Analysis of the Intel Five-Machine Six Step Mini-Fab

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Introduction

The aspects of controlling a re-entrant flow line are illustrated by the Intel Five-Machine Six Step Mini-Fab case [1]. The line is sketched in Figure 1. The target of the line is to reach a throughput of 84 lots/week.
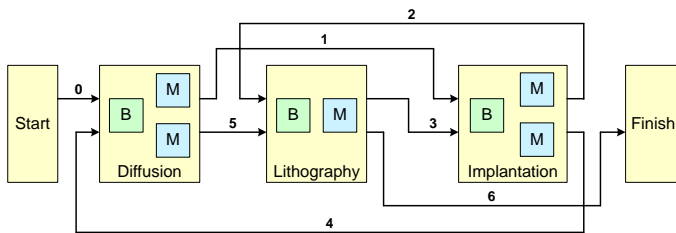

Figure 1: Sketch of flow line

Objectives and approach

- Design an elegant χ model [2] of the line
- Determine if the required throughput can be met by solving an ILP model
- Try to obtain the maximal throughput for the line by improving its control

χ model

The complexity of the model is increased in small steps, starting from a basic flow line. Subsequently added are:

- machine input restrictions,
- product transportation,
- two operators,
- one technician.

Elements operate FIFO. The steady state behavior of the line is shown in the Gantt chart of Figure 2. The throughput equals 57.5 lots/week.
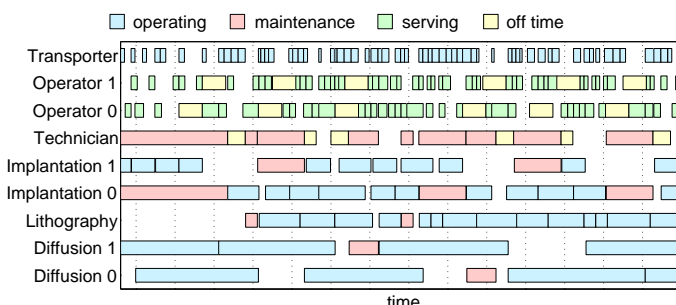

Figure 2: Flow line with FIFO control

Time-indexed model

A time-indexed model [3] has been formulated to determine if the required throughput can be met:

$$
\begin{aligned}
\min_{x_{jt}} \quad & z, \\
\text{s.t.} \quad & \sum_{t=0}^{T-p_j} x_{jt} = 1 && \forall j, \\
& \sum_{j} \sum_{s=t+1-p_j}^{t} x_{js} \leq 1 && \forall t, \\
& z \geq (t+p_j) \cdot x_{jt} && \forall j,t, \\
& x_{jt} \in \{0,1\} && \forall j,t.
\end{aligned}
$$

Improved control

Finally, the control of the lot generator, buffers and personnel of the line has been improved. The steady state behavior of the line is shown in Figure 3. The throughput equals 80.4 lots/week.
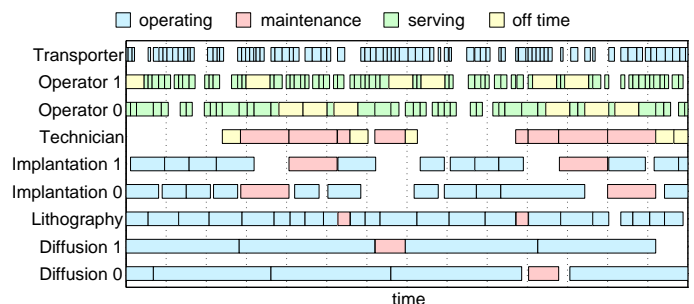

Figure 3: Flow line with improved control

Conclusions

- An elegant χ model has been designed containing all aspects of the Intel case
- The required throughput can be met
- Further research is required to improve the throughput

References

[1] Kempf, K., *Intel Five-Machine Six Step Mini-Fab Description*, Intel/ASU Report, http://www.eas.asu.edu/~aar/research/intel/papers/fabspec.html, 1994.

[2] Rooda, J.E. and Vervoort, J., *Analysis of Manufacturing Systems*, lecture notes, Eindhoven University of Technology, 2003.

[3] Sousa, J.P. and Wolsey, L.A., *A time-indexed formulation of non-preemptive single machine scheduling problems*, Mathematical Programming 54, pag. 353-367, 1992.