakh p.a.	NA*	−63	NA*	0.447

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
9.	Vertical roller mill (Fan optimization)	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 4.1 lakh Rs. 0.15 lakh p.a. 3.5 years 2% Rs. 0.0856 lakh p.a. **Rs. 0.1425 lakh p.a.** **3000 (kWh) p.a.** Rs. 1.298 lakh p.a.	Rs. 9.9 lakh Rs. 0.37 lakh p.a. 1.7 years 5.5% Rs. 0.114 lakh p.a. **Rs. 1.82 lakh p.a.** **38,500 (kWh) p.a.** Rs. 5.873 lakh p.a.	−95.6	**−69.7**	0.1097	**0.310**

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
10.	To stop the bag filter fan by connection of venting line with ESP inlet	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 3.6 lakh Rs. 0.245 lakh p.a. 3 years 4.5% Rs. 0.04 lakh p.a. **Rs. 0.1638 lakh p.a.** **3450 (kWh) p.a.** Rs. 1.391 lakh p.a.	Rs. 11.95 lakh Rs. 0.084 lakh p.a. 1.5 years 8.5% Rs. 0.02 lakh p.a. **Rs. 2.622 lakh p.a.** **55,200 (kWh) p.a.** Rs. 7.37 lakh p.a.	−91.09	**−64.71**	0.1177	**0.3555**

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
11.	Belt conveyor and Pipe conveyors	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 234 lakh Rs. 2.5 lakh p.a. 4 years 4% Rs. 0.95 lakh p.a. **Rs. 1.733 lakh p.a.** **36,500 (kWh) p.a.** Rs. 58.66 lakh p.a.	Rs. 400 lakh Rs. 7 lakh p.a. 5 years 5% Rs. 0.5 lakh p.a. **Rs. 2.63 lakh p.a.** **55,000 (kWh) p.a.** Rs. 83 lakh p.a.	**−98.65**	−100	0.0295	**0.0316**
12.	Coal Mill Sp. Power Reduction by output increased	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 10 lakh Rs. 0.05 lakh p.a. 5 years 3.5% Rs. 0.06 lakh p.a. **Rs. 0.4275 lakh p.a.** **9000 (kWh) p.a.** Rs. 1.98 lakh p.a.	Rs. 15 lakh Rs. 0.03 lakh p.a. 5 years 6% Rs. 0.04 lakh p.a. **Rs. 0.522 lakh p.a.** **11,000 (kWh) p.a.** Rs. 2.85 lakh p.a.	-161.25	**-97.4**	**0.215**	0.029

(continued)

Table 1 (continued)

S. no	Technology	Cost variables	Conventional technology parameters	Cleaner technology parameters	Return on investment (ROI)		Cost-Benefit ratio (CBR)	
					Conventional Technology (%)	Cleaner Technology (%)	Conventional technology	Cleaner Technology
13.	Air pollution	1. CI 2. Variable Cost 3. Viability period 4. BuyBack cost 5. Depreciation cost **6. Profit** **7. Benefit** 8. TC	Rs. 445.8 lakh Rs. 40 lakh p.a. 4.5 years 6% Rs. 30.5 lakh p.a. **Rs. 2.137 lakh p.a.** **45,000 (kWh) p.a.** Rs. 133.18 lakh p.a.	N.A	−121.2	N.A	0.0160	N.A

N.A- Not Available, TC–Total cost, CI-Capital investment, kWh- kilowatt-hour

Explanation of Cost Analysis using ROI and CBR for (VRM) inlet duct Modification

Vertical roller mill (VRM) machinery had a huge amount of modification in this cement industry. Considering the (VRM) inlet duct modification the return on investment in conventional technology (non-renewable energy) was (−79.3%) and cleaner technology (VRM) inlet duct Modification was (−93.3%) for Rs. 1 investment. On comparing the two technologies there is a loss in ROI. In terms of cost-benefit ratio, conventional technology (non-renewable energy) (0.2341) and cleaner technology (VRM) inlet duct Modification (0.0640) and in terms of cost-benefit ratio, conventional technology shows a higher benefit. But in cleaner technology, energy conservation was done due to less use of pressure and temperature, sensors and automated flow meters were attached for more accurate readings leading to energy saved as 58,400 Kwh per year and profit of Rs. 2.77 lakh per year, though ROI showed loss as shown in Table 1.

