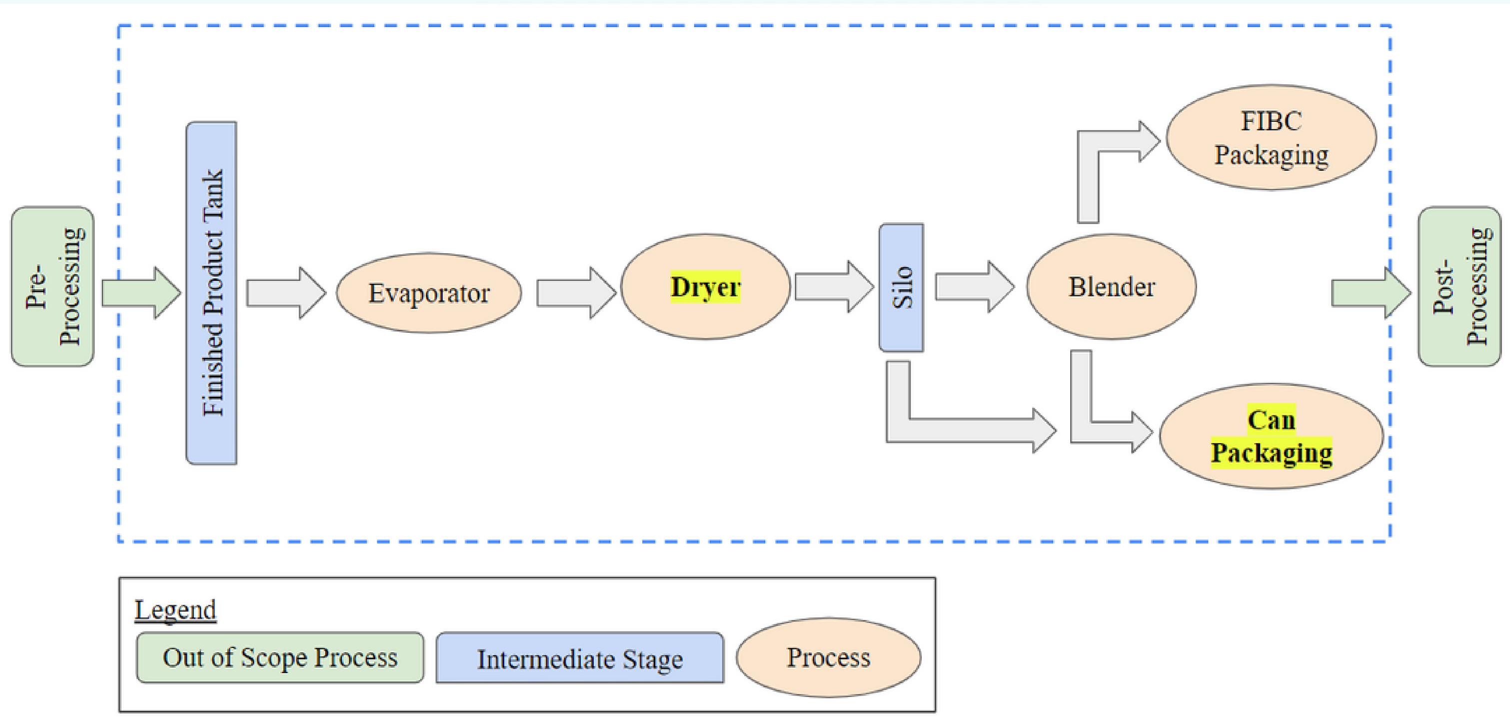
Abbott Nutrition Plant Scheduling Optimization

IE3100R System Design Project / Department of Industrial Systems Engineering and Management
Team (Abbott Group 2): Hans Sebastian Mulyawan / Ong Jing Xin / Tan Jia Jing / Yang Jing
Academic Advisor: Professor Chew Ek Peng
Abbott Supervisor: Mr. Lee Hwee Huat, Mr. Lester Eng

Introduction

Abbott is a global leader in the healthcare and nutrition industry.

