Waste Heat Recovery- The Sustainable Solution for Cement Plants

D. T. Arjun
Director & CEO

M/s. TECHCEM Consulting and Engineering Pvt. Ltd.

A-102, THE ORIEN, Plot no. 12/13, Sector-20, Kalamboli, Navi Mumbai, INDIA

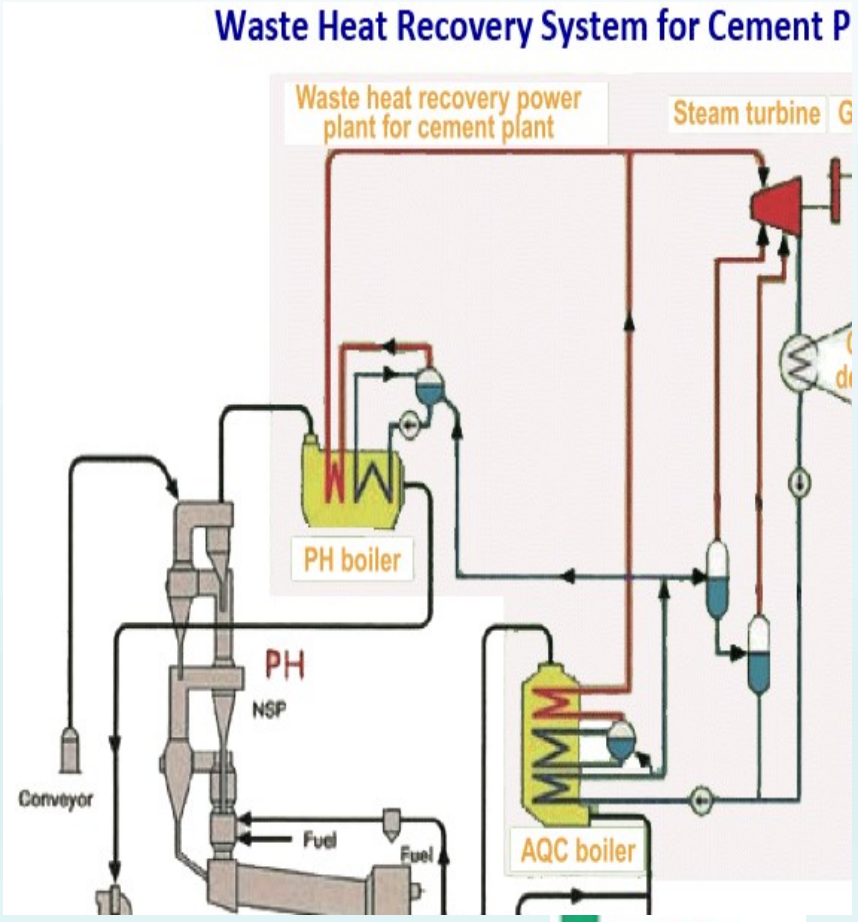
info@techcem.net | www.techcem.net

TECHCEM
Consulting and Engineering

What is WHRS ?

- Waste Heat Recovery System is an energy recovery system by using waste heat.

- Mostly installed in cement plants, use the heat generated through rotary kiln, preheater (PH) and Cooler exhaust hot gases for power generation.



TECHCEM
Consulting and Engineering

How WHRS Contribute To Optimize The Process Of Cement Manufacturing

Waste heat recovery system in a cement plant is a driver in terms of -

1. Reducing operational cost
2. Resource Conservation
3. Waste Reduction

TECHCEM
Consulting and Engineering

Statics Of cement industry

- Cement manufacturing in kilns continues to produce 8% of the Global GHG emissions, the conversion of limestone to clinker is where the bulk of the heat energy is expended.
- Theoretically 710 Kcal needs to be generated to convert one kg of clinker, out of which actual conversion process would need 410 Kcal, the rest ending up as losses, which can be recovered.
- In reality the Indian Cement industry average is 744 Kcal of heat input for producing one kg of clinker, which means the actual losses are even more than the theoretical possibility.

TECHCEM
Consulting and Engineering

Statics Of cement industry

- The Indian cement plants require electrical power of 20 Billion kWh per year. The coal needed for generating this much amount of power accounts to 32 Million Tons per year. A significant portion of this power could be replaced by the Waste Heat Recovery systems that will use waste heat from the kilns to generate electricity.
- The other area of concern is the price trajectory of fossil fuels, which would continue to move northwards; Waste Heat Recovery systems is one simplest way of insulating the industry from the unpredictability of future price increases.