2.5 *Vertical Roller Mill Grit Cone Modification*

Older technology

Vertical roller mill is used directly and there were no modification done so if there is solid waste it should be recycled at the end of the process, due to this process again the operational cost can be higher due to energy use.

Vertical roller mill Grit Cone Modification

The process of grit cone is used in between the vertical roller mill to separate the particles in two different way coarse and fine particles High efficiency and sharpness of separation, using of different separation of materials of different grain size distribution, Easy for adjustment of the fineness of the product, Low specific power consumption, High drying efficiency within the separator, Cooling of the material with ambient air is also made has an add-on technology.

Explanation of Cost Analysis using ROI and CBR for VRM girt cone modification

Analysis of (VRM) grit cone Modification, the return on investment in conventional technology (non-renewable energy) was (−72.1%) and cleaner technology (VRM) grit cone Modification was (−30.4%) for Rs. 1 investment. On comparing the two technologies, both show loss in ROI. In terms of cost benefit ratio conventional technology (non-renewable energy) (0.3115) and cleaner technology (VRM) girt cone Modification (0.762) and cleaner technology showed a higher benefit (Table 1). Despite the loss in ROI and cost-benefit ratio of cleaner technology, the added benefits like energy benefit of 95,900 kWh per year and a profit of Rs. 4.5 lakhs per year was recorded. Advantage of Vertical roller mill Grit Cone Modification: Less maintenances and operational cost, High energy efficiency, recycle the fine particles

2.6 Vertical Roller Mill Internal Modification

Process: The vertical roller mill was modified for raw meal grinding because of the movement inside is different in terms of speed. A high speed horizontal attrition mill for dry grinding with a higher Rotation per minute (RPM) is a used to conserve energy by optimizing the electricity level from the variable frequency drive which changes the direct current (DC) to alternate current.

Explanation of Cost Analysis using ROI and CBR for VRM internal modification

For (VRM) internal modification, the return on investment in conventional technology (non-renewable energy) was (−100.89%) and cleaner technology (VRM) internal Modification was (−26.5%) for Rs. 1 investment. On comparing the two technologies both show loss in ROI. In terms of cost benefit ratio conventional technology (non-renewable energy) (0.0220) and cleaner technology (VRM) internal Modification (0.76) where cleaner technology showed a higher benefit. Along with loss in ROI and gain in cost-benefit ratio, cleaner technology also benefits by energy saved of 120,000 kWh per year and Rs. 5.7 lakh monetary profit per year as shown in Table 1.

2.7 Vertical Roller Mill Cement Girding CVRM Sp. Power Reduction in OPC Portland Cement Grinding

Operational process: The older switch is a direct current (DC) switch mode power supply change into alternate current (AC) supply modification has been done called power reduction switch.

Explanation of Cost Analysis using ROI and CBR for VRM girt cone modification

(VRM) Special Power Reduction in OPC showed return on investment in conventional technology (non-renewable energy) as (−119.19%) and cleaner technology (VRM) Special Power Reduction in OPC as (−67.8%) for Rs. 1 investment. On comparing the two technologies recorded loss in ROI. In terms of cost benefit ratio conventional technology (non-renewable energy) (0.0341) and cleaner technology (VRM) Special Power Reduction in OPC (0.337), cleaner technology shows a higher benefit. With loss in ROI and gain in cost-benefit ratio the cleaner technology added benefit by energy saved amount of 52,600 Kwh per year and Rs. 2.50 lakhs per year (Table 1).

2.8 Variable Frequency Drive (VFD Installation)

Principle of working: Direct current (DC) is changed into alternate current (AC)

Working of Variable frequency drive (VFD)

In Cement Industries, three phase induction motors are used because of its robust characteristics and simple maintenance. Rotating direction and speed of the three phase induction motor can be changed using Variable Frequency Drive (VFD) which is happening in recent years. The advantages of VFD are that they are energy saving, consumes less current for starting of motor, thermal and mechanical losses are less on motors, maintenance is not required often, has high power factor and a low KVA. The PLC controls and monitors VFD and VFD acts as a conciliator between 3 phase induction motor and the PLC. A conveyer is connected to the induction motor and cell sensor input is connected uniformly across the conveyer. The sensor input is connected to the PLC. This processes the input according to the ladder logic programming and initiates corresponding output to the VFD.

