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Investigation of waste heat recovery in cement industry: A case study

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Abstract
Recovery and re-use of commercial waste heat is an attractive idea that would simultaneously scale back energy prices and greenhouse gas emissions. This study has developed a unique approach to quantifying the chance, involving the creation of an innovative techno-economic model that links energy and carbon costs and capitalist priorities with the first of a kind data base of commercial waste heat production, process heat use, and heat recovery technologies. The results based on the operational information which is collected from Birla Corporation Cement Plant (SCW). A 33470352 MW/annum electricity generation were achieved. The value saving was calculable of 148842655 INR/annum additionally to 40 months was expected as the simple payback period.

Keywords: Waste heat recovery, Cement Industry, Energy Saving, Cost Saving

1. Introduction
The industrial sector accounts to 30-70% [1] of the total global energy consumption of which cement sector is one among the foremost energy intensive industries [2]. The clinker calcination process is the most energy exhaustive in cement production, as a result of the exit gases from the clinker cooler and pre-heater at the top and tail of a kiln with temperature below 400 °C are wasted. As a result of the antecedently mentioned, the heat losses accounted for over 30 minutes of thermal consumption for clinker production that considered massive energy quantity was wasted. Thus to scale back each energy consumption and greenhouse gas emission, the waste heat can be recovered for power generation [3].
Energy consumption by a cement industry is estimated at about 2% of the worldwide primary energy consumption (or) that is sort of 5% of total global industrial energy consumption [4]. Cement production, which is highly captivated with the supply of natural resources, will face severe resource in the future [5]. Cement producing has considered an intensive consumer of natural raw materials, fossil fuels, energy and major sources of multiple pollutants [6]. Because of the dominant use of carbon-intensive fuels like coal, the cement industry is also a significant source of CO_2 [2, 4]. The cement industry contributes 5% of total greenhouse gas emissions [7].
For clinker production, a cement industry needs the substantial energy consumption. Regarding 70% of energy consumption lies at the unit of rotary oven system. The upper quantity of energy consumption is due to the shortage of work efficiencies tools leading the waste heat [8].
Optimized the operational parameters such as lots of cooling air and clinker, cooling air temperature, and grate speed to enhance the energy, exergy and recovery efficiencies of a Grate cooling system. Using heat recovery from the exhaust air, energy and exergy recovery efficiencies of the cooling system were enhanced by 21.5% and 9.4%, respectively. About 38.10% and 30.86% energy value will be saved by dynamic mass rate of flow of clinker and mass rate of flow of cooling air, respectively.
Besides these studies, the exergy analysis the complete system in the cement production was demonstrated by Koroneos *et al* [9].
At the range of temperature of 200 to 300 ^{0}C, almost 40% of total input of heat is emitted from The exit gases of pre-heater and clinker cooler.
The waste heat is employed in several applications, such as drying of raw materials; air preheating that is needed for the coal combustion cogeneration [10].
Al-Rabghi *et al* [11] reviewed the use of waste heat recovery in various industry sectors. Saneipoor *et al*. [12] studies the performance of a new Marnoch heat engine (MHE) in a typical

cement plant. Sogut *et al.* [13] examined rotary kiln heat recovery for a cement plant in Turkey. Jiangfeng Wang *et al.* [14] used four types of power station to recover the waste heat from the exit gases of pre-heater and grate cooler in order to get the power in a cement plant.
This work determines the electricity saving that is led to reduction in energy consumption, and thus, reduction in cost saving. As well as, estimation of the simple payback period was accomplished.