TECHCEM
Consulting and Engineering

Energy Consumption of Cement Plants

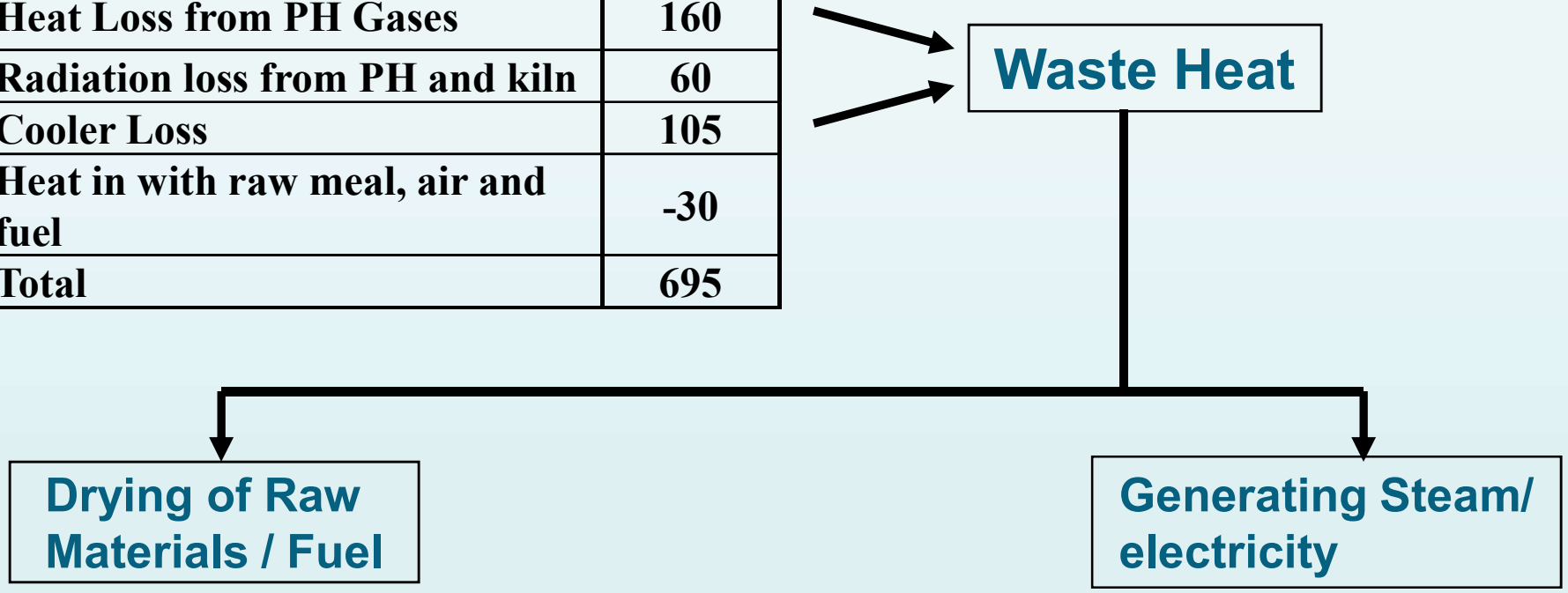
- Old SP kilns :
  - ~ 1000 kcal/kg clinker
- State of art dry process kilns :
  - < 700 kcal/ kg clinker

[- ~ 100 kWh/ per ton OPC]

TECHCEM
Consulting and Engineering

What is waste heat?

