Industrial Thermal Energy Recovery Conversion and Management

What is the waste heat recovery potential of a steel manufacturing plant?

Rebecca McGinty, Thursday 19th October, ICSEF2018
Research estimates potential waste heat globally is estimated to be 68.2 PWh. Estimated feasible heat recovery potential for industrial sector: 10-20 TWh.

Largest heat loads are in the Iron and Steel, chemicals, aluminum and non-metallic minerals sectors. The landscape is continually changing as technology enablers are developed and processes improved.
Steel Manufacturing Plant
Methodology

Quantifying the potential of the waste heat

1. Site energy audit
2. Temperature, pressure and mass flow rate measured
3. Alternatively energy balances completed
4. Areas ordered in terms of exergy content
5. Highest potential areas reviewed further
Exergy: The achievable recoverable energy available at a given temperature

Carnot Efficiency: Specifies the limits on maximum efficiency any heat engine can obtain

Connected to economic value
Barriers Beyond Thermodynamics

- **Financial Barriers**
  - Cost of installation
  - Capital cost of equipment
  - Cost of sales

- **Lack of Technology**
  - Enablers for low-temperature heat
  - Coatings resistant to acidic condensate
  - Novel uses for energy once harnessed

- **Site obstacles**
  - Non-uniform or interrupted supply
  - Requirement to transport heat for utilisation
  - Risk of disturbance to primary process
  - Contamination and waste management of waste streams
  - Availability of cold sink

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Example A: Underfiring Gas

Gas Temperature $> 200\,^\circ C$ to maintain flows
Gas Temperature $> 215\,^\circ C$ to avoid acidic condensate
Installation costs to lift stack exorbitant

$220\,^\circ C$

$\sim 22\,\text{MW}$
Example B: Turbine outlets

Primary demand is the steam turbines for COG
Resultant LP steam is used downstream for other processes
LP Steam Production > Demand
Venting superheated steam

HP Steam

Steam Turbine

LP Steam

Steam Turbine

Steam Turbine

~133°C

To Plant
What do we need from Technology Enablers?

- Competitive cost
- 2-3 year payback
- Plug and play
- Low maintenance
- Automatic in operation
- Invisible to process
- User-friendly
- Application for recovered energy

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Trilateral Flash Cycle (TFC)

- Thermodynamic Cycle first coined in the mid 1980's
- Expansion starts from liquid rather than gas
- Applicable to low-grade heat sources
- Can generate 2-3 times more power than other conventional cycles
- Historical barriers to commercialisation include excessive pumping power
- Developed beyond state-of-the-art

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Trilateral Flash Cycle (TFC)

• To harness low-grade waste heat
• Working fluid = R1233zd
• Key components;
  – Mag-drive pump
  – GPHE Heater
  – Twin-screw expander
  – PM Generator
  – BPHE Condenser
  – Varied Instrumentation
• Thermal input = 1MW
• Electrical output ~ 100kW
• Plug and play system
I-ThERM: Trilateral Flash Cycle

- Proof of concept rig developed and under test
- Manufacturing strategy underway for demonstration system
- Full testing programme at Spirax Sarco Technology Centre in UK
- Delivery to Steel Manufacturing Site Q2 2019

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Summary

Waste heat audit completed at a Steel Manufacturing Plant in the UK

Identified barriers beyond thermodynamics are extremely influential on success

Developing TFC system to enable the recovery of waste heat

Demonstrate next year with a field trial site at Steel Manufacturing Plant
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