Simulation-Aided Decision Making in Order-Driven, High-Variety Production

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Abstract

Many small and mid-sized job shops engage in complex, order-driven, high-variety production on a daily basis. They do not have simple, cost-effective methods for simplifying the complexity caused by high-variety production in order to adopt popular methodologies for easier and efficient production management. Managerial decision making is tough in such systems. Managers can take advantage of simple production simulation for efficient decision making in complex production on a daily basis.

Keywords: Job Shop, Order-Driven, High-Variety, High-Mix-Low-Volume, MTO, ETO, Custom Manufacturing, Production Management, Decision Making, Scheduling, Simulation and Software.

In many order-driven manufacturing units, managers run their production using experience, knowledge, intuition, commonsense, adhoc decisions in real time and firefighting without much confidence. They lack confidence because they feel that there are too many variables in their production system to handle efficiently. The methodologies like lean manufacturing which are currently popular among manufacturing industries aim to simplify production system so that production management becomes easier. However, for various reasons, the system simplification approaches are not still widely adopted for managing complex production systems, particularly in order-driven, high-variety, discrete manufacturing units. Decision making is tough in such complex production units. This is where a scientific method like production simulation has great potential to help with decision-making on a regular basis. Given the industry's current focus on a purely practical methodology like lean manufacturing, any suggestion for running production simulations on computer for making right decisions in production management on a daily basis may look weird and academic. This is true even in the era of Industry 4.0.

Two major advantages of simulation in order-driven, high-variety production are (1) reliable prediction of work flow, order completion times and bottleneck formations over time and (2) quick what-if analysis. Both of them make decision making very efficient in complex production which cannot be simplified easily and economically. For daily usage in production environment in support of managerial decision making, simulation does not have to be as sophisticated as described in literature and the users do not need to be simulation experts either. Simple, judicious applications of even deterministic, discrete-event simulation can significantly help with decision-making in the management of most production systems. We do not need as much perfection in production simulation as many academicians suggest. If the required input data and a right software tool are available, then normal, computer-literate factory managers should be able to do

it regularly and easily for efficient decision making using only the knowledge of production system. Such data is indeed available in many industries nowadays.

Management of Order-Driven, High-Variety Production

Management of order-driven, high-variety, discrete production is quite tough in general. Managers who handle such production on a daily basis understand this difficulty more accurately. They compare management of a variety of orders for meeting respective due dates to juggling several balls in air. They manage such production using experience, intuition, gut feelings, firefighting and commonsense without a strong hope for efficient production control. A majority of job shops engage in order-driven, high-variety, discrete production which is described in various industries as high-mix, low-volume (HMLV), make-to-order (MTO), engineer-to-order (ETO), mixed-model value stream, etc. Such job shops are mostly small in size and revenue but difficult for production management. They include machine shops, forge shops, fabrication shops, print shops, tool makers, mold makers, repair shops, custom woodworking units, etc.

The difficulty of managing order-driven, high-variety production is caused by many factors including:

1. Unpredictability of process requirements, quantities and receiving times of orders
2. Unpredictability of progress and completion times of work orders even for given priority rules for work order selection by resources
3. Infeasibility or disadvantages of keeping final goods inventory
4. Very limited production resources
5. Unexpected interruptions in resource availability.

For a detailed discussion on job shop production management, you may read my article, "Scientific Management of High-Variety, Complex Production in Job Shops" at http://optisol.biz/jobshopmanagement.pdf .

Figure 1: Decision Making in Order-Driven, High-Variety Production

Managerial Decisions Concerning Production

Managerial decision making is tough in order-driven, high-variety production due to the above mentioned factors. The managerial decisions which are taken on a regular basis include:

- Quoting a lead time for a new order while negotiating with customer
- Determining material release time for a work order
- Accepting a rush order
- Accepting a new order with specific due date
- Expediting an existing order
- Changing priority or due date of an existing order
- Changing a resource capacity or changing resource calendars
- Adding or removing a resource
- Training people on additional skills
- Setup reduction on a machine
- Outsourcing some operations to a vendor
- Revising the start time of an order due to unexpected material delay
- Etc.