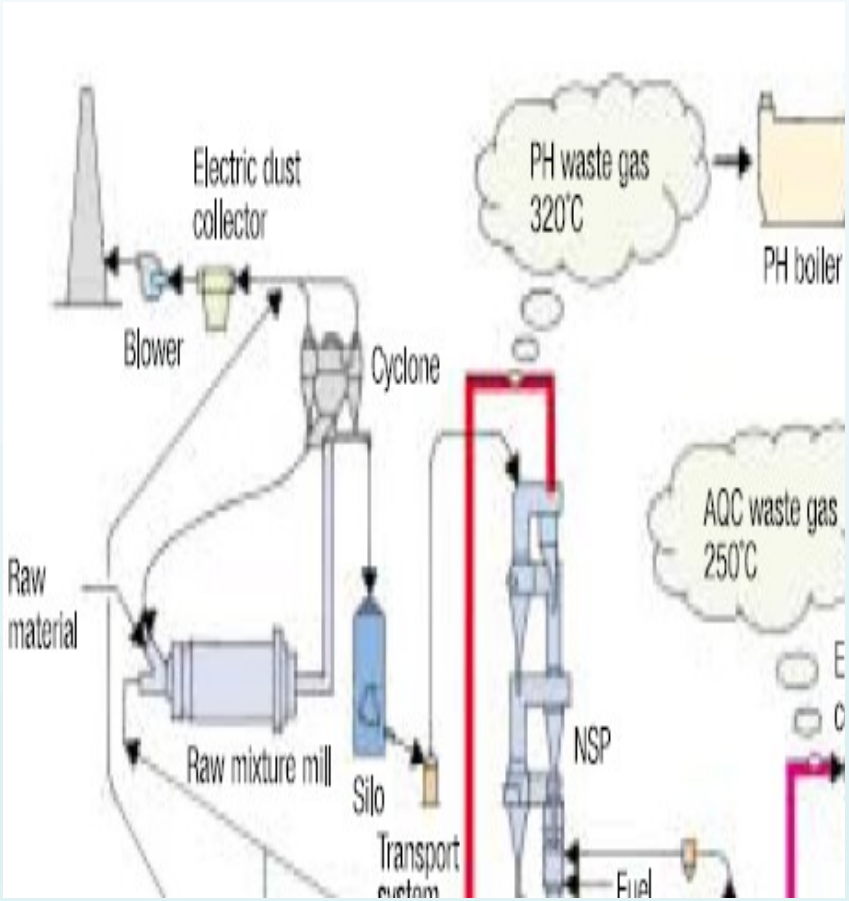
Parameter	kcal/ kg cli
Heat of reaction	400
Heat Loss from PH Gases	160
Radiation loss from PH and kiln	60
Cooler Loss	105
Heat in with raw meal, air and fuel	-30
Total	695



TECHCEM
Consulting and Engineering

WHR Design Issues

1. **HIGH DUST LOAD IN WASTE GASES**
2. **DUST CLOGGING, WEAR & TEAR**
3. **LAYOUT CONSTRAINT IN EXISITNG PLANTS**
4. **LONG DUCTING LEADING TO PRESSURE LOSS AND DESIGN COMPLEX**



TECHCEM
Consulting and Engineering

WHR Process Design Inputs

- **Raw material moisture**
- **Preheater gas /Cooler gas exit temperature (Operating range)**
- **Gas flow rates (Operating range)**
- **Process Fan Curves and operating points**
- **Dust content of gas**
- **Plant Layout**

