webindustries

Georgia Tech | ISyE
H. Milton Stewart School of Industrial and Systems Engineering

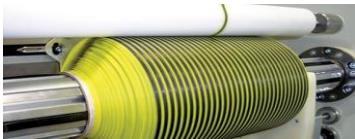# Cost Minimization Through Manufacturing Scheduling

Haval Amedi   Suyoun Choi   Camille George   Mallory Herrmann   Jin Soo Kim   Maryam Moshrefi   Nicholas She
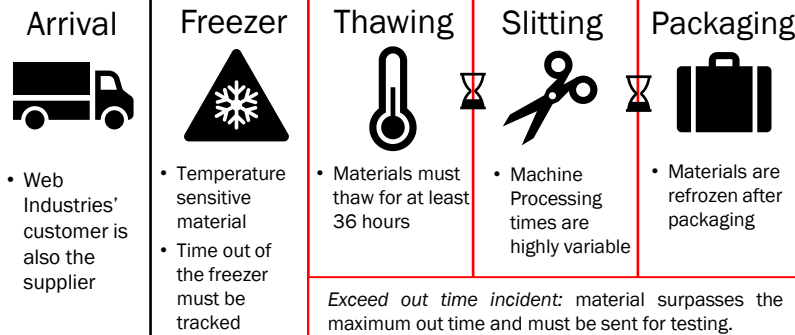
Overview

- Suwanee facility dedicated to precision slitting of carbon fiber composite materials
- Used in the construction of aircraft
- Subject to strict regulations due to the nature of the aerospace industry

Spool of carbon fiber composite material

System

Arrival
- Web Industries' customer is also the supplier

Freezer
- Temperature sensitive material
- Time out of the freezer must be tracked

Thawing
- Materials must thaw for at least 36 hours

Slitting
- Machine Processing times are highly variable

Packaging
- Materials are refrozen after packaging

Exceed out time incident: material surpasses the maximum out time and must be sent for testing.

Opportunity

Minimize cost through improved scheduling

Unplanned Downtime
- Processing times are highly variable.
- When processing times vary, Web Industries incurs costs due to down time and out time.
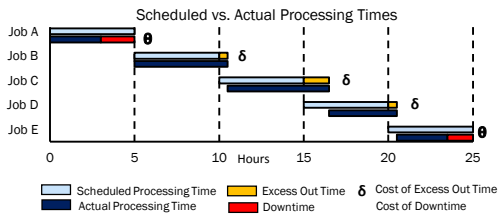- Recalculate pull times to balance the trade-off.

Planned Downtime
- Switching between work orders requires a set-up.
- Currently ordered by earliest due date.
- Order jobs to minimize set-up costs while maintaining on-time job completion.

Reducing Unplanned Downtime

Objective: Calculate new pull intervals (p*) to minimize cost by balancing the trade off between downtime and out time.

Quantifying Costs

X: Random variable of processing time with distribution F
p: Allotted processing time

Scheduled vs. Actual Processing Times

Scheduled Processing Time	Excess Out Time (δ Cost of Excess Out Time)
Actual Processing Time	Downtime (Cost of Downtime)

$$Total\ Cost = \theta \sum_i Downtime_i + \delta \sum_i Out\ Time_i$$

Newsvendor Formulation

p* is calculated for each of the 12 distributions

Value of Tardiness
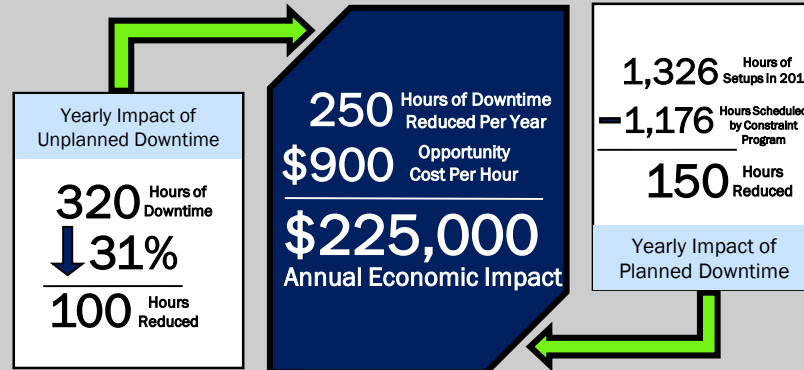$$\delta = \frac{\$15,000}{72-36-E[X]\ Hours}$$

Value of Earliness
$$\theta = \$300\ /\ Hour$$

$$p^* = F^{-1}\left(\frac{\delta}{\theta + \delta}\right)$$

Value

Yearly Impact of Unplanned Downtime

320 Hours of Downtime
↓ 31%
100 Hours Reduced

250 Hours of Downtime Reduced Per Year
$900 Opportunity Cost Per Hour
$225,000 Annual Economic Impact

1,326 Hours of Setups in 2018
− 1,176 Hours Scheduled by Constraint Program
150 Hours Reduced

Yearly Impact of Planned Downtime

Multifunctional Scheduling Tool

Inputs
1. List of work orders with due dates.
2. Cost of *out time* (δ)
3. Cost of *downtime* (θ)

Outputs
1. Order of jobs
2. Required set-ups
3. Scheduled pull time of each job

Reducing Planned Downtime

Objective: Formulate a constraint program that minimizes the length of set-ups required between work orders.
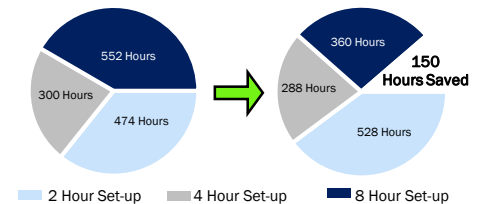
Formulation

1. **Parameters**
   - P_i = processing time of job i
   - C_{ij} = time penalty of going from job i to job j
   - D_i = due date of job I

2. **Decision Variables**
   - B_i = start time of job i
   - E_i = end time of job i
   - $A_{ij} = \begin{cases} 1 & \text{if transitioning from job i to j} \\ 0 & \text{otherwise} \end{cases}$

3. **Objective:** minimize makespan
   - $min[(max(E_i)]$

4. **Constraints:**
   - Subject to setup matrix and system constraints.

Ordered Schedule that:
1. Minimizes Makespan
2. Minimizes Set-up Time

Results

552 Hours
300 Hours
474 Hours

360 Hours
288 Hours
528 Hours
150 Hours Saved

2 Hour Set-up   4 Hour Set-up   8 Hour Set-up