Cement Waste Heat Recovery Options & Opportunities

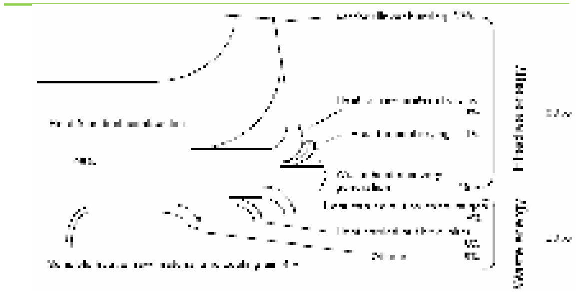
CII Meeting

13-14 May 2010

Contents

- Sources of heat
- Cement Waste Heat Recovery Technologies available
- Feasibility
- Technology details
  - PH Boiler
  - AQC Boiler
  - Overall WHR Power Plant Schematic
- Horizontal Vs Vertical PH boilers
- Our experience in Cement Waste Heat Recovery
- JK Lakshmi, Sirohi & JK Nimbahera – Design Basis
- JK Nimbahera – Performance
- A word about us

Sources of heat and waste heat



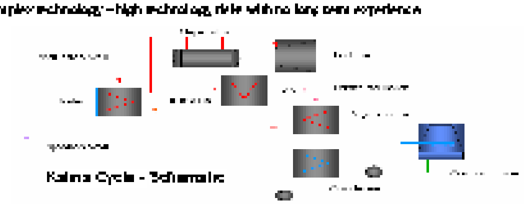
Heat from suspension preheater gas stream (PH)
Heat from calciner gas stream
Heat from clinker cooler gas stream (both outlet and centre tap off)
Heat from DG sets running at base load

Options available in Cement WHR

- Kalina Cycle
- ORC/WHR Cycle
- Steam Based Rankine Cycle
  - Separate WHR STG
  - Separate steam for injection in Existing STG
- Steam used in Supplementary Heat Heating
- Generation of LP steam for use in Deaerators
- Generation of LP steam for partial usage in absorption cooling machines

Kalina Cycle

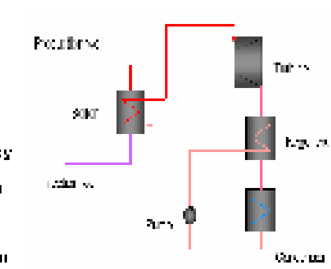
- Thermodynamic cycle
  - Working fluid is a binary mixture of Ammonia & Water
  - Working fluid composition is varied by means of a separator & absorber
- Variable Composition of Water & Ammonia
  - Results in changing the Saturation Temperature of the Fluid
- Ammonia with risk of corrosion
- Used primarily in Geo Thermal Energy due to very low Temperatures available
- Complex technology – high technology risk with no long term experience



Kalina Cycle - Schematic

Organic Rankine Cycle

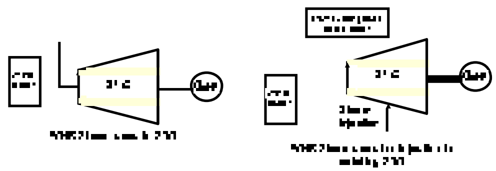
- Two Working Fluids
  - Thermic Oil
  - Pentane
- Two heat transfer cycles
  - Over all lower heat transfer efficiency
- Water Free System – ideal for areas with low water availability
- Pentane availability could be problem



Organic Rankine Cycle Schematic

Steam based Rankine Cycle

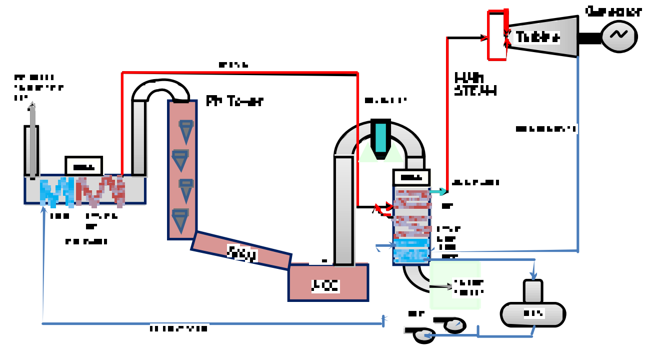
- Based on proven Rankine cycle based power plants
- Uses only DM Water / Steam as the working fluid.
- Environment friendly, considering no impact on the surroundings.
- Optional: Air cooled condenser for water starved areas.



