HyNet Hydrogen Production Plant 1 – Technical Note

EPR RESPONSE - 9eiii - BAT for energy efficiency

Summary

Problem Statement

A quantitative estimate of waste heat, and its thermal level, that could be potentially recovered from the hydrogen compressor to potential users either within the hydrogen plant flow sheet or to external users.

Quantify the potential benefit on the overall energy conversion figure presented in Table 3-4 of the Application Supporting Document, from the potential heat recovery from the hydrogen compressor.

Notes: In responding to this question, we expect you to demonstrate that you have assessed all the possible waste heat recovery options, including the use of an organic Rankine cycles to produce electric power from the heat rejected by the compression systems, when this is technically and economically viable. You should provide a justification as to why technically viable options have been discarded, such us cost-benefit information when applicable, explanation of operational constraints. When certain waste heat recovery options might be investigated and implemented at future stages of the operational life of the proposed plant, you should describe any readiness features implemented at this stage in the design to allow future implementation of the measures identified.

Response

Part 1

The response is discussed in 2 parts. Part 1 is:

A quantitative estimate of waste heat, and its thermal level, that could be potentially recovered from the hydrogen compressor to potential users either within the hydrogen plant flow sheet or to external users.

Quantify the potential benefit on the overall energy conversion figure presented in Table 3-4 of the Application Supporting Document, from the potential heat recovery from the hydrogen compressor.

Part 1 Response

The hydrogen compressor (C102 A/B) is a single stage unit with no interstage cooling and the heat of compression is removed in the Product Cooler (E123) with cooling water. The duty of this exchanger is 2,978kW which could be available for heat integration if there is a suitable cold stream match for heat integration. The options are discussed below.

A cooling optimisation study is planned and the outcome of that will support evaluation of heat integration and waste heat recovery from the Hydrogen Product Cooler. The streams are included below for consideration subject to the study outcome.

1. Boiler Feed Water: Boiler Feed water is at 129.6°C (Stream 705) and will not be a source of cooling for the hydrogen product stream.
2. Demineralised Water heating: Referring to data sheet 5194812-100-45ED-3-0011 for the demineralised water heater, the water stream is heated from 4°C to 120ºC by cooling a syngas stream from ca 135°C to 124°C. This system (demin water heating) is already heat integrated and will not be a source of cooling for the hydrogen product stream.
3. Oxygen from ASU: this stream is heated from 30°C (stream 114) to 210°C (stream 211) in heater E-103 requiring 1200kW of duty. However, from Enquiry 9e, Table 2-4: HPP Utilities states: “It is noted in passing that for safety reasons there will be no integration between the ASU and the wider HPP.” Oxygen from the ASU is not available as a source of cooling for the hydrogen product stream.
4. The NG Feed is heated in electrical heater 10-AAF-H-001A from 5°C to 40°C. The duty of the electrical heater is 789.9kW from data sheet 5194812-000-45ED-4-0037. This stream is a good match and could save electrical import of 789.9kW however it is operated intermittently.

5. NG Feed is also heated in electrical heater 10-AAF-H-002A. The heat duty from data sheet document 5194812-000-45ED-4-0039 reports a duty of 327kW heating natural gas from 4.5°C to 20.5°C however it is operated intermittently.

By way of example, to illustrate potential benefit waste heat recovery – leading to power import savings - on the energy conversion figure in Table 3-4, see Table 1 below. If 1,000kW of power import is reduced this leads to ca 0.3% efficiency saving and if the full heat duty can be recovered as power savings, this results in an efficiency improvement of 0.9%

Table 1. Power import savings impact on efficiency

Electrical Import reduction	Change in efficiency (increase)
kW	%
1000	0.30%
2978	0.90%

In conclusion, there are possibilities for use of the hydrogen product stream for heating colder process streams. This will be looked into at the next phase of engineering in which cooling system optimisation will be evaluated.

Part 2

Notes: In responding to this question, we expect you to demonstrate that you have assessed all the possible waste heat recovery options, including the use of an organic Rankine cycles to produce electric power from the heat rejected by the compression systems, when this is technically and economically viable. You should provide a justification as to why technically viable options have been discarded, such us cost-benefit information when applicable, explanation of operational constraints. When certain waste heat recovery options might be investigated and implemented at future stages of the operational life of the proposed plant, you should describe any readiness features implemented at this stage in the design to allow future implementation of the measures identified.

Part 2 Response

Discussion on Organic Rankin cycles

Organic Rankin Cycle (ORC) technology is similar to a conventional steam turbine, but with a different working fluid. Instead of using water vapor, the ORC system vaporizes an organic fluid – one with a high vapour pressure, low boiling point. This fluid drives a turbine for power generation.

Choice of working fluid is influenced by the factors below:

- Low environmental impact: The fluid should have no ozone depletion potential and low global warming potential (GWP)
- Safety: The fluid should be non-flammable, nontoxic, and non-corrosive
- Thermodynamic properties: The fluid should absorb the low-temperature heat and efficiently convert it to usable energy.

Evaluation during FEED

Potential OPEX Saving identified was estimated at: **£200k - £2.4M (likely max. 1.0 M).** Potential CAPEX addition was estimated at **>10.0 M.**

Reduction in imported power: assuming 15% efficiency for all waste heat over 80°C, could generate 3MW of reductions. If streams over 100°C could give 20% efficiency, estimated reduction falls to 250kW.

The ORC system would add significant complexity and CAPEX due to the points raised below.

- The system would need 2 heat exchangers for every 1 currently (one hot oil, one to atmospheric cooling)
- A hot oil collection header would be required.
- There would be additional compressor complexity for multiple coolers at each stage
- It is noted that ASU vendors have not offered this – see back up info from BOC

- Large additional ORC unit (expected £multi-million additional CAPEX) for a closed Rankine cycle (pumps, HXs, expanders). Refrigerant would be needed for waste heat recovery from low temp waste heat.

In conclusion: The ORC cycle will add substantial operational complexity and is unlikely to be technically and economically feasible.