Heat Integration Potential in Batch Processes Using PinCH 2.0

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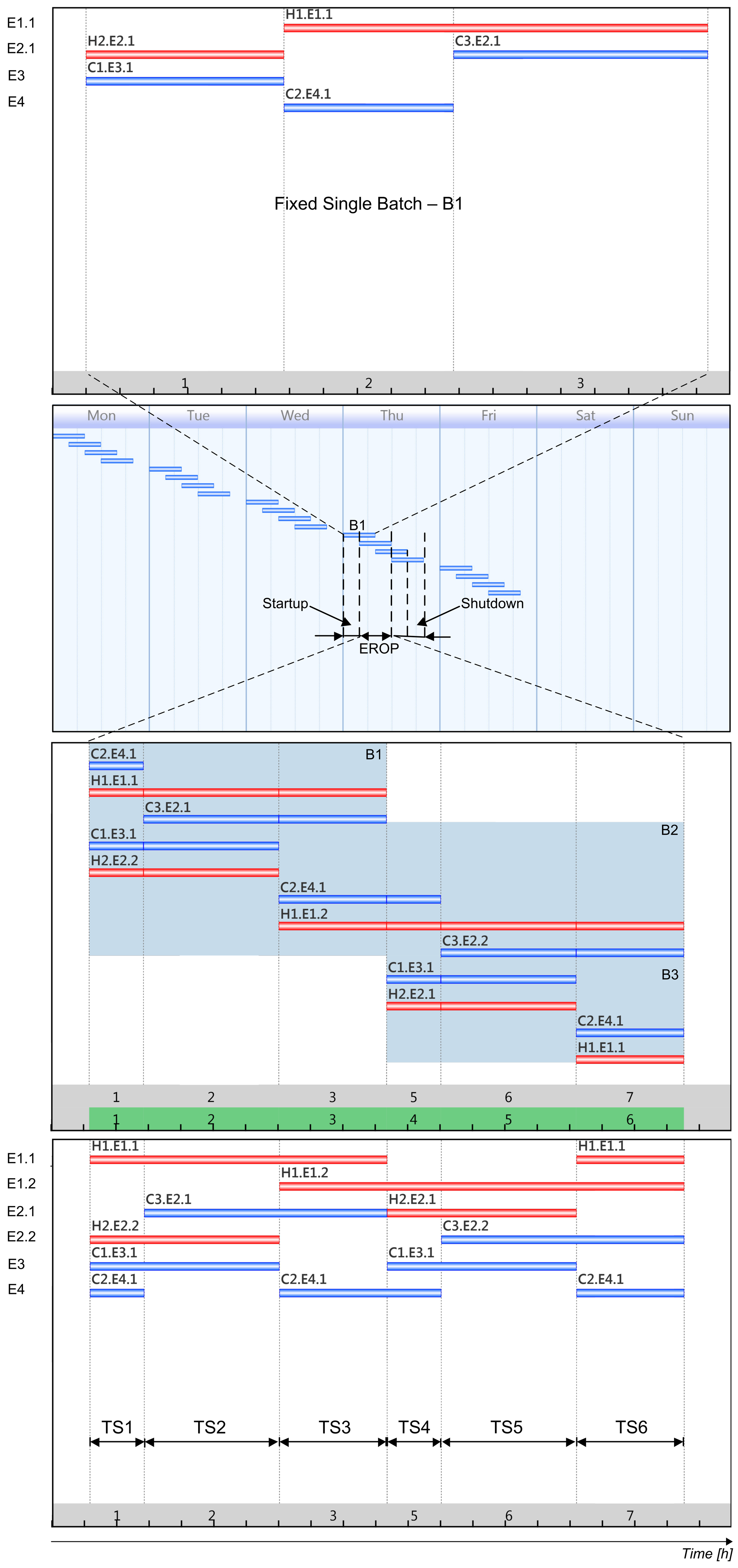
1. Characteristics of Repeated Single Product Batch Processes



Overview:

- Batch process production cycles are often operated in a repeated and overlapped manner to maximize production capacity.
- Pieces of **equipment** can contain multiple streams, e.g. reactor with two non-flowing streams as illustrated by E2.1.
- Within the weekly production cycle, an equipmentwise repeated operation period (EROP) can be identified that consists of time slices (TS) to be used for direct heat integration, not only in the single product batch itself, but also across overlapped batches.

Goals:

- Batch processes and their time dependent nature provide a unique challenge in achieving optimum heat integration.
- Our goals in developing PinCH 2.0 are to provide practical features and graphical tools that an engineer in the practice can use in such batch process optimization.

Fig. 1: Batch example [1] showing the weekly production cycles diagram and the associated equipmentwise repeat operation period (EROP) time slice model formed due to the overlap of the individual batches as calculated in PinCH 2.0.

