# Labatt Oland Brewery - Brewhouse Scheduling Optimization

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## Background

Labatt Oland Brewery, Nova Scotia's largest brewery, brews local and global brands across Canada. Weekly schedules are developed to meet demand. Meeting demand can be challenging, especially if downtime is caused by avoidable situations. Suboptimal schedules can lead to unnecessary downtime, inefficient production, and an inability to meet production targets.

**Problem Statement:** The objective was to improve Labatt Oland Brewery's schedule by minimizing production makespan based on brewing targets, whilst standardizing and improving their Excel scheduling tool.

**Project Scope:** Develop an optimized brewhouse schedule by changing scheduling elements and standardizing the scheduling tool.

### Brewhouse Process

**Brewing:** 11 different brand types utilize a sequence of 5 different types of vessels, as shown in Figure 1.


*Figure 1: Brew flow in vessel sequence*

**Fermentation:** 15 fermentation tanks of 4 types based on brew capacity and brand type.

**CIP (Clean in Place):** Process of cleaning the brewhouse kettle and is performed every 16 brews or less, delaying the following brew.

**Scheduling:** Brews are scheduled prior to start of production week. The schedule is manually created based on experience and historical knowledge. Frequent changes are done throughout the production week. Current scheduling tool is shown in Figure 2.

**Brew Schedule**

| Planned final cool in time: | 10-12-20 3:25 AM | Current final cool in time: | | 10-12-20 3:25 AM | | Estimated lost days from plan: | 0:00 | | |
|---|---|---|---|---|---|---|---|---|---|
| First Brew | 1138 | Week Starting: | | 5-Oct | Week Number | 41 / 52 | | | |

| Day | Time | Updated Day | # | Boiler CIP | CC CIP | Mash In Time | Cool In Time | pitch brew | Brew Number | Ferm | Brand | Target Brew Volume | QC Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monday | 4:30 | 5-Oct | 1 | 0 | | 19:00 | 4:30 | | 1138 | 1 | BUD LIGHT RICE | 300 | |
| | | 5-Oct | 2 | 0 | | 0:15 | 9:45 | | 1139 | 1 | BUD LIGHT RICE | 300 | |
| | | 5-Oct | 3 | 0 | | 5:30 | 15:00 | | 1140 | 1 | BUD LIGHT RICE | 300 | |
| | | 5-Oct | 4 | 0 | | 10:45 | 20:15 | | 1141 | 1 | BUD LIGHT RICE | 300 | |
| | | 5-Oct | 5 | 0 | | 17:05 | 23:40 | | 1142 | 2 | BUDWEISER | 300 | |
| Tuesday | | 6-Oct | 6 | 0 | | 20:30 | 3:05 | | 1143 | 2 | BUDWEISER | 300 | |
| | | 6-Oct | 7 | 0 | | 23:55 | 6:30 | | 1144 | 2 | BUDWEISER | 300 | |
| | | 6-Oct | 8 | 0 | | 3:20 | 9:55 | | 1145 | 2 | BUDWEISER | 300 | |
| | | 6-Oct | 9 | 0 | | 4:25 | 12:25 | | 1146 | 6 | BUSCH | 400 | |
| | | 6-Oct | 10 | 0 | | 8:10 | 16:10 | | 1147 | 6 | BUSCH | 400 | |
| | | 6-Oct | 11 | 0 | | 11:55 | 19:55 | | 1148 | 6 | BUSCH | 400 | |
| | | 6-Oct | 12 | 0 | | 16:50 | 23:25 | | 1149 | 3 | BUDWEISER | 300 | |
| Wednesday | | 7-Oct | 13 | 0 | | 20:15 | 2:50 | | 1150 | 3 | BUDWEISER | 300 | |
| | | 7-Oct | 14 | 0 | | 23:40 | 6:15 | | 1151 | 3 | BUDWEISER | 300 | |
| | | 7-Oct | 15 | 0 | | 3:05 | 9:40 | | 1152 | 3 | BUDWEISER | 300 | |

*Figure 2: Current Brewhouse Scheduling Tool*

## Results

**90** — Average minutes of production time saved per week.

**3,300** — Amount of extra hL of brews can be manufactured a year.

**1,000,000** — Beer cans worth of extra volume available to be produced per year.

## Methodologies

### 5 Why Analysis

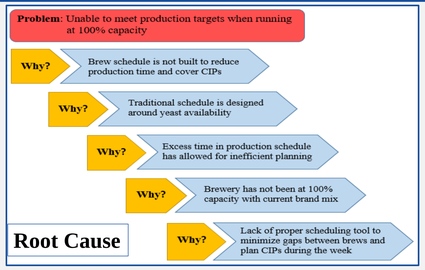


*Figure 3: 5 Why Analysis*

### Data Analysis

**Collection:** Vessel cycle and transition time data was collected using the client's Remote HMI system and previous brewhouse schedules.

