UMNL Scheduling & Inventory Optimization

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Background

TE Connectivity designs & manufactures connectivity and sensor parts. The Automation Manufacturing Technology team is looking to minimize total inventory and production costs of their Universal Mate-n-Lock manufacturing processes.

Problem Statement

Connector assembly machine schedules do not include C segment (low volume) parts, and as a result the process is not optimal.

Current State

Machines 1455 and 1456 are running 24/7, and the production is separated by volume into three product segments--A, B, and C.

Forecast
20% overestimation
32% parts within +/- 10% actual demand

Scheduling (Machines 1455 & 1456)
1455 Utilization ~75%
1456 Utilization ~50%

Objectives

- Improve demand forecasts based on historic volumes
- Recommend an optimized sequence for scheduling
- Recommend minimum order quantity for C segment parts

Assumptions

1. Historical sales data is accurate
2. Inventory cost is minimal, but not negligible
3. Products are held in inventory for a finite duration
4. C segment products are only produced when they are ordered

Constraints

1. Limited historical data may hinder the accuracy of the forecast
2. Time available for changeovers cannot exceed current operator availibility
3. Finite machine operating time - optimized schedule will be constrained to hours available in a workweek

Data Input

Historic Purchase Order Data
- **PN:** unique part number
- **Request Date:** order number with customer request date
- **Shipment Quantity:** monthly demand volume

Scheduling Data
- **Part Description:** housing, terminal, segment, part features, # of positions
- **Sequence:** production sequence
- **Standard Rate:** cycle time
- **Setup Time:** changeover/setup time
- **Lot Size:** TE current lot size

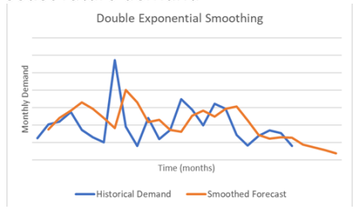
Data Restructuring

1. Analyze Current Schedule and Order History
2. Ingest Historic PO Data
3. Aggregate by PN & Order Month
4. Remove duplicate purchase orders

Forecast

Predictive Methodology
- Exponential Smoothing Models [1]
  a. Double Exponential
  b. Additive Holt-Winters
  c. Extended Holt-Winters
- Low Volume/C Segment Forecast

What is Exponential Smoothing?
Technique for smoothing time series data (i.e. the historic shipment quantities) to forecast future demand



Why use a forecast?
Forecasting allows for
- Predicting demand several months into the future
- Determining optimized scheduling based on required production quantities

Forecast Results

- One month forecast is more accurate for A & B segments.
- Two month forecast is as accurate for A and more accurate for B.
- C segment forecast is less accurate but more stable.

Scheduling

Scheduling Methodology
- Lean Manufacturing
  a. Reduce machine set-up time
  b. Reduce non-valued activities
  c. Better utilize resources

How is machine set-up time reduced?
- Balance C segment production
- Produce C segment parts bi-weekly
- Regroup parts with similar setups

Why produce C segments bi-weekly?
- Balance productivity and efficiency
- Include a safety buffer for shortages
- Reduce impact of forecast errors

Why reduce set-up time?
- Increase machine utilization
- Increase schedule availability
- Increase overall production size

Scheduling Results

	Machine 1455	Machine 1456
Weekly Set-Up Time	-22.05%	-35.27%
Machine Utilization	+6.03%	+77.17%
Ideal Availability	+2.93%	+13.82%
Production Size	+5.62%	+53.70%

Minimum Order

Minimum Order Quantity Methodology
- Reorder point formula
- Safety stock inventory
- Just-in-time production
- Demand forecast

How is the lot size calculated?
- **Cycle Stock:** calculated using average daily demand and replenishment lead time
  - Average daily demand is based on forecasted demand
  - Replenishment lead time: 7 days for A&B segment parts; 14 days for C segment parts
- **Buffer Stock:** calculated using service level, CoV, and cycle stock
  - CoV = Coefficient of Variation
- **Safety Stock**: calculated using safety factor, cycle stock, and buffer stock
- **Lot Size:** calculated using cycle stock and buffer stock

How is the MOQ calculated?
- MOQ is calculated using minimum set-up time, cycle time, and forecasted demand
- Recommended MOQ is ~500 to ~800 pieces.

Note: We are not able to share the exact formulas as they are confidential.

Forecast Accuracy

Months	Forecast	Segment A	Segment B	Segment C
+1	TE	120%	126%	95%
	New	96%	97%	85%
+2	TE	139%	151%	75%
	New	140%	120%	76%

Figure I: Our forecast is most accurate for A/B segments; continue to use TE's forecasts for C segment

References

[1] Liljana Ferbar Tratar, Blaž Mojškerc, Aleš Toman, Demand forecasting with four-parameter exponential smoothing, International Journal of Production Economics, Volume 181, Part A, 2016, Pages 162-173, ISSN 0925-5273, https://doi.org/10.1016/j.ijpe.2016.08.004.

Impact

Financial Metrics

17% **cost reduction for A & B segments**

11% **cost reduction for C segments with bi-weekly production**

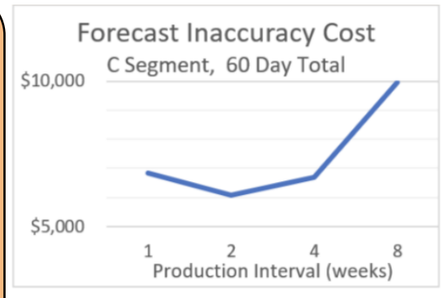


Figure II: The graph shows the overall cost of producing weekly, bi-weekly, monthly and bi-monthly.

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