Steam Rankine vs Organic Rankine

- Steam Rankine
  - Well proven technology
  - Trained manpower available to operate & maintain
  - Higher efficiency at higher temperatures
  - Standard major equipment
- Organic Rankine
  - Recovery working references.
  - Trained manpower is less to operate & maintain
  - Higher efficiency at lower temperatures
  - Pentane availability needs to be addressed
  - Safety issues in handling Pentane (Highly explosive)

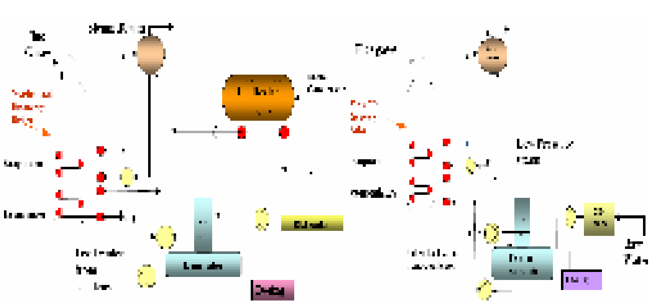
Cement WHR based CPP Schematic



Other Options

LP Steam for Boiler water preheating

LP Steam for Deaerator

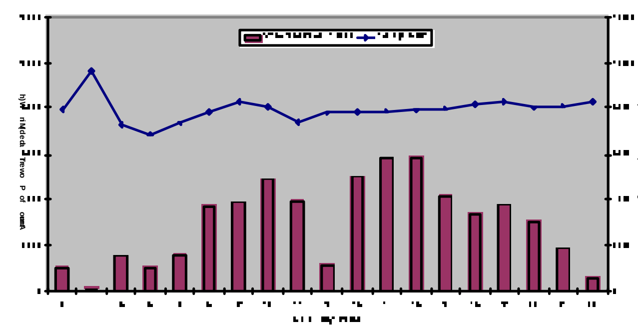


Feasibility

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
[illegible] Cement Plant	[illegible] MTPA	[illegible] MTPA	2.00 MTPA	2.00 MTPA	2.00 MTPA	[illegible] MTPA	[illegible] MTPA
[illegible]	-	2	2	3	2	2	3
[illegible]	2	4	[illegible]	[illegible]	[illegible]	4	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Power Generation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Payback	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Sale thru Power Exchange Possible New Revenue Source



Considerations for PH Boiler design

SN	Parameter	Horizontal	Vertical
1	Gas Flow Pattern	Vertical Tubes, Horizontal Flue Gas Flow	Horizontal Tubes, Vertical Flue Gas Flow
2	Nature of Dust	Highly Sticky	Highly Sticky
3	Dust Handling	Effective Dust removal is possible only using the hammering system. [illegible]	Effective Dust removal not possible. [illegible]
4	Dust Removal System	[illegible]	[illegible]
5	Accessibility	[illegible]	[illegible]
6	Availability / Reliability	Higher	Lower

Why Horizontal PH Boiler?

SN	Parameter	Horizontal	Vertical
1	[illegible]	[illegible]	[illegible]
2	Pressure Drop [illegible]	[illegible]	[illegible]

90% of Cement WHR PH Boilers are Horizontal in Japan

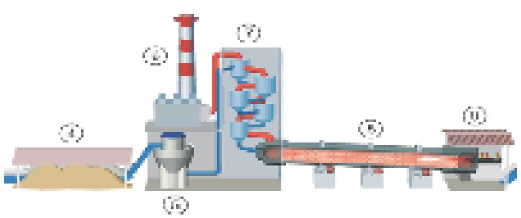
Thermax – WHR Experience

Horizontal Boilers	Vertical Boilers
Cement Waste Gases – Pre Heater	Cement Waste Gases – Cooler
Glass furnace	Electric Arc Furnace
Incinerators (MSW & Hazardous)	Sponge Iron Exhaust Gas
Iron pyrites roasters	Blast Furnace Gas
Zinc pyrite roasters	Coke Oven Gas
Copper smelters	DG Exhaust Gas
Copper converters	GT Exhaust Gas
Glass Furnace	[illegible]
	Sulphur Recovery Plant
	Sulphuric Acid Plant

[illegible]

Taiheiyo Experience in WHR

- Have been operating Cement WHR based Power Plants for last 20 Years.
- All Plants (Except One) in Japan have Horizontal Boilers
- TEC provided Technological Support to Japanese Boiler Manufacturers also.
- Also providing Services to Cement Companies in India



PH Boiler – Technology

- Horizontal Boiler, Vertical Tubes
- Cross Flow Design
- Forced Circulation
- Proven technology to handle Dust Laden Gases (100gm/Nm3)
- Proven De-Dusting Hammering Mechanism
- Bare Tube Design
- Better water hold up to cater to steam fluctuations
- Better Accessibility

Thermax – Taiheiyo partnership

Exclusive tie-up for technical assistance from Taiheiyo Engineering Corporation, Japan for cement process back up to offer world class waste heat recovery solution services in India include

- Site investigation in pre-order stage to mark out the Locations of Boilers to have most Process Friendly Layout
- Basic engineering schematic of flue gas ducting / Preheater Arrangement
- Boiler's design by Thermax guidelines from Taiheiyo
- All boilers ducting & pre-duster drawings vetted by Taiheiyo

Case 1 - J.K. Nimbahera - Design

- Capacity of Plant — 13.2 MW
- Time of Completion — 22-24 months
- Number of Boiler — 5
  - [illegible]
  - [illegible]
  - [illegible]
- Steam Parameters — [illegible]
- Plant O & M by Thermax Limited
- Water Cooled Condenser.