Plant Process Flow



Objective: Optimize the production schedule by
- Identify and mitigating the bottleneck in the current production process
- Maximizing plant coupled capacity by reducing Changeover (CO) time

***Plant Coupled Capacity:** Dryer Capacity * Blockage Factor (in MM lbs)

Data

- Forecasted production demand data for 2026 and 2027
- Demand refers to the production amount and frequency of Product Labels
- 1 Product Label can consist of >1 products with different production frequencies
- Demand for 1 year is inputted into Abbott's simulation model to obtain results

Project Milestones

Automation → Exploratory Approach → Heuristic Approach

Automation of Scheduling Process

Translation of current manual scheduling process into a 3-Step Approach with 3 Excel VBA Macros.

1. **Balancing** - Balance irregular production frequencies within each product label for each month to spread production uniformly across the year in a fixed manner
2. **Wheel** - Generate schedule entries based on the monthly schedule
3. **Preparation** - Generate discrete entries as input for simulation model

Reduces manpower and time required for manual schedule generation by at least 10 man-hours, more efficient usage of human resource

Exploratory Approach

Exploration and Analysis of impact of sequencing by various product characteristics on coupled capacity, using an iterative design process.

Design 1: Group by Product Family, sequence by Flavor within group
Design 2: Group by Product Family + Flavor, sequence by Flavor within group
Design 3: Group by Product Family + Flavor + Pack Type
Design 4: Group by Product Family + Flavor + Pack Type, intra-product sequence by Pack Type

Findings

Design 4 is the most effective in improving coupled capacity.

Heuristic Approach

Application of computational algorithms to optimize production schedule using Python.

1. Greedy Algorithm

Selects the best option available at each step.

2. Asymmetric Traveling Salesman Problem (ATSP)

Uses Held-Karp Algorithm, a dynamic programming approach that breaks the problem down into smaller sub-problems.

3. Vehicle Routing Problem (VRP)

Finds best routes (Schedule) for multiple vehicles (Months) visiting a set of locations (Product Labels).
2 Objective Functions:
1. Minimize the total CO time of the month with the greatest CO time
2. Minimize the total CO time across given months

Comparison of Heuristic Approaches

Approach	Advantages	Disadvantages
1. Greedy Algorithm	• Most intuitive • Computationally inexpensive • Generally more efficient than dynamic programming approaches	• May arrive at a local optimal point instead of a global optimal point • Only 1 month of demand data per run
2. ATSP	• Dynamic programming, guarantees a global optimal solution	• Long runtime for large input • Only 1 month of demand data per run
3. VRP	• Able to optimize schedule across multiple months in a single run • Able to distribute Product Labels more evenly across months	• May arrive at a local optimal point instead of a global optimal point • Long runtime for large inputs

Production schedule of a full year obtained from each approach can be enhanced further using the best design from Heuristics milestone

Results

Approach	Total CO across 12 months (min)
1	25020
2	24300
3 (Obj Fn 1)	21360
3 (Obj Fn 2)	20220

Comparing results of heuristic approaches before and after adding Design 4 of Exploratory Approach

Approach	Coupled Capacity	Coupled Capacity (with Design 4)
1	55.37	55.44
2	55.77	55.83
3 (Obj Fn 1)	55.16	55.16
3 (Obj Fn 2)	55.76	55.63

Findings

- Although Approach 3 attains best (lowest) total CO, Approach 2 achieved the best Coupled Capacity.
- Incorporating Design 4 leads to a better **Coupled Capacity** for all heuristic approaches except VRP.
- Lower CO time does not always translate to the improvement in **Coupled Capacity**.
- The heuristic approach helps to reduce man-hours required for manual production scheduling by about 2-3 weeks per production site.

Recommendations

Based on our findings, the recommended approaches are to
1. Apply VRP prior to balancing the schedule
2. Apply Greedy or ATSP after balancing the schedule

Conclusion

The automation tools and optimization methods covered in this project were developed and explored to improve operational efficiency, and can be applied to Abbott's other production plants with similar processes.

Future Improvements

Milestone 1: Explore alternative algorithms for Balancing Macro that can optimize the production schedule while adding or removing products
Milestone 2: Explore grouping and sequencing using other product characteristics for more insights
Milestone 3: Extend algorithm from per-month optimization to all 12 months' schedule to attain more optimal solution