Increasing Plant Productivity by Improving the Current Scheduling Process

Team: Dasher Smith (PM), Andrew Burroughs, Elisa Daniel, Oscar Guzman, Joe Thongsavath

Industry Partners: Marc Schwartz and Craig Short

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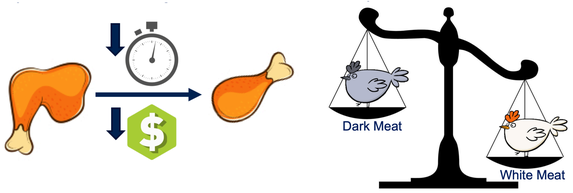
Project Objective

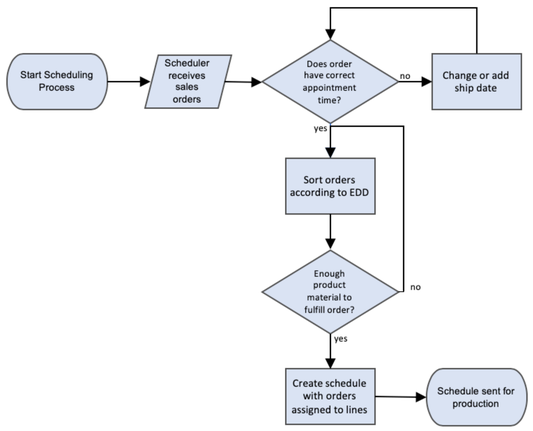
The purpose of our project is to help Tyson Foods increase production productivity in their Shelbyville, Tennessee chicken tray packing plant. Due to the nature of the current scheduling process, the plant yields a higher number of changeovers and experiences an imbalance of production across all packaging lines leading to increased idle time and non-value-added activities. Our objectives include minimizing line imbalance, changeover time, and changeover cost.

1. Minimize Changeover Time & Cost **2. Minimize Line Imbalance**



Current Process

The current scheduling process utilizes an earliest due date method, and the scheduler primarily focuses on having orders en route to customers on time and filling truck trailers with product.



Line imbalance, changeover time, and changeover cost currently aren't considered while scheduling. We believe if orders of like tray sizes are grouped together while scheduling, many 4 minute changeovers may be reduced to 1 minute changeovers. With our optimization model and decision support tool, we attempt to accomplish our objectives by reducing the number of 4 minute changeovers and achieving a more balanced machine utilization rate across the 19 packaging lines.

Changeover Qualifications

Tray Change	Part Change	Film Change	
X		X	4 minute changeover
X	X	X	
X		X	
X	X	X	
	X		1 minute changeover
		X	
	X	X	

Optimization Model

A mixed integer program was written in AMPL with an objective of minimizing total changeover time for packaging lines. In order to meet the objective of balancing production on the packaging lines, a constraint was implemented to ensure the number of whole birds scheduled across all packaging lines are within the specified lower and upper bounds.

Objective: Minimize total changeover time for all packaging lines

$$min \sum_{l \in C} \sum_{i \in O^l} \sum_{j \in O^l} \sum_{k \in K^l} S_{i,j} * X_{i,j,k} \quad (1)$$

Subject to:

Ensures we do not schedule more orders than we have supply for

$$\sum_{l \in C} \sum_{i \in O^l} \sum_{k \in K^l} W_i * Y_{i,k} \leq W\_max \quad (2)$$

Ensures we do not exceed packaging line capacity

$$\sum_{i \in O^l} P_i * Y_{i,k} \leq P_k \qquad \forall\, l \in C, \forall\, k \in K^l \quad (3)$$

$$\sum_{k \in K^l} Y_{i,k} = 1 \qquad \forall\, l \in C, \forall\, i \in O^l \quad (4)$$

$$\sum_{j \in O^l} X_{i,j,k} \leq Y_{i,k} \qquad \forall\, l \in C, \forall\, i \in O^l, \forall\, k \in k^l \quad (5)$$

$$\sum_{i \in O^l} Z_{i,k,s+1} \leq \sum_{i \in O^l} Z_{iks} \qquad \forall\, l \in C, \forall\, k^l, s = 1, \dots, N_l - 1 \quad (6)$$

$$Z_{i,k,s} + Z_{j,k,s+1} \leq 1 + X_{i,j,k} \quad \forall\, l \in C, \forall\, k^l, s = 1, \dots, N_l - 1, \forall\, (i,j) \in O^l \mid (i \neq k) \quad (7)$$

$$\sum_{k \in K^l} \sum_{s \in 1..N_l} Z_{i,k,s} = 1 \qquad \forall\, l \in C, \forall\, i \in O^l \quad (8)$$

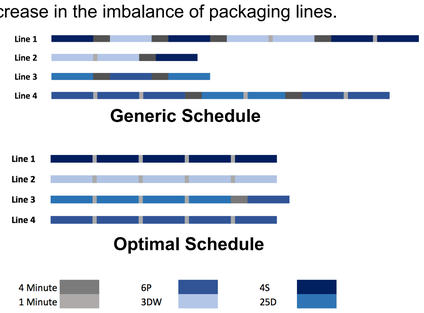
$$\sum_{i \in O^l} z_{i,k,s} \leq \sum_{i \in O^l} y_{i,k} \qquad \forall\, l \in C, \forall\, k \in K^l, s \in 1..N_l \quad (9)$$

$$\sum_{s \in 1 \text{ to } N_l} z_{i,k,s} = \sum_{s \in 1 \text{ to } N_l} y_{i,k} \qquad \forall\, l \in C\, \forall\, k \in K^l, i \in O^l \quad (10)$$