Job shop managers generally make this kind of decisions using their experience, intuition, gut feelings, firefighting and commonsense. But, they may not have much confidence in the effectiveness of those decisions because they cannot easily assess the potential consequences in advance. What-if analysis capability is essential for such advance assessment in a reliable manner in order-driven, high-variety manufacturing and it comes with the capability to predict work flow (progress of work orders) in production.

The methodologies like lean manufacturing, theory of constraints (TOC), quick response manufacturing (QRM), CONWIP etc. are not known to provide managers with necessary means for work flow prediction and what-if analysis.

Production Simulation for Work Flow Prediction and What-If Analysis

Discrete event simulation of production can be easily adopted for work flow prediction and what-if analysis which are very useful for assessing potential consequences of the above mentioned managerial decisions. For all practical purposes, this scientific, rigorous, computationally intensive method is usually done on computer with the help of simulation software. It also requires good effort from users. Meaningful production simulation usually requires knowledge of simulation and probability distributions, production modeling skills and good simulation software. For these reasons, unlike planning and scheduling activities, production simulation is currently an uncommon activity in manufacturing units. Many production people in real world, particularly in small industries are quite unlikely to adopt production simulation as an aid to decision making for the same reasons.

Proposed Deterministic Simulation for Work Flow Prediction and What-If Analysis

To eliminate the difficulty of using simulation as an efficient aid to decision making by typical production managers, I am proposing here a simple and effective simulation approach mainly for production systems like order-driven, high-variety manufacturing units. The approach is deterministic simulation enabled by powerful scheduling software. If uncontrollable variation due to randomness in resource-constrained production system is not very high, then deterministic production simulation is practically good enough for work flow prediction and what-if analysis. In such cases, a powerful, versatile production scheduling software will easily support deterministic simulation of work flow in production. The proposed deterministic simulation ignores individual random elements in the system while judiciously creating time buffers in the flow of work orders to take into account the aggregate effect of the random elements.

Requirements of Proposed Simulation Approach

1. All the data required for generating a meaningful, detailed, operations-level production schedule. It includes due dates, priorities and routing information of work orders (jobs), available times of all relevant production resources and rules, policies and constraints in the system, etc.
2. A powerful software tool for generating a meaningful, detailed, operations-level production schedule quickly (almost instantaneously)
3. Ability to configure the versatile scheduling software for a given production system.

Nowadays, the data required for the proposed production simulation is already available in a majority of ERP systems. Many small factories without a full scale ERP package maintain such data in Excel / Access files. There are some powerful software tools for detailed production scheduling available to small and mid-sized job shops at affordable prices. For any powerful tool, its vendor can give good guidance on how to configure it for a target production system, if necessary.

Typical factory managers having basic experience with computers can easily adopt the above proposed simulation approach for efficient, confident, data-based decision making in production. To run such simulations on a regular basis, they do not need any special knowledge outside their production system. They can make necessary changes in the input data quickly and easily and run simulation to find the potential impact of those changes.

One of the software tools that fully support this approach for order-driven, high-variety manufacturing systems is our software product, Schedlyzer which is affordable to most job shops. Powerful and versatile scheduling software like Schedlyzer for such systems help not only schedulers in detailed production scheduling but also managers in doing what-if analysis for efficient decision making related to sales and operations and capacity planning. Quick and simple simulation-based analysis aided by powerful software tools can greatly help decision making in complex production.

In order-driven, high-variety manufacturing systems, practically meaningful production simulation can be easily adopted for making better and more confident decisions in production control and management on a regular basis. Factory people need not be simulation experts to run simulations of their production for this purpose. The approach of simulation-aided decision making in production requires production data that is usually available in ERP systems or in Excel/Access files for most industries nowadays. It also requires an appropriate software tool. It is a scientific, effective and helpful decision support method for the management of complex production in order-driven, high-variety manufacturing systems which cannot be simplified easily and economically.

With a PhD in scheduling, Dr. Prasad Velaga worked as Operations Research faculty at prestigious academia for many years. For the last nineteen years, he has been implementing powerful scheduling solutions for job shops with high-variety, complex production. He gained a lot of experience in developing scheduling models and algorithms for complex production systems, particularly in order-driven, high-variety manufacturing environment.