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

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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.

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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

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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

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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

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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)

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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

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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

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Process Integration

Natural Gas Processing Plant
E.On, Connah's Quay,
North Wales, UK

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

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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)

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Natural Gas Liquefaction (Das Island)

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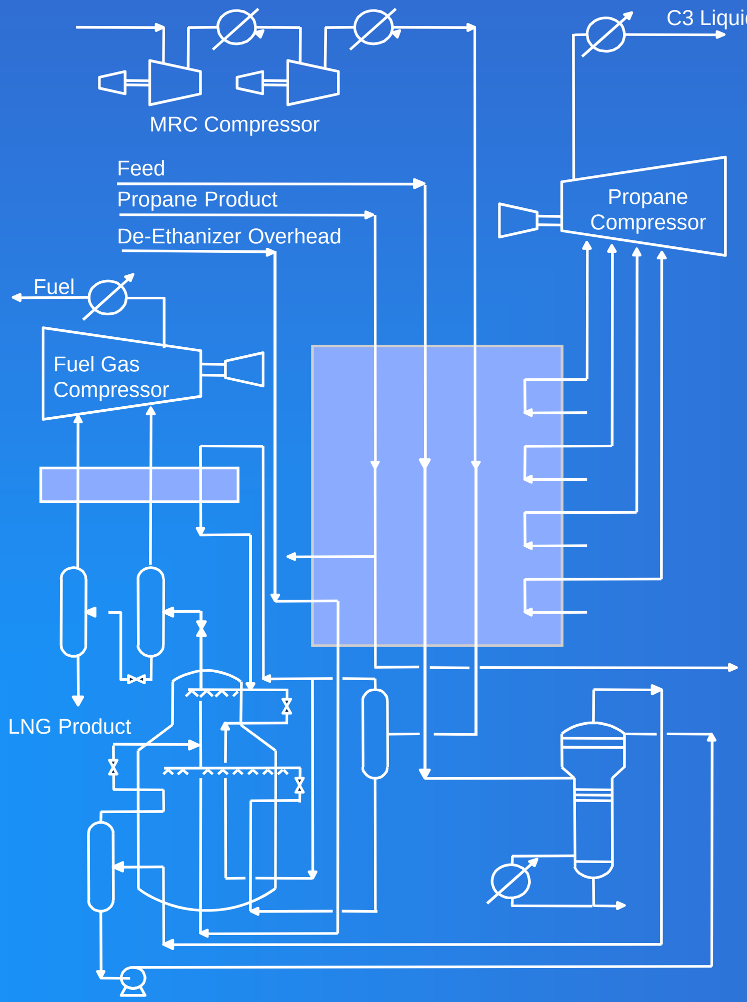
APCI Propane Pre-Cooled MR Cycle



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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
- Mimimise sink temperature for refrigerant cooling
- All consistent with “Guidelines”

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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 ?

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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

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