Challenges – beyond technology

- [illegible]
- [illegible]
  - [illegible]
- [illegible]
  - [illegible]
- [illegible]
  - [illegible]



Case 1 - J.K. Cement performance parameters

	[illegible]		[illegible]	[illegible]	Temp.	[illegible] Temp	[illegible]	[illegible]	[illegible]
	TPD		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Kiln-1	[illegible]	PH	4	[illegible]	[illegible]	[illegible]	[illegible]	72.2 TPH	13.2 MW
Kiln-2	[illegible]	PH	4	[illegible]	[illegible]	[illegible]	[illegible]		
Kiln-3	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		

Case 2 - J.K. Lakshmi, Sirohi - Design

- Capacity of Plant — [illegible] MW
- Time of Completion — [illegible] months
- Number of Boiler — 5
  - [illegible]
  - [illegible]
- [illegible]
- Steam Generation — 72 TPH
- Air Cooled Condenser

J.K. Nimbahera-Performance

Month	Availability
Nov. 08	[illegible]
Dec. 08	[illegible]
January 09	[illegible]
Feb. 09	[illegible]
March 09	[illegible]
April 09	[illegible]
May 09	[illegible]

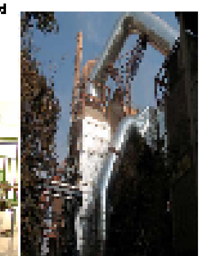
Month	Availability
June 09	[illegible] *
July 09	[illegible]
August 09	[illegible] *
Sept. 09	[illegible]
October 09	[illegible]
Nov. 09	[illegible] *
Dec 09	[illegible]

[illegible]

J.K. Nimbahera-Performance

- Pressure Drop — Successfully Demonstrated
  - Designed: [illegible]
  - > Achieved [illegible]
- Dust Removal System — Successfully Demonstrated
- Boiler O/L Temp. — Successfully Demonstrated
  - Designed: [illegible]
  - Achieved: [illegible]





Thermax Experience in Power Sector

Power Division

- Over 1000 MW on EPC basis
  - 37 projects in India
  - [illegible]
- [illegible]
  - [illegible]

Boiler Division

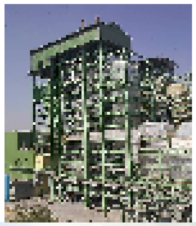
- 7000+ MW equivalent [illegible]

Water Division

- Over 3000 TPH cooling water for Power plants

Enviro Division

- [illegible]



Chemical offerings

A) Present offerings to Cement industries (for Captive Power Plant)

Cooling water treatment
Boiler water treatment
RO (Reverse Osmosis) Chemicals
Fuel additive for Coal / Lignite
Polyelectrolyte for water and waste water

Satisfied customers – 1. JK Cement 2. Ambuja Cement 3. Birani Cement 4. Madras Cement 5. ACC

B) Entering CEMENT ADDITIVE business

Products and applications for Grinding aids, chemicals and quality improvers for CEMENT INDUSTRY

MOU signed with European company for Technology and application knowledge

Final agreement will be signed in Jun-July 2010

Projects in Cement Industry

- JK Cements – 22 MW
- Saurashtra Cement – 25 MW
- Jay Kay Cem – 50 MW
- JK White – 7.5 MW
- Grasim Cement * 50 MW
- Ultratech Cement – 25 MW
- Deccan Cement – 18 MW
- Shree Cements * 36 MW
- Madras Cements – 36 MW
- Madras Cements – 40 MW (TN)
- Madras Cements * 36 MW (AP)
- Anamalai (Lafarge) – 40 MW
- ACC (Holcim) – 25 MW
- JK Lakshmi Cements * 36 MW
- JK Lakshmi Cements – 18 MW
- JK Lakshmi Cements – 12 MW (Waste Heat)
- JK Cements – 13.5 MW (Waste Heat)

* Under Execution

Over 1300 MW under EPC

Integrated Green Power Solutions

Value Propositions

1. Energy Assessment and Balancing
2. Project Structuring
3. Optimum configuration and sizing Power Plant
4. Innovative Financial Engineering with
   a) Thermax Equity Participation
   b) Equity Syndication
   c) Debt Syndication – preferably non recourse funding
   d) Complete Financial and Legal documentation
   e) Liaison with financial institution
5. Fast track least cost project execution
6. Operational Excellence through Thermax O&M
7. Least lifetime energy cost

To conclude

- Technology time tested and field proven
- Financially viable
- One decision that takes care of
  - Energy intensity requirements
  - Renewable Portfolio requirements
  - Corporate social obligations
- Harness the power of [illegible] project
  [illegible]

For further details :

Vivek Sarup
Head of Business Development (Power)
Thermax Limited
Ph. 91 20 6641 4314 (D)
Ph. 91 20 2554 1010
Email: vsarup@thermaxindia.com