1. VFDs taken in line for energy conservation and optimization (More than 65 Nos of VFDs Installed for Fans, Pumps etc.)
2. VFD for Compressors (HAG–Hot generator Coal Blower)
3. Continuous monitoring of false air in each section and reduction activities (Raw mill circuit −7% including seal Air and Kiln 3.8%)
4. All major drives like Process Bag filter Fans, PH Fans, Coolers Fans; Kiln etc., are running in VFD
5. Expert Optimizer (EO) implemented for Raw Mill, Cement Mill, Coal Mill and Pyro.
6. Automated and flow meters connected to it on consumption.
7. Direct current (DC) is changed into alternative current (AC)

Explanation of Cost Analysis using ROI and CBR for VFD

The Table 1 shows, Variable frequency drive (VFD), the return on investment in conventional technology (non-renewable energy) was (−96.54%) and cleaner technology Variable frequency drive (VFD) was (−61.9%) for Rs. 1 investment. On comparing the two technologies recorded loss. In terms of cost benefit ratio conventional technology (non-renewable energy) (0.115) and cleaner technology (VRM) Special Power Reduction in OPC (0.564). Where the conventional technology showed higher benefit. Though loss in ROI and cost-benefit ratio, the cleaner technology would still provide benefit through energy saved to an extent of 80,000 kwh per year and Rs. 2.46 lakh per year.

2.9 False Air Reduction

Process of False air reduction

The false air which has been escaped from the equipment can be collectively infiltrated and reused by the keeping the temperature and pressure in a minimum level of maintain if this temperature is recycled in that process is called has false air reduction (Udara et al. 2014).

For this process energy audit should be done properly 1. Optimizations of the output 2. Reduction in specific energy consumption 3. Trouble shooting in electrical, mechanical and process systems 4. Dust abatement 5. Quality assurance.

Explanation of Cost Analysis using ROI and CBR for False air reduction

The return on investment in conventional technology (non-renewable energy) was (−103.59%) and cleaner technology (False Air Reduction) was (−109.97%) for Rs. 1 investment. On comparing the two technologies were in loss. In terms of cost benefit ratio conventional technology (non-renewable energy) (0.00 713) and cleaner technology (False Air Reduction) (0.1184) and cleaner technology showed a higher benefit. Along with loss in ROI and higher benefit in cost-benefit ratio of cleaner technology, added benefits are energy saved as 1600 kWh per year and profit earned as Rs. 0.076 lakhs per year (Table 1).

Operational modification done in areas: Ball mills kiln burner, Clinker cooler, Kiln shell.

2.10 Compressor Power Reduction

Working process of compressor power reduction

Compressed air systems has various modification depends on the capacity like Incoming air filters, inter-stage coolers, after coolers, air dryers, and moisture drain traps, receivers, piping network, filters, regulators and lubricators Air compressors can save significant amount of energy. Air compressors are used in a variety of large scale industries to supply energy requirements, to operate air tools, equipment, and instrumentation needs. Only 10–30% of energy reaches at the process end-use, and balance 70–90% of energy is being converted to useless heat energy is lost in form of sound energy, mismanagement and friction (Saidur et al. 2010).

Explanation of Cost Analysis using ROI and CBR for Compressor Power Reduction

The return on investment in conventional technology (non-renewable energy) was (−98%) and cleaner technology (Compressor Power Reduction) was (−95.8) for Rs. 1 investment. On comparing the two technologies showed loss in ROI. In terms of cost-benefit ratio conventional technology (non-renewable energy) was (0.033) and cleaner technology (Compressor power reduction) was (0.070) and cleaner technology showed a higher benefit. Additionally cleaner technology showed benefits in energy saved as 6500 kWh per year and profit as Rs. 0.308 lakh per year (shown in Table 1).

Advantage of Compressor power reduction

Energy saving technology, Operational and maintenance cost is less

2.11 Reduction of Specific Power and Fuel Consumption in Pyro Section

Process: Clinker is produced by the pyro-processing section were in this industry it has been modified to Optimize heat recovery by upgrading the clinker coolers for making in rotary kilns, Preheater/ pre-clinker kilns for clinker making in vertical shaft kilns and Low temperature heat recovery for power generation for clinker making in rotary kilns High temperature heat recovery for power generation for clinker making in rotary kilns is attached and used. (Kabir et al. 2010; Emad et al. 2013).

