On-line Heat Exchanger Fouling Mitigation Methods

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Problem Statement

- One of the major unsolved problems in heat exchanger (HEx) design and operation is to prevent the build-up of unwanted deposits on heat exchanger surfaces.
- These deposits impede the performance of the HExs while simultaneously increasing the costs of maintenance and carbon emissions from inefficiencies.
- This research was carried out to fill the gap in literature of the advancements of two newer on-line fouling mitigation methods and pave the way for future research.

Background

- HExs are the components in plants used to heat or cool a process stream.
- They have a wide range of applications which include pasteurizing milk in dairy industries, or heating pressurized water by geothermal steam so that power may be generated via generators.
- Fouling occurs when the surface of the HEx develops a layer of unwanted solid materials.
- Fouling happens via corrosion of metal surfaces, particulates forming, precipitation and chemical reactions resulting in a reduced heat transfer coefficient, higher costs to meet demands at lowered efficiency.

Mitigation Methods

**Thermal shock:** The slow decrease, and sudden increase in flow of a hot stream causes rapid change in temperature gradient which results in cracking of fouling layers from heat transfer surfaces.

**Ultrasound:** The use of ultrasonic waves to avoid/minimize the build up of deposits from heat transfer surfaces.

Studied Techniques

**Ultrasound**

- Figure 4. *Ultrasound waves prevent deposits forming.*

Advantages

- Ultrasound technology could lower the rate of plant shut-down and costs for maintenance.
- The use of ultrasound is known to enhance the heat transfer capability of the exchangers.
- Ultrasound waves prevents the build up of deposits.

Disadvantages

- The technology is achievable in the laboratory scale, but not much advancements have been made for industries.
- The current literature suggest that foulant cannot be fully removed via ultrasonics and mechanical methods still need to be used for complete clean.
- The technique is limited to the type of heat exchangers i.e. only shell-and-tube or double pipe HExs.

Conclusions

- Solving the HEx fouling problem in industries would lower the operational costs as well as plant down-time from repeated maintenance and refurbishments.
- From the recent advancements, it can be argued that the two on-line techniques are close to being implemented in industrial scale with further developments and research.
- One of the more important benefits of fouling removal is minimizing the carbon footprint of every plant from improved efficiency and lowered fuel use.

- The abstract for this research has been submitted to the “23rd Conference on Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction (PRES’20)“ Xian-China.
- References for all figures (*) are available in the report.
Developing a Business Case for the Cultivation of *Ecklonia radiata*

Robbie Maris, Tim Colman, Marie Magnusson

BACKGROUND

Globally, the seaweed industry is growing exponentially (Fig. 1). Domestically, aquaculture contributes $500 million to the NZ economy with a government target of growing this industry to $3 billion by 2035. Seaweed aquaculture is currently non-existent in NZ but could contribute to this goal. From a commercial perspective, a first step in developing domestic seaweed aquaculture is to build a business model around a target species. In this regard, *Ecklonia radiata* (Fig. 2) is a native species that has a diverse range of established applications and is already listed on 148 commercial fishing licenses.

![Figure 1. Global seaweed production](image1.png)

![Figure 2. Live E. radiata](image2.png)

PROJECT AIM

To deliver a business case for the cultivation of *E. radiata* in New Zealand. This involves developing a business model and assessing its economic feasibility.

METHODOLOGY

A business model was developed using the business model canvas. It is a useful framework that lays out a company’s nine core elements. Market research was carried out directly with 30 relevant stakeholders and 16 interviews.

![Figure 3. Final business model canvas](image3.png)

In the final business model canvas (Fig. 3), green notes are relevant to mussel farmers and white for seaweed processors. If the note is in a plain font, it has not been changed. All other notes have arisen as a result of the following scientific method (Fig. 4).

![Figure 4. Initial model created, underlying hypothesis determined, market research carried out, final model established.](image4.png)

ECONOMIC FEASIBILITY RESULTS

<table>
<thead>
<tr>
<th></th>
<th>20 Tons</th>
<th>40 Tons</th>
<th>60 Tons</th>
<th>80 Tons</th>
<th>100 Tons</th>
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<tr>
<td>Revenue ($)</td>
<td>52,786</td>
<td>105,481</td>
<td>158,237</td>
<td>210,983</td>
<td>263,739</td>
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<tr>
<td>Operating Costs ($)</td>
<td>78,327</td>
<td>135,620</td>
<td>182,940</td>
<td>230,260</td>
<td>277,520</td>
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<tr>
<td>Margin (%)</td>
<td>-47.56%</td>
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<td>EBIT (%)</td>
<td>-44,182</td>
<td>-65,428</td>
<td>-85,280</td>
<td>-104,432</td>
<td>-126,747</td>
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<td>Recovery Time (yr)</td>
<td>15.9</td>
<td>8.4</td>
<td>4.4</td>
<td>2.4</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table 1. Key economic indicators for the cultivation of *Ecklonia Radiata*

Using the final business model and revenue estimates, an economic model was created (Table 1). The breakeven production scale is 45 x 100 m longlines. Above this, the model is economically feasible.

RECOMMENDATIONS

- Success requires a broad ecosystem (important to work with MPI to resolve regulatory barriers).
- Begin cultivation trials, progressing to a commercial pilot (Fig. 5).
- Mapping of channel partners and vertical integration opportunities.
- Test assumptions to validate the economic model.

![Commercial seaweed farming](image5.png)

I would like to express my gratitude to both the University of Waikato and PriorityOne for funding this project. I would also like to thank my supervisors Marie and Tim.