2. Direct Heat Integration Potential

- An increase in the energy efficiency of batch processes can be achieved through direct heat exchange.
- However, heat exchanger network (HEN) design for minimal investment cost is a challenge due to the time dependency of the streams.

Separate Design Mode

TS 1 TS 2 TS 3

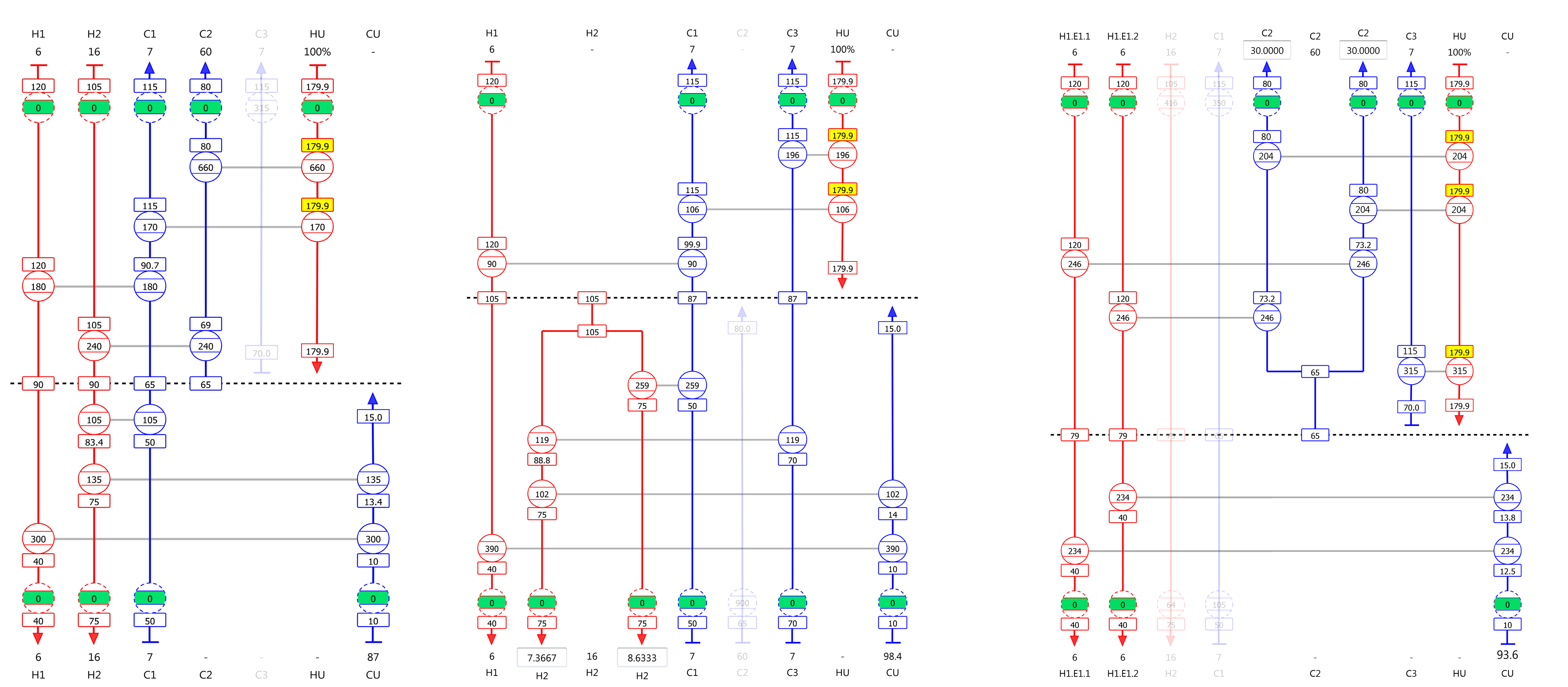


Fig. 2: HEN designs for time slices 1 - 3 assuming separate networks in each time slice (i.e. no reuse of heat exchangers has been accounted for).

3. Batch Supertargeting Optimization

- In order to achieve minimum investment cost for batch processes, it is important to reuse heat exchangers and maximize the **common area** over all the time slices [2].
- Supertargeting optimization to minimize total cost can be done based on **conventional and resequence design** constraints [3].