Explanation of Cost Analysis using ROI and CBR for Reduction of specific power and fuel consumption in pyro section

The return on investment of Cleaner technology (Reduction of specific power and fuel consumption in pyro section) is (−63%) for Rs. 1 investment, depicting loss. In terms of cost benefit ratio cleaner technology (Reduction of specific power and fuel consumption in pyro section) is (0.447). Though loss in ROI and cost-benefit ratio for cleaner technology, benefits in the form of energy saved 80,000 kWh per year and profit earned Rs. 3.8 lakh per year (Table 1) were offsetting the loss. Advantage: Low operational cost, Energy conserving technology.

2.12 Vertical Roller Mill Fan Optimization

Process of Fan optimization: High power consumption and low productivity. For stable long term operation, when the system is found occurring a large variations to control the grinding dust is accumulated in fan and when the system under small variation adjustment automatically done so the machine speed varies. Due to the decrease in the machines fan has a maximum optimization reduction occurs due to this process by temperature and pressure, energy is conserved (Danielle and Patrick 2010).

Explanation of Cost Analysis using ROI and CBR for Vertical roller mill Fan optimization

The return on investment in conventional technology (non-renewable energy) was (−95.6%) and cleaner technology (Vertical roller mill Fan optimization) was (−69.7%) for Rs. 1 investment, the two technologies were in loss. In terms of cost benefit ratio conventional technology (non-renewable energy) was (0.1097) and cleaner technology (Vertical roller mill Fan optimization) was (0.310) leading to cleaner technology showing a higher benefit. Despite loss in ROI and higher gain in Cost benefit ratio cleaner technology added further benefits through energy saved as 38,500 kWh per year and profit accrued as Rs. 1.82 lakh per year (Table 1).

2.13 To Stop the Bag Filter Fan by Connection of Venting Line with ESP Inlet

Process

Process Modification is done using venting line in Electrostatics precipitator (EP) inlet to conserve energy by adding automated sensor and variable frequency drive (VFD).

Cost analysis for to stop the bag filter fan by connection of venting line with ESP inlet

The return on investment in conventional technology (non-renewable energy) was (−91.09%) and cleaner technology (To stop the bag filter fan by connection of venting line with ESP inlet) was (−64.71%) for Rs. 1 investment, both losses. In terms of cost-benefit ratio conventional technology (non-renewable energy) was (0.1177) and cleaner technology (To stop the bag filter fan by connection of venting line with ESP inlet) was (0.3555) and cleaner technology showed higher benefits. Also cleaner technology had extra benefits in the form of energy saved as 55,200 kWh per year and profit as Rs. 2.622 lakhs per year (Table 1).

Advantage: Automated and sensors are available, Energy saving technology connected to variable frequency drive

2.14 Belt Conveyor and Pipe Conveyors

Process

Due to transport of materials like lime stone and calcium carbonate inside the industry conveyor systems were used. And this conveyor are classified into two, Belt and Pipe conveyor

Belt conveyor: Belt conveyor is an old method of transport using to rotatory poles was used.

Pipe conveyor: Pipe is used in a vacuum method using (air sucking) in this method there is no spillage and dispersion of air.

Advantage: No spillage, dust emission, Lesser area required for plant and machine, Reduced maintenance costs, Investment required for 6 Numbers of Auxiliary bag filters eliminated.

Explanation of Cost Analysis using ROI and CBR using for Belt and Pipe conveyor

The return on investment in conventional technology (non-renewable energy) was (−98.65%) and cleaner technology (Belt conveyor) was (−100%) for Rs. 1 investment, both losses. In terms of cost-benefit ratio conventional technology (non-renewable energy) was (0.0295) and cleaner technology (Belt conveyor) was (0.3168) where cleaner technology showed a higher benefit. Added benefits like energy saved 55,500 kWh per year and profit obtained Rs. 2.63 lakhs per year were attributed to cleaner technology (Table 1).

2.15 Coal Mill Sp. Power Reduction by Output Increased

Process

Specific heat capacity is recycled by using dry heat and increase the capacity of energy resources without using coal (non-renewable energy resource has been used less).

Explanation of Cost Analysis using ROI and CBR using for Belt and Pipe conveyor

The return on investment in conventional technology (non-renewable energy) was (−161.2%) and cleaner technology (Coal Mill Sp. Power Reduction by output increased) was (−97.4%) for Rs. 1 investment. On comparing the two technologies charted loss in ROI. In terms of cost-benefit ratio conventional technology (non-renewable energy) was (0.215) and cleaner technology (Coal Mill Sp. Power Reduction by output increased) was (0.029) and cleaner technology showed a higher benefit, along with energy saved as 11,000 kWh per year and profit got as Rs. 0.52 lakhs per year.

