Costain Oil, Gas & Process Limited

Guidelines for Energy Efficiency in the Design of Process Plant

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Reduce Emissions – Reduce Energy Use

• Use low energy process technologies
• Advanced control strategies
• Good housekeeping – insulation, avoid steam leaks, flaring

• All are important but focus on improved energy saving by design
Thermodynamic Fundamentals

• For “Energy” consider “Work”

• Work quantifies both energy load & level e.g. Potential of 1kJ of HP Steam > Potential of 1kJ of MP Steam

• Complements conventional energy saving methods
Processes and Work Consumption

• Work needed for separation, heating, increasing pressure

• Obtain work from compressors, pumps, heaters, refrigeration systems. And process streams themselves

• The less well that available work is exploited, the more is needed to ensure work balance…and energy consumption increases

• “Extra” work can increase capital cost, not just the cost of external energy or power.
Reversibility

• A reversible process consumes minimum work – provides an “ideal”

• In real processes work is “lost” and the work required exceeds the minimum

• Some “lost work” is inevitable

• Reduce the “lost work” that is NOT inevitable – focus on what you can really influence
Process Integration

- Take an overall view of the total process and utility system – the total site

- Consider integrated processes - unit operations perspective does not give energy efficiency

- The interactions between the parts of the overall process and the utilities offer the main opportunities for savings
Why Guidelines? For Pragmatism

- Thermodynamic efficiency is not everything
- Calculations are difficult, data collection is difficult - easy to get lost in the detail and “miss the point”
- How implement the results?
- Use “Guidelines” to identify the best opportunities
Guidelines

• Simple but based on formal thermodynamics (just as “Pinch Technology” is) – that is why they work

• Generate process flowsheet options, ideas and energy targets – look for efficiency improvements

• Process Engineer’s choice on how to use

• Can incorporate real issues e.g. operability, flexibility, physical distance

• Complement Process Engineer’s own experience – guidelines not rules
Identify The Sources Of “Lost Work”

• High (or below ambient) temperature processes
  – Minimise very high temperatures as much as possible
  – “Waste heat” rejected to ambient that could be used for low level heating, absorption refrigeration, combustion air preheat, boiler feed water etc.
  – Use warmest refrigeration level feasible

• High Pressure
  – Don’t waste pressure energy – use the available work for power generation or motive power
Identify The Sources Of “Lost Work”

- Mixing of streams of different composition
  - A major reason for high energy use in multicomponent distillation – “reverse fractionation”

- Conflicting Process Steps
  - Don’t heat up, cool down and then heat up again (or vice versa)
Avoid Large Driving Forces

• Use “site-wide” Pinch Technology to ensure utility levels optimised (for energy and power)

• May mean more or larger heat exchangers, but at what cost? Take an overall perspective

• The energy penalty probably appears elsewhere
  – Need high temperature heat but already used elsewhere
  – Revamp to use available work – often just piping modifications
Minimise Driving Forces

- Split process streams via Pinch Technology
- Optimal operating pressure for energy integration
- Heat pumped distillation
- Intermediate condensers / reboilers
- Optimise steam levels
- Check pressure drops are not excessive
- Multistream heat exchangers for efficiency
Process Integration

- Double Effect Distillation
- Integrated Condenser & Reboiler
- Minimal Temperature Driving Forces

Natural Gas Processing Plant
E.On, Connah’s Quay, North Wales, UK
Minimise Process Steps

• All process steps are wasteful – ensure each one is needed and contributes to overall objective

• Is there another, better way? Is the technology the best from an overall energy perspective?

• Only separate to the required specification (and use better process control to reduce energy)
Natural Gas Liquefaction (Das Island)
APCI Propane Pre-Cooled MR Cycle
Natural Gas Liquefaction

- Over 5 million tonnes per annum – very large, energy intensive @ -160 °C (~ 200 MW)
- Carnot efficiency of ~40%
- Optimise refrigerant composition for low delta T
- Limited opportunity for waste heat utilisation is leading to electric motor drives (VSD)
- Liquid expanders on process and refrigerant
- Minimise sink temperature for refrigerant cooling
- All consistent with “Guidelines”
Process Energy Efficiency

• How energy efficient are your process facilities?

• What is the “ideal” work consumption?

• What is the “pragmatic” work consumption?

• Where are the main “losses” (of work)?

• What opportunities are there for energy saving?
Conclusions

• Guidelines based on Thermodynamic Principles

• Identify the best opportunities to reduce work consumption (even with limited time or resources)

• Identify best use of capital. Even save on capital

• Better, More Energy Efficient Plants