Assessment and Design of a Waste Heat Recovery and Energy Conversion System

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**Supervisors:** Dr. Vladimir Mahalec, Elizabet Cruz

**Project Goal:** To design an economically sound automated waste heat recovery and energy conversion system with minimal process interference

**Objectives**
- AMD: Reduce utility costs and lower environmental impact
- Hatch: Step forward for HEROS program

**Approach**
- Recover waste heat and convert to power using Organic Rankine Cycle (ORC) principles
- Simulations modeled for base case, vendor’s system, process variability and optimization

**ORC System for AMD**
- Working fluids selected based on saturation curves
- Power output: 176 kW; Efficiency: 16%
- Vendor’s power output: 130 kW (equivalent power for 99 homes in Ontario)
- Overall layout:
- Process Variability (effects of change in waste heat source parameters):
  - Levelized Cost of Elec.: $0.073/kWh (14% savings)
  - GHG emission reduction: 182 t CO₂ eq./yr

**Optimization**
- Typical ORC efficiencies: 10-18%
- Multi-stage ORC:
  - 2-Stage ORC: 24% efficiency
  - 3-Stage ORC: 30% efficiency

**Risk Assessment**
- Divided into 7 categories
- Major risks moderated:
  - Process interference
  - Worker safety
  - Pollution
  - ORC reliability
  - Space availability

**Process System Design & Operation**

<table>
<thead>
<tr>
<th>Power Output (kW)</th>
<th>Volumetric Flow Rate (m³/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kW</td>
<td>500 kW</td>
</tr>
<tr>
<td>500 kW</td>
<td>1000 kW</td>
</tr>
<tr>
<td>1000 kW</td>
<td>1500 kW</td>
</tr>
<tr>
<td>1500 kW</td>
<td>2000 kW</td>
</tr>
</tbody>
</table>

<p>| Effect of Change in Exhaust Gas Flow Rate and Temperature on Power Output |</p>
<table>
<thead>
<tr>
<th>Effect of Ambient Air Temperature on Condenser Duty</th>
<th>310°C</th>
<th>315°C</th>
<th>320°C</th>
<th>325°C</th>
<th>330°C</th>
<th>335°C</th>
<th>340°C</th>
<th>345°C</th>
<th>350°C</th>
<th>355°C</th>
<th>360°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condenser Duty (kW)</td>
<td>0.50</td>
<td>0.55</td>
<td>0.60</td>
<td>0.65</td>
<td>0.70</td>
<td>0.75</td>
<td>0.80</td>
<td>0.85</td>
<td>0.90</td>
<td>0.95</td>
<td>1.00</td>
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