TECHCEM
Consulting and Engineering

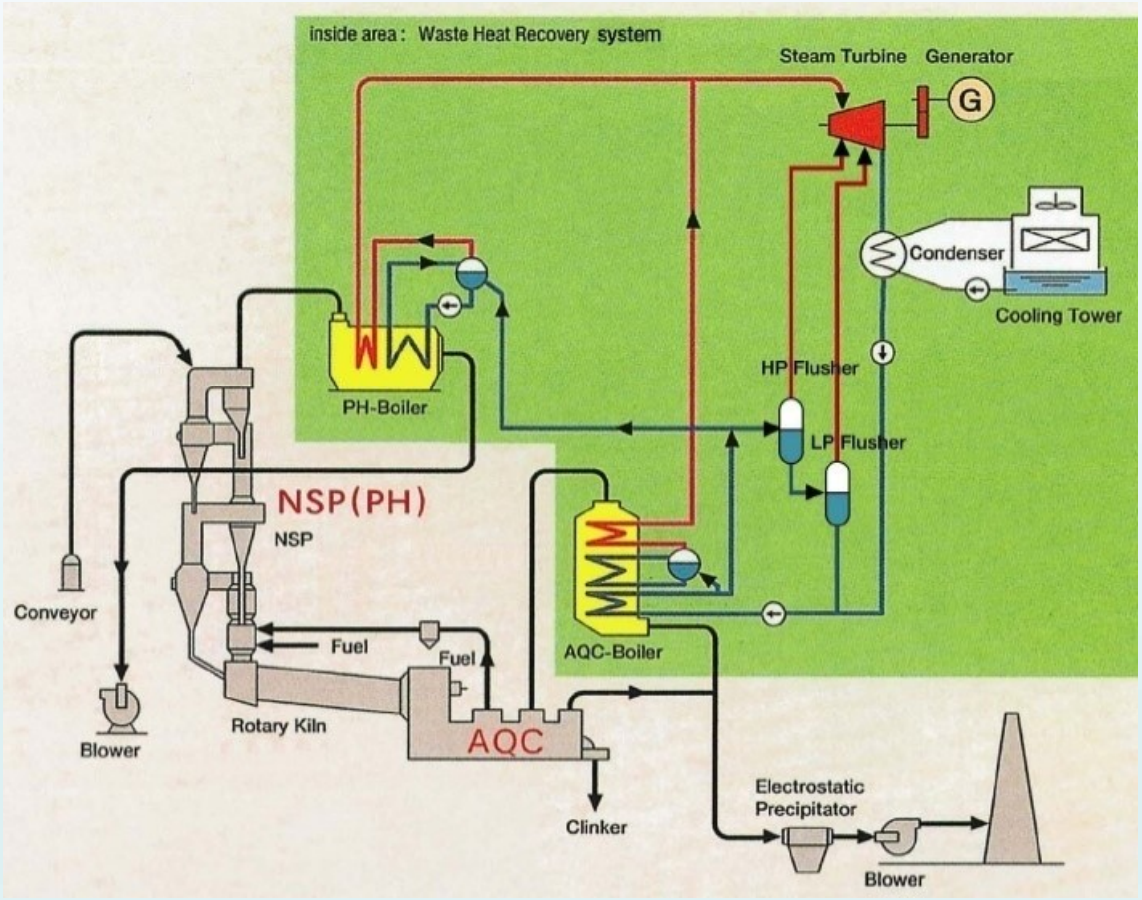
WHR Technology

1. **Steam Rankine Cycle**
2. **Organic Rankine Cycle / Kalina Cycle**
3. **Desalination**

	Steam Rankine	Organic Rankine	Kalina
Waste heat temperature needed (°C)	>250	>200	>200
Approximate capital cost (INR/MW generating capacity)	09-10 Cr	11-12 Cr	10-11 Cr
Electric Generation relative to Steam Rankine	1	1.3-1.5	1.2-1.4

TECHCEM
Consulting and Engineering

WHR Configuration – Entire plant



WHR - RECENT DEVELOPMENTS

WASTE HEAT BOILER 'THERMOWIR'

1. REMOVING 60% (48-60gm/NM 3) DUST FROM THE GASES REDUCING LOAD ON EXISTING ESP

2. HIGHER EFFICIENCY COMPARED TO CONVENTIONAL HEAT EXCHANGER

TECHCEM
Consulting and Engineering

WHR - RECENT DEVELOPMENTS

MODIFIED RANKINE CYCLE SYSTEM 'KALINA CYCLE'

1. **USES BINARY FLUID OF AMMONIA AND WATER**

2. **EFFICIENCY GAINS OF UPTO 50% FOR LOW TEMPERATURE (200-280 oC) AND UPTO 20% FOR HIGHER TEMPERATURE HEAT SOURCES COMPARED TO RANKINE CYCLE**

TECHCEM
Consulting and Engineering

WHR - RECENT DEVELOPMENTS

ORMAT ENERGY CONVERTER (OEC)

1. USES ORGANIC FLUID AS WORKING MEDIUM INSTEAD OF STEAM

2. SUITABLE FOR MUCH LOWER TEMPERATURE HEAT SOURCES AS ORGANIC FLUID HAS A MUCH LOWER BOILING POINT THAN WATER

TECHCEM
Consulting and Engineering

WHR system design features

- Boiler and Ducting Pressure drop (generally 80-120 mm)
- Margins available on Existing fans
- Design of boiler tubes
  - Handle abrasive dust
  - Prevent clogging of tubes with dust
- Trouble free Process Control

TECHCEM
Consulting and Engineering

WHR sytems in Indian Cement Plants

Location	MW Installed	Vendor
J.K cement Nimbahera, RJ 1200 + 1800 + 4800 TPD	13.2 steam turbine generator	Thermax boiler + Taiheiyo Engg. Corporation, Japan
KCP cements; Mancherla, AP, 1800 TPD	2.35 steam turbine generator Rankine Cycle;	Transparent Energy Systems, Pune
Shree Cement, Beawar, Unit 1, I million TPA	5- 6 MW Steam generated	Transparent Energy Systems, Pune
Ultratech, Tadipatri, AP	4 MW Organic Rankine Cycle,	Transparent Energy Systems, Pune and ORMAT Systems
Shree Cement	16.8MW	2010 commissioning
JK Lakshmi, Sirohi, Rajasthan	12 MW	2011 commissioning

TECHCEM
Consulting and Engineering

Cogeneration Potential in the country

- Brownfield projects

Plants amenable for Cogeneration	68
Total Cogeneration Potential	~210 MW

- Greenfield projects
  - 30 MTPA in the next 3 years

Power Source	**Cost of Power**
Grid Supply	6.5-7.5 INR per kWh
Diesel Captive Generation	9.5 to 10.5 INR per kWh
Cogenerated Power	2.10 to 3.0 INR per kWh