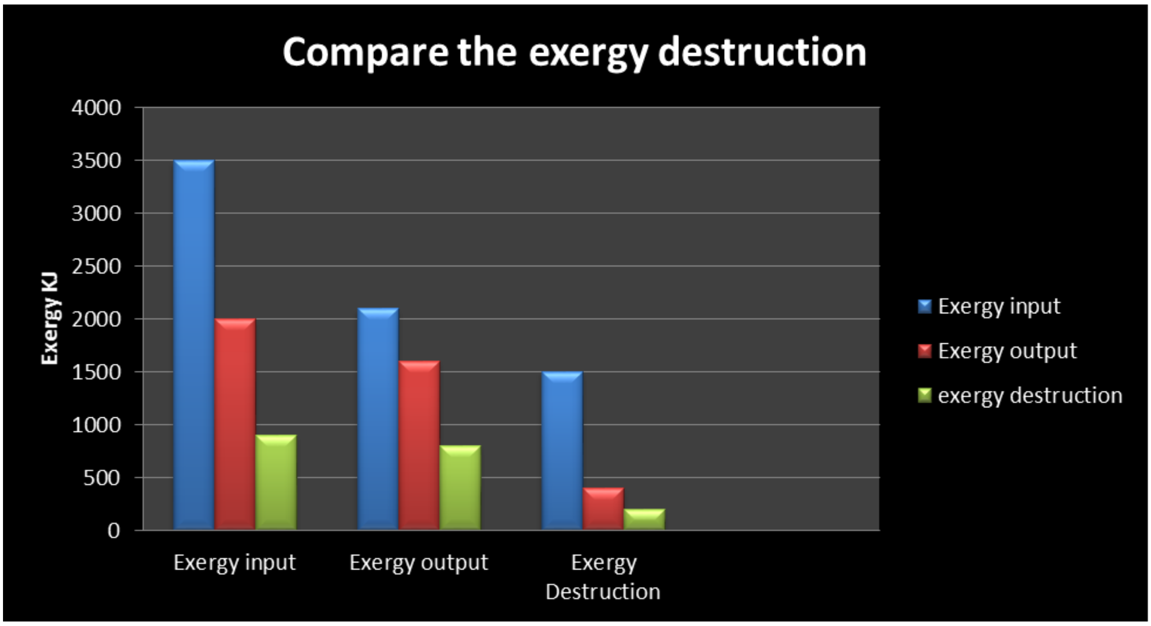
2. Waste Heat Recovery
In addition to the plan of reducing of energy consumption in cement production process, the recovery waste heats can be achieved in order to produce the electrical energy by utilization cogeneration power plant. This means no additional fuel consumption and thus, reducing the high cost of electrical energy and the emissions of greenhouse gases. The waste heats can be classified as waste heats of middle and low temperatures. Some power plants are available and suitable to recover the waste heats [15]. The waste heat sources in the cement plant include the exit gases from the pre-heater and therefore the clinker cooler ejection hot air. And for cogeneration power, these sources that have various level of temperature can be used separately or together. The temperature of ejection hot air from the cooler is 250 °C and the temperature of gases which leave the suspension pre-heater is 350 °C. The steam which is generated via WHRSG by utilizing these two sources would be used to drive a steam turbine. A steam turbine will drive the electric generator to produce the electricity. This will reflect in reduction of electricity demand.

3. Performance of WHRS Cycle
For the WHRSG cycle, the performance of WHRSG is summarized in Table 1

Table 1: SCW WHRS Performance 2014-2015

	Total	Minimum	Maximum	Avg.
Kiln Running hrs.	7403.46	168.50	738.61	616.96
TG Running hrs.	6374.62	164.60	675.20	531.22
Generation Kwh.	33470352	972000	4165632	2789196
Avg. Load Kwh	5250.56	3076	6708	5251
Aux. Power con kwh	2310368	60876	263309	192531
Aux. Power %	6.90	5.69	9.58	6.90
Cllinker Prod. MT	1199971	27895	122481	1199971
Cost per unit Rs/kwh	0.553	0.37	0.84	0.553
System output units/ton of cllincker [Design -31.46u/ton	27.89	16.56	39.58	27.893
TG running factor Kiln Vs TG	0.86	0.54	0.98	0.86
Water conc. Lit/unit	5.8	5.24	6.40	5.83

The Preheater and Precalciner exergy efficiency = 58.2%
The kiln exergy efficiency = 77.82%
Cooler exergy efficiency= 83.72%



4. Cost Saving and Payback Period
Electricity generation- 33470352 Kwh/annum
Generation cost Rs/kwh-0.553
Total generation cost Rs- 33470352×0.553=18509104.656
Considering the average of electricity unit price can be taken as 5.0 Rs/kWh.
Total cost saving= (Energy saving ×Energy cost)-total generation cost
Total cost saving= (33470352×5.0)-18509104.656
Total cost saving per annum=Rs.148842655
Budget together with shipping and installation is 540000000 INR, consequently, a roughly valuation for payback period would be
Payback period = (Cost of implementation cost)/ (Annual cost savings)
Payback period= (540000000 INR/148842655 INR/annum)
Payback period=3.7≈40 month

5. Conclusion

1. The cost saving was 148842655 INR/annum.
2. Payback period for this system will be roughly 40 months.
3. The Waste Heat Recovery Technology, as any other technology, is in an incessant phase, and many more innovations, in terms of equipment and applications may be expected in future.

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