Enforces the number of whole birds scheduled for each line to be within the LB and UB

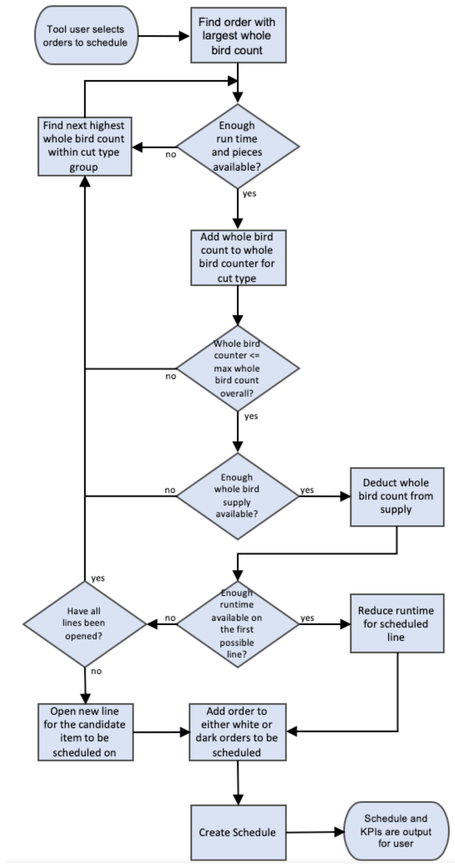
$$\frac{\sum W_i}{19} \leq \sum_{i \in O^l} Y_{i,k} * W_i \leq \mathrm{B} \qquad \forall\, l \in C, \forall\, j \in K^l \quad (11)$$

Using a small sample set of orders, the results of the mixed integer program shows a decrease in the number of 4 minute changeovers and a decrease in the imbalance of packaging lines.



Decision Support Tool

The tool applies sequential optimization techniques to allocate orders using a variation of a bin packing heuristic and then sequences the orders by grouping like tray sizes together to reduce changeover time. The basic logic performed within VBA is illustrated below.



The tool provides the user a schedule of what orders are to be ran on each of the 19 tray packaging lines. The sample output is provided below.

White Line 1

Order	SKU	Run Time
1	102515-0929	156.0
2	102515-0929	156.0
3	102515-0929	154.5
4	102520-0929	9.4
5	601946-0929	3.4
6	002871-0929	1.3
7	601946-0929	0.9

White Line 10

Order	SKU	Run Time
1	102515-0929	105.0
2	102515-0929	105.0
3	702946-3504	102.9
4	702946-3504	77.1
5	703946-0417	44.7
6	703946-0417	36.0
7	601946-0929	5.1
8	603871-0027	3.4
9	601829-0929	1.0

Dark Line 1

Order	SKU	Run Time
1	101782-0929	4.29
2	101782-0929	3.43
3	102760-0929	46.62
4	102751-0929	21.28
5	102755-0929	19.80
6	106755-0929	18.00
7	102760-0929	40.32
8	106760-0929	40.32
9	102755-0929	12.60

Dark Line 9

Order	SKU	Run Time
1	603872-0027	60.00
2	002872-0929	54.86
3	002872-0929	48.69
4	002873-0929	28.11
5	603872-0027	44.57
6	002873-0929	19.54

Results

Three key performance measures are presented to the user based on the created schedule.

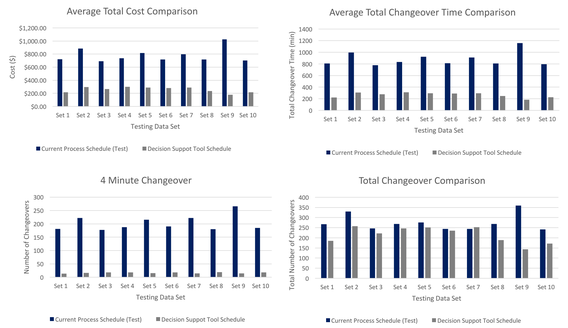
Changeovers	#	Minutes	Cost
Total Changeovers	193	265	$ 253.00
4 min Changeovers	24	96	$ 84.00
1 min Changeovers	169	169	$ 169.00

Line	Utilization (%)	Changeovers	Cost
White Line 1	96.9%	9	$ 14.00
White Line 2	95.4%	19	$ 21.50
White Line 3	95.6%	18	$ 20.50
White Line 4	95.8%	14	$ 19.00
White Line 5	97.1%	8	$ 13.00
White Line 6	90.6%	27	$ 42.00
White Line 7	97.3%	7	$ 12.00
White Line 8	91.3%	2	$ 2.00
White Line 9	0.0%	0	$ -
White Line 10	0.0%	0	$ -

Line	Utilization (%)	Changeovers	Cost
Dark Line 1	93.3%	23	$ 30.50
Dark Line 2	92.9%	31	$ 33.50
Dark Line 3	92.3%	27	$ 34.50
Dark Line 4	24.6%	8	$ 10.50
Dark Line 5	0.0%	0	$ -
Dark Line 6	0.0%	0	$ -
Dark Line 7	0.0%	0	$ -
Dark Line 8	0.0%	0	$ -
Dark Line 9	0.0%	0	$ -

Impact

To assess the impact of our decision support tool on the current scheduling process, 10 sets of testing data were created and used to schedule orders according to the current process. The results of these schedules are compared to the schedules output by the decision support tool and are shown below.



The logic implemented in our decision support tool helps to significantly reduce the total changeover time and cost resulting from a production schedule.

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