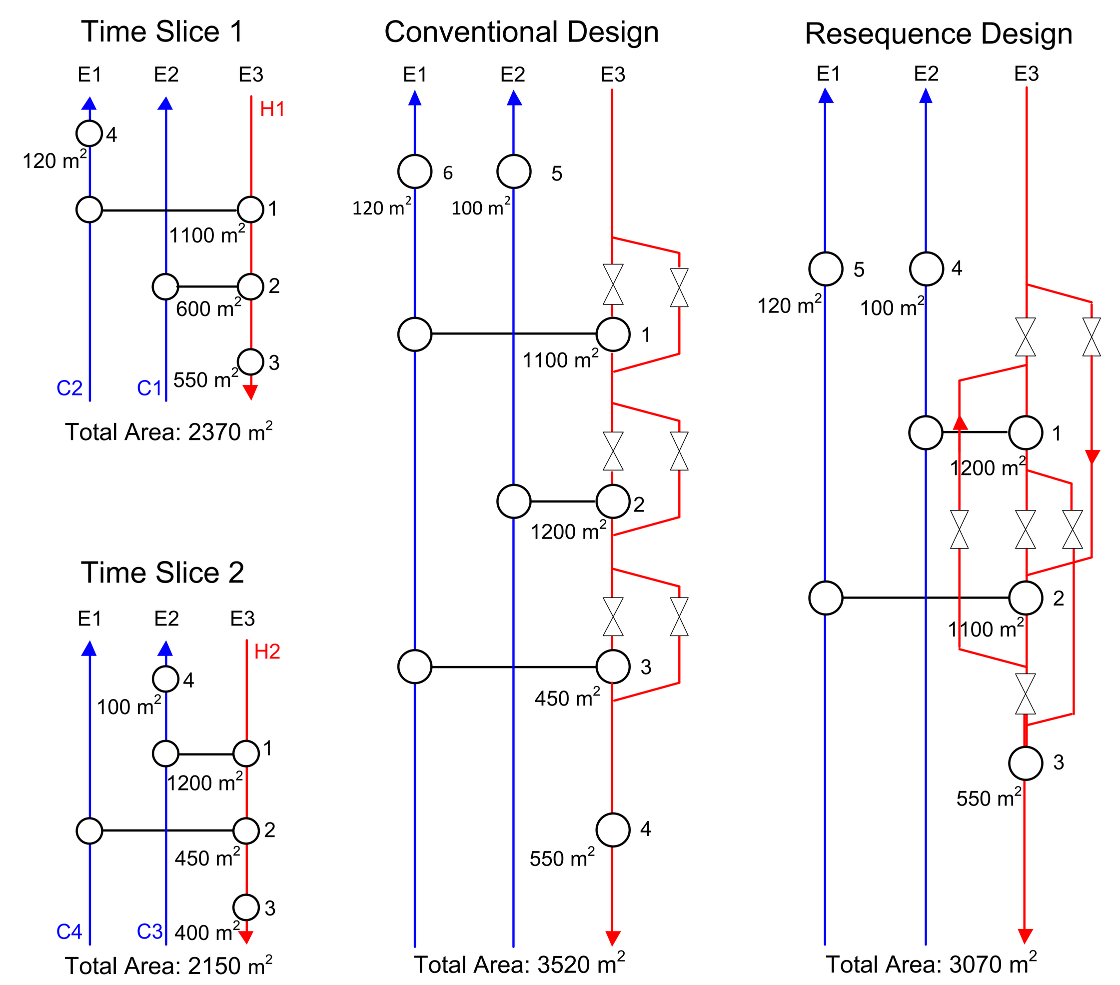


Fig. 3: Simple two time slices example illustrating HEN design for conventional and resequence design type contraints.

4. Batch Supertargeting Results

- The method combines energy and cost optimization with the required flexibility for HEN design.
- The target results aid the practicing engineer in making critical decisions when designing the HEN (in addition to the optimized area matrices and key pinch match matrices).

Design Method	Separate Design	Conventional Design	Resequence Design
Opt. *ΔTmin* **TS1**	25	25	20.5
TS2	18	18	18
TS3	14	14	8
TS4	25	25	20.5
TS5	18	18	18
TS6	14	14	8
Number of Units	40	19	11
Total Area [m²]	440	244.8	231.7
Total Cost [kCHF]	475.7	390.7	345.9

Fig. 4: Optimal ΔTmin values per Time Slice and associated number of units, minimum total HEN area and minimum cost for the shown Batch Example [1].

5. Significance and Future Work

- Supertargeting optimization is applicable to multiple base case operation [3].
- **PinCH 3.0 to include support for indirect heat transfer, i.e. heat storage.**

6. References

[1] R. Kislig: Batch Supertargeting Analysis - Conventional Design and Resequence Design, Hochschule Luzern, Master Thesis, 2012.

[2] P. Krummenacher: Contribution To The Heat Integration Of Batch Processes (With or Without Heat Storage), Thèse No. 2480, École Polytechnique Fédérale de Lausanne, Switzerland, 2001.

[3] P. Jones: Targeting and design of heat exchanger networks under multiple base case operation, PhD Thesis, University of Manchester Institute of Science and Technology (UMIST), U.K., 1991.

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