**Cleansing:** Box plot was used to remove any outliers in the data, as shown in Figure 4.

**Application:** Delays are used in the algorithm to determine the minimum optimal makespan.

**Analysis:** Equations were created to determine the minimum delay between brews.

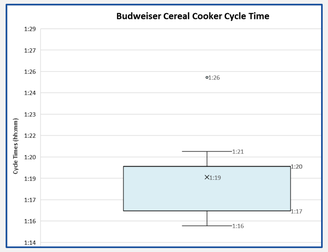


*Figure 4: Boxplot Data Cleansing*

### Mathematical Model & Algorithm

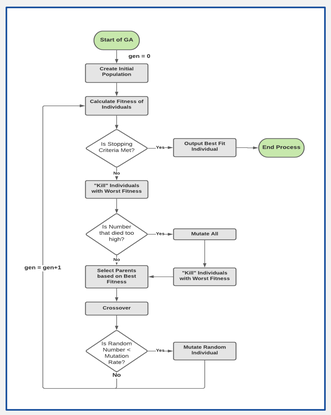


*Figure 5: Genetic Algorithm Process Map*

**Mathematical Model:** The problem was formulated as a No-Wait Permutation Flow Shop Problem (NWPFSP) with the objective to minimize the total makespan. Batching, CIP allocation, and fermenter availability were formulated within the model.

**Algorithm:** Based on literature review a genetic algorithm was developed to solve the model, as shown in Figure 5.

### Implementation

The client tested 3 versions of the tool to examine the reliability and ease of use of the model and gather feedback to implement improvements. A user guide was provided as a standard procedure to utilize the tool and provide training.

### Future Improvements

- Expand scheduling time horizon.
- Incorporate other types of vessel CIPs in the scheduling tool.
- Incorporate propagation into scheduling tool.

## Details of Interface Design

**Data Input**

| Brand | Number of brews | Number of brews yet to be assigned |
|---|---|---|
| BUDWEISER | 6 | 0 |
| BUSCH | 9 | 0 |
| KEITH'S IPA | 0 | 0 |
| 275hl KRAUSEN | 0 | 0 |
| SCHOONER | 1 | 0 |
| ROLLING ROCK | 4 | 0 |
| BLUE MSB | 2 | 0 |
| MICHELOB ULTRA | 3 | 0 |
| BUD LIGHT RICE | 16 | 0 |
| BUSCH CC | 0 | 0 |
| Prop Keiths | 0 | 0 |
| Total | 41 | |

| | |
|---|---|
| Start Time | 2:45 AM |
| Start Date | 2021-03-27 |
| Week of | 13 |
| Brew Number | 23 |
| Propagation Fermenter | N/A |

| Ferm. | Batch Size | Brand |
|---|---|---|
| F1 | 3 | BUSCH |
| F2 | 2 | BLUE MSB |
| F13 | 1 | SCHOONER |
| F10 | 3 | MICHELOB ULTRA |
| F16 | 6 | BUDWEISER |
| F4 | 4 | BUD LIGHT RICE |
| F5 | 4 | BUD LIGHT RICE |
| F6 | 4 | BUD LIGHT RICE |
| F12 | 4 | BUD LIGHT RICE |
| F11 | 4 | ROLLING ROCK |
| F7 | 3 | BUSCH |
| F3 | 3 | BUSCH |

| Fermenter | Time Available |
|---|---|
| F1 | 03/16/2021 |
| F2 | 03/17/2021 |
| F3 | 03/16/2021 |
| F4 | 03/17/2021 |
| F5 | 03/15/2021 |
| F6 | 03/06/2021 |
| F7 | 03/07/2021 |
| F8 | 03/08/2021 |
| F9 | 03/09/2021 |
| F10 | 03/16/2021 |
| F11 | 03/11/2021 |
| F12 | 03/12/2021 |
| F13 | 03/13/2021 |
| F14 | 03/14/2021 |
| F16 | 03/15/2021 |

Starting Time 03/27/2021 02:45

*Figure 6: Input Page*

**Input**

Users input key information such as, number of brews of each brand type, start time and date, and fermenter allocation and availability time, as shown in Figure 6.

**Logic**

The code reads in the inputs and the genetic algorithm generates the best solution in an average of 16 mins.

**Output**

Users press the "Generate Solution" button to output brand order of sequence. The schedule page is then populated with predicted start and end times with other brand specific data, as shown in Figure 7.

**Brew Schedule**

Restore Previous Solution | Export Schedule

| Start Time | Start Date | Week Number | First Brew Number | Predicted End Time |
|---|---|---|---|---|
| 2:45 AM | 2021-03-27 | 13/52 | 23 | 04/03/2021 03:00 PM |