Advantage of Compressor power reduction

Energy saving technology, Operational and maintenance cost is high.

2.16 Air Pollution Control

Process

Air pollution control technology is used in this industry, conventional End Of Pipe (E-O-P), technology. The air is sucked by a method called as vacuum and blower is attached and then it's connected to a stack in a height for dispersion of air particulate. the CPCB has given some subsides for using Advance technology and old technology still prolong in updating technology by using senor, automated flow meters, Bag filter-cement mill, Bag filter–Coal mill, Bag filter-Cement silo, Bag filter-Fly ash silo, Bag filter-Raw mill Bag filter-Roto packers, Bag house-cement mill, Bag house-coal mill, Cooler ESP (Electrostatic precipitator) and fan, Dust suppression, Raw mill reverses air bag house and Small nuisance bag filters.

Explanation of Cost Analysis using ROI and CBR for air pollution control

The return on investment in conventional technology (Air pollution control) was (−121.2%) for Rs. 1 investment, loss in ROI. In terms of cost-benefit ratio conventional technology (Air pollution control) was (0.0160). Still other benefits like energy saved as 45,000 kWh per year and Profit as Rs. 2.13 lakhs per year could be seen as the positives of conventional technology. Advantage: Cost-effective and maintenance is less, Adsorption and odor is less consumption of energy is less (Table 1).

3 Other Environmental Management Systems in Cement Industry

1. Used oil is recycled and reused to a quantity of 120 kg per year and the method of disposal, storing in separate area and selling to authorized recyclers.
2. Quantity of waste fuel used (Tons) 11,210 per year and Equivalent of Conventional energy used (Tons of fuel) 4839 per year and Waste fuel total energy was 3.97%.
3. Fly ash is added and recycled to an extent of 42.5 ton per day and reused in manufacturing itself.
4. Bed ash is added and recycled, 7.5 ton per day with limestone.
5. Rain water harvesting pond Capacity was 40,000 m^3 and saved water to a value of Rs. 3 lakhs.
6. On line dust monitoring system has been attached towards vertical rolling machine for 6.5 lakhs.
7. To reduce dust insufflations in pulverized coal, High efficiency Twin Cyclone has been installed in the Coal mill circuit for a cost of Rs. 5 lakh.
8. Adsorption of air takes places in cement industry to minimize the level of adsorption various remedial measures like Sprinklers, Short sprinklers, Moisture sprinklers and Mist spray sprinklers employed.
9. High coal CV Quantity of waste fuel of 800 Tons Equivalent of conventional energy was used (Kwh of electricity or tons of fuel) converting 164.43 MT Waste to 0.77% of total energy.
10. Heat Consumption reduction by Kiln TPD increased 6500 TPD Capital Investment of Rs. 20.4 lakh, Variable cost of Rs. 1.5 lakh per year, viability period of the mechanism was 4.5 years, Benefited cost was Rs. 3.59 lakh per year, Buy back cost stood at 7.8%.
11. The Green supply chain management (GSCM) introduce new regulation norm by research and development of plants towards, Green belt (GB) management for specifically to control air pollution (absorption and adsorption) in cement industry, In this select cement industry there are 250 different type of species trees are grown predominately, this are classified into neem, Pungan and teak etc. with a survival rate of 85-90% (*Tamrindus indicus*), Neem (*Azadirecta indica*), Kalli (*Euphorbia* sps.), Echam (*Phoenix syevestris*), Mango (*Mangifera indica*), Palmyra (*Borassus flabelifera*), etc. were dominant species. Presence of large number of Phanerophytes (shrubs and trees) and therophytes (annuals) converted the semiarid region to a tropical vegetative area in the study area. Hemicryptophytes (predominantly grasses and sedges) were found to be significantly grown. CPCB recommend 63,819 trees for plantation and were planted at a cost of Rs. 7 lakh around the industry to adsorb air pollution.
12. Every cement industry has to be doing energy audit due to expansion and retention of heat every 6 months and every three years equipment modification should be carried out by changing the mechanism (Viredra et al. 2015), Energy management system: EnMS: ISO: 50001 Energy performance was 4.9% of total

energy. Cost incurred over improvement was 2060,000 USD to implement total EnMS Rs. 5.4 lakh payback per year on EnMS implementation for 25 years. Total energy saving over improvement period was (GJ) 38,303 GJ, Total CO_2 emission reduction over improvement period was 38,371 MT of $CO_{2.}$

Effluent treatment plant is used to treat the sewage from the cooling tower water through the process of activated sludge process (ASP), secondary treatment process also used and finally passed into the dairy farming, plantation and green belt.

