Application of Optimization-Based Production Loading at Toshiba Corp.

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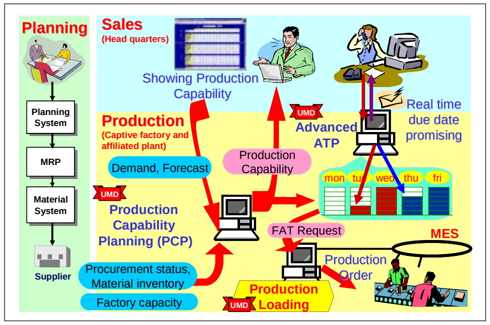
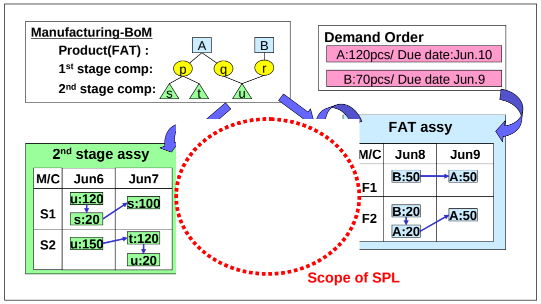
Background

- UMD and Toshiba have collaboratively developed advanced Available to Promise (ATP) and Production Capacity Planning (PCP)
- Optimization-based Production Loading (OPL) extends ATP to shop-floor level by considering detailed production information.



Concept of OPL

- Model should determine optimal daily production schedule for each production stage based on Final Assembly and Testing requirements.
- The goal of this project is to develop optimization-based OPL prototype to reduce production lead-time and total inventory level, to improve throughput and order commitments (customer service level).

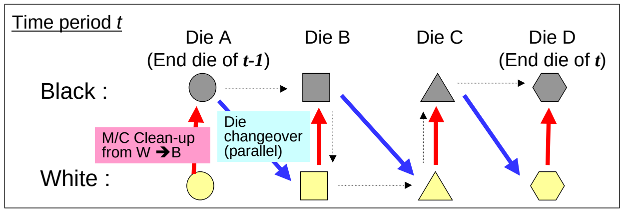


Single-Stage OPL (SPL) and Motif

- Develop OPL prototype for single bottleneck stage
- A factory producing electronic appliance from Toshiba Corp. is selected as motif for the development.
- One product can be produced with multiple available combinations of machine, die (injection module), and material.
- Changeover loss including die changeover and material changeover when switching products are significant.

Mixed Integer Programming (MIP) Formulation

- Material change from black (B) to white (W) should be done in parallel with die change, unless initial matl is B and there is no W with initial die.



Objective Function

Minimize:

Due date violation + Inventory holding cost + Change-over time

Major Decision Variables

- $C_j(t,t^k)$: Quantity committed for component *j* in time period *t*.
- $Q_{(m,d,j)}(t)$: Quantity produced by using of machine *m*, die *d* and component *j* in time period *t*.
- $O_m(t)$: Total changeover time on machine *m* in time period *t*.
- $Z_{(m,d)}(t)$: Die indicator, equal to 1 as die *d* is allocated to machine *m* in time period *t*.
- $\hat{Z}_{(m,d)}(t)$: Ending die indicator, equal to 1 as die *d* is allocated as ending die to machine *m* in time period *t*.
- $X_{(m,d,j')}(t)$: Material change indicator, equal to 1 as there is material change-over between component group *j`* at machine *m* and die *d* in time period *t*.

Major Constraints

- Demand commitments :

$$\sum_{t \in T} C_j(t,t^k) \le L_j(t^k) + r_j(t^k)$$

- Production conservation :

$$I_j(t) = I_j(t-1) - \sum_{t^k \in T} C_j(t,t^k) + \sum_{(m,d)\in MD} n_d \cdot Q_{(m,d,j)}(t)$$

- Capacity balance :

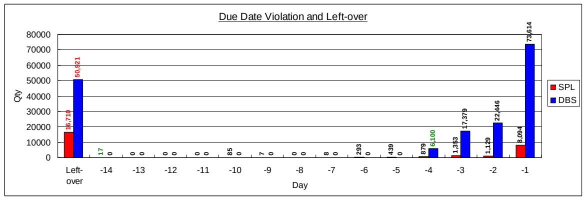
$$\sum_{(d,j)\in DJ} Q_{(m,d,j)}(t) \cdot c_{(m,d,j)} \le \kappa_m(t) - O_m(t)$$

- Changeover calculation constraints
  - ✓ Available combinations of die and machine for each component
  - ✓ Ending die for each machine and day

Experimental Comparison with a Commercial Dispatching Rule Based Scheduler (DRBS)

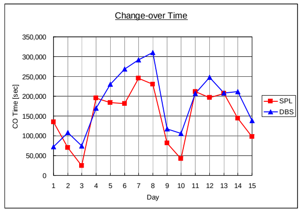
- Data was collected from an electric appliance company
  - ✓ OPL time horizon: 15 days
  - ✓ Total number of machines: 80
  - ✓ Total number of dies: 870
  - ✓ Total number of component types: 870
  - ✓ Total number of material types: 2 (black or white)
  - ✓ Possible component, machine die combination: 1300
  - ✓ Variation of the total number of orders per day: 1 ~ 287
  - ✓ Quantity variation of orders: 750 ~ 210,000
- Total computation time of SPL including pre-possessing, database querying and optimization: 180 minutes
- Demand Commitment:

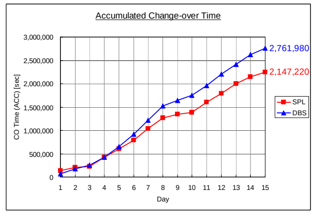
  Total quantity of the violated orders and left-over orders is reduced 6.2% by using SPL compared to DRBS.



- Changeover Loss:

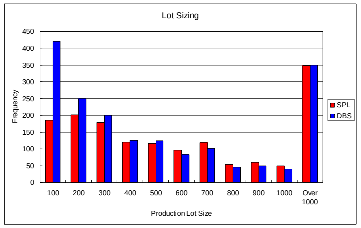
  Total changeover time can be reduced 18.2% by using SPL compared to DRBS.





- Production Lot Sizing :

  Total number of lots in SPL is 14.5% less than the ones in DRBS.



	Number of lots
DBS	1,789
SPL	1,529

	Average lots
DRBS	662
SPL	770