| Date | Sequence # | Brew Number | Brand | Fermenter | Comments | Target Brew Volume | Air/O2 | Start Time | Actual Start Time | Actual Start Date | Time Difference (mins) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2021-03-27 | 1 | 23 | SCHOONER | F13 | | 330 | O2 | 2:45 AM | 2:55 AM | 2021-03-27 | 10 |
| 2021-03-27 | 2 | 24 | BUD LIGHT RICE | F4 | | 300 | Air | 3:25 AM | 3:38 AM | 2021-03-27 | 13 |
| 2021-03-27 | 3 | 25 | BUD LIGHT RICE | F4 | | 300 | Air | 8:28 AM | 8:28 AM | 2021-03-27 | 0 |
| 2021-03-27 | 4 | 26 | BUD LIGHT RICE | F4 | | 300 | Air | 1:18 PM | 1:17 PM | 2021-03-27 | -1 |
| 2021-03-27 | 5 | 27 | BUD LIGHT RICE | F4 | | 300 | Air | 6:07 PM | 6:09 PM | 2021-03-27 | 2 |
| 2021-03-28 | 6 | 28 | ROLLING ROCK | F11 | | 310 | Air | 2:44 AM | 2:59 AM | 2021-03-28 | 15 |
| 2021-03-28 | 7 | 29 | ROLLING ROCK | F11 | | 310 | Air | 5:46 AM | 6:06 AM | 2021-03-28 | 20 |
| 2021-03-28 | 8 | 30 | ROLLING ROCK | F11 | | 310 | Air | 8:53 AM | 9:22 AM | 2021-03-28 | 29 |
| 2021-03-28 | 9 | 31 | ROLLING ROCK | F11 | | 310 | Air | 12:09 PM | | | |
| 2021-03-28 | 10 | 32 | BUD LIGHT RICE | F12 | | 300 | Air | 12:29 PM | | | |
| 2021-03-28 | 11 | 33 | BUD LIGHT RICE | F12 | | 300 | Air | 5:19 PM | | | |
| 2021-03-28 | 12 | 34 | BUD LIGHT RICE | F12 | | 300 | Air | 10:09 PM | | | |
| 2021-03-29 | - | - | Kettle CIP | N/A | | - | - | 6:59 AM | | | |
| 2021-03-29 | 13 | 35 | BUD LIGHT RICE | F12 | | 300 | Air | 4:00 AM | | | |
| 2021-03-29 | 14 | 36 | BUSCH | F7 | | 400 | Air | 10:23 AM | | | |
| 2021-03-29 | 15 | 37 | BUSCH | F7 | | 400 | Air | 2:43 PM | | | |
| 2021-03-29 | 16 | 38 | BUSCH | F7 | | 400 | Air | 7:03 PM | | | |
| 2021-03-29 | 17 | 39 | BUD LIGHT RICE | F5 | | 300 | Air | 10:23 PM | | | |

*Figure 7: Schedule Page*

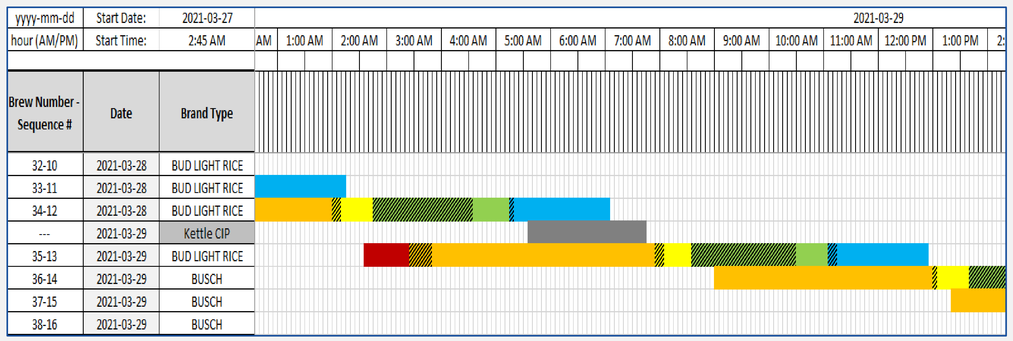


*Figure 8: Gantt Chart*

A Gantt chart was created to display when each brew passes through each vessel, as shown in Figure 8. This allows the users to see when there are time gaps in the process, to potentially add vessel CIPs.

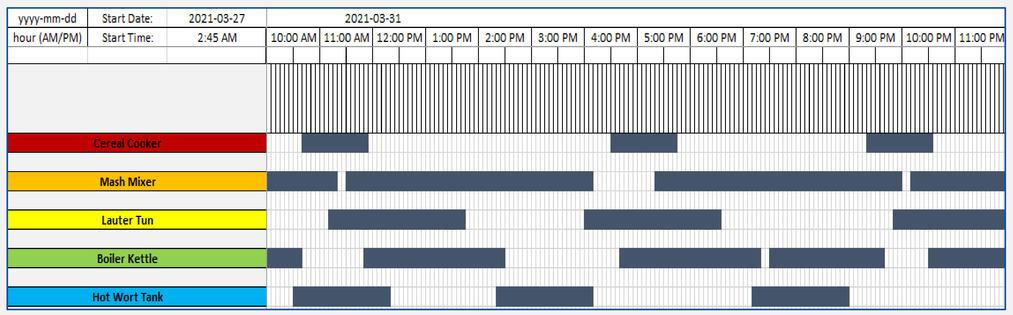


*Figure 9: Vessel Gantt Chart*

The Vessel Gantt chart, as shown in Figure 9, provides a visual method to find time gaps between vessels and show vessel utilization.

## Acknowledgements

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