4 Reuse of Treated Trade Effluent in Process

Investment of Rs. 3 Lakh as part of the initiative to conserve natural resources, Captive Power Plant effluent (waste water) was used for internal water spray in cement mill by which it was able to reduce the raw water consumption by approximately 80 KL (kilo liter) water per day, leading to raw water conservation.

5 Discussion

The Cement plant falls under large scale industry and Red category (Annexure A, in EIA). In Ariyalur in Tamil Nadu, calcium carbonate and gypsum was available in higher quantity. Originally Installed capacity (Clinker), Installed capacity (Cement) 3MTPA, but currently has a rated capacity of Raw mill, Specific Power Consumption—Section wise 15.14 (kWh/Mt), Specific Power Consumption—Section wise 4.36 (kWh/Mt), Klin productivity Average is 4643 TPD, Ordinary pozalanna cement OPC cement grinding 30.20 (kWh/Mt), Cement Dispitch—14.55 LacMT. Cement industry has adopted cleaner technology on process modification but Industry ecology in air pollution control was still using conventional technology at the End process. With Vertical roller mill inlet duct Modification the ROI was (−79.03%) but still conventional technology has a loss but on CBR value of conventional technology is 0.2341 higher that cleaner technology, on energy savings of 518,400 kWh per year, Vertical roller mill Grit Cone Modification has the of ROI (−30.4%) and CBR value (0.762) cleaner technology is higher than conventional technology. Energy saving was 95,900 kWh per year. Vertical roller mill internal modification had a ROI of (−26.5%) loss for Rs. 1 investment and the CBR value 0.76) in cleaner technology, Energy savings 120,000 kWh per year. Power Reduction in OPC Portland cement grinding showed (−67.8%) loss in two technology for Rs. 1 investment and CBR value is 0.337, energy savings 52,680 kWh per year. Variable frequency drive (VFD) ROI was loss in two technologies for Rs. 1 investment and CBR value is higher in cleaner technology 0.564, Energy saving 51,840 kWh per year. False Air Reduction had the ROI which was loss but cost benefit ratio value is higher in cleaner technology 0.1184, energy is gained, 1600 kWh per annum. Compressor Power Reduction ROI was loss in two technologies with CBR value is 0.070 in cleaner technology and Energy savings of 6500 Kwh per year. Coal Mill Sp. Power Reduction by output increased with ROI was a loss but in CBR conventional technology value is higher 0.21 and energy saving was 11,000 kWh per year. Vertical roller mill Fan optimization ROI was loss in two technologies and CBR cleaner technology value is high (0.310), Energy saving was 38,500 kWh per year. To stop the bag filter fan by connection of venting line with ESP inlet ROI was loss for Rs. 1 investment and CBR cleaner technology value is high (0.3555), energy savings 55,2000 kWh per year. Pipe conveyor ROI was 0.97, 426% and the energy savings 55,500 kWh. Air pollution control Conventional technology ROI was (−121.2%) and CBR is 0.0160 but still using conventional technology Energy savings 45,000 kWh per year. Recycling Technology like oil disposal, Waste fuel, fly ash, bed ash, green belt and trade effluent were used. Green rating project (GRP) and Energy management system (Energy audit) EnMS-50001 was used in this industry to calibrate data, analysis (life cycle of energy assessment (LCEA), calculate, document, review, feedback, comparing the efficacy, interpretation and planning per annum is done.

6 Conclusion

The present study aimed at analyzing the pros and cons of old pollution control technology against newer cleaner technology in select cement is a most polluting large scale industry. From the results it could be construed that the old technology was not redundant as some are still economically viable than newer ones. Most new technologies are "add on" ones wherein the old technology has been upgraded with new inputs and thereby leading to better environmental protection. Although the total investment and the operation and maintenance cost on cleaner technology was high in all the selected units of study, but the environmental benefits in terms of water and energy saving, besides recycling of water was greater due to the application of cleaner technologies Therefore, cleaner technology will be the future in India and abroad towards sustainable industrial production.

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