TECHCEM
Consulting and Engineering

INVESTMENT ANALYSIS

TYPICAL FOR 1.5 MTPA PLANT WITH 6 MW POWER GENERATION

1.0	PROJECT SPECIFICATION			
1.1	Power Generated (Gross)		MW	6.00
1.2	Sefl Consumption @	10%	MW	0.60
1.3	Power Generated (net)		MW	5.40
1.4	Number of days of operation per annum		days	317
1.5	Number of hours of operation per day		hours	24
1.6	Overall Project implementation period		months	20
1.7	Electricity cost		Rs/kWh	6.75
1.8	Operating Expenses incl. Givt. Duty and cess		Rs/kWh	0.62
1.9	Admin & General Expenses		Rs/kWh	0.32

TECHCEM
Consulting and Engineering

INVESTMENT ANALYSIS

TYPICAL FOR 1.5 MTPA PLANT WITH 6 MW POWER GENERATION

ESTIMATED COST OF THE PROJECT

ANNEXURE - 10.1

(All figures are in Lakh Rs)

S.NO.	PARTICULARS	ESTIMATED COST
1.0	Land & Site Development	-
2.0	Revamping Cost	-
3.0	Buildings	790.50
4.0	Plant & Machinery	4,302.18
5.0	Engineering Services	143.06
6.0	Miscellaneous Fixed Assets	120.00
7.0	Pre-operative Expenses	332.01
8.0	Provision for Contingencies	284.39
9.0	Margin money for Working Capital	23.77
TOTAL		5,995.91
	Say	6,000.00

TECHCEM
Consulting and Engineering

INVESTMENT ANALYSIS

TYPICAL FOR 1.5 MTPA PLANT WITH 6 MW POWER GENERATION

2.0	**FINANCE**		
2.1	Project cost	Rs. Lakhs	6000.00
2.2	Debt-Equity ratio	2 : 1	
2.3	**Equity**		**1.0**
2.3.1	**Promoter's Contribution**	Rs. Lakhs	**2000.000**
	Promoter's Equity	Rs. Lakhs	0.00
	Internal accruals	Rs. Lakhs	2000.00
2.4	**Debt :**		**2.0**
2.4.1	**Bank Term Loan**		**4000.00**
2.4.2	Rate of Interest on bank loans		14.00%
2.4.3	Moratorium period	No. of quarters	4
2.4.4	Number of repayment instalments	No. of quarters	24
2.4.5	Up-front charges		0%
2.4.6	Interest on margin money		14%

TECHCEM
Consulting and Engineering

INVESTMENT ANALYSIS

TYPICAL FOR 1.5 MTPA PLANT WITH 6 MW POWER GENERATION

RESULTS OF FINANCIAL ANALYSIS

Sl. No.	Particulars	Value
1.0	**Project cost (in Lakh Rs)**	6,000
2.0	**IRR (%)**	29.67%
3.0	**Average DSCR (for 5 yrs)**	2.58
4.0	**Pay back period**	
	- Year(s)	3
	- Month(s)	3
5.0	**NPV before Tax**	4,179

TECHCEM
Consulting and Engineering

REDUCTION OF CO2 GAS

TYPICAL FOR 1.5 MTPA PLANT WITH 6 MW POWER GENERATION

Quantity of power generated	**KWh**	**6,000**
In-house power consumption	KWh	600
Reduced power purchased	KWh	5,600
Annual operating hours	Hrs	8,000
Annual Reduction of fossil fuel consumption at the existing power station (on a crude oil basis)	T/Y	11,560
Annual Reduction of CO2 emission	T/Y	38,080

TECHCEM
Consulting and Engineering

WHR in Cement Industry- Path ahead

- Cogeneration potential of 27- 36 KWh/ton clinker (3.0 to 20.0 MW)
- CDM Credits- ACM 004 "Consolidated baseline methodology for waste gas and/or heat for power generation"
  - 1 MW results in reduction of 5000 Tones of CO_2 / Annum
- Time to tap the potential in waste heat!!!

TECHCEM
Consulting and Engineering

Waste Heat Recovery- Sustainable Solutions for Cement Plants

M/s. TECHCEM Consulting and Engineering Pvt. Ltd.

A-102, THE ORIEN, Plot no. 12/13, Sector-20, Kalamboli, Navi Mumbai, INDIA

info@techcem.net | www.techcem.net

TECHCEM
Consulting and Engineering