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Effectiveness of Manufacturing Rules on Driving Daily Production Plans

Hung-Nan Chen and **Jeffery K. Cochran,** Arizona State University, Tempe, Arizona, USA

Abstract

Production plans are usually driven by manufacturing rules, with the objective of improving the factory's performance metrics. However, due to the dynamic nature of the manufacturing environment, an effective rule in one situation may be very ineffective in another. This study inspects the effectiveness of three manufacturing rules in terms of three important performance metrics. The three manufacturing rules are (1) line balance, (2) on-time delivery, and (3) bottleneck utilization. The three associated performance metrics are (1) effective WIP (work-in-process), (2) on-time delivery, and (3) bottleneck loading. Manufacturing data extracted from a former Motorola wafer fab is used to evaluate the effectiveness of these production plans. Analysis shows when each rule is effective or ineffective based on different factory conditions. Guidelines for manufacturing rule selection are then provided that are responsive to the current situation in a factory.

Keywords: *Production Planning, Line Balancing, On-Time Delivery, Bottleneck Loading, Simulation*

Introduction

Competition between manufacturers is intensifying due to the advance of technologies as well as the increasing need to reduce production cost. Manufacturers who do not efficiently utilize their resources and information will eventually be out of the business. A good production plan is essential for a manufacturing firm to meet its goals and stay competitive.

A production planning system basically deals with capacity and priority. Depending on purposes and time frame, production plans can be classified into five levels of plans, each with a different level of horizon and detail (Arnold 1996).

Table 1 summarizes the horizon, focus, inputs, level of detail, and term of measurement for the five levels of manufacturing plans. In this paper, the interest is in the production activity control and purchasing (PAC) plan. The PAC plan focuses on how materials flow into the factory, how finished goods are shipped, and how work in process flows through the factory. The planning horizon is usually one day to one month depending on the process times in the system. This plan takes input from each individual component, workstation, work in process, and demand and details how work should flow from workstation to workstation through the factory. This is also the plan that the manufacturing team deals with on a daily basis to make sure inventory is moving properly to contribute to the overall goals of the company.

Consider the inventory levels, WIP (work in process), at each operation of a factory's major product line, shown in *Figure 1*. WIP levels at operations S-25 to S-29 and S-37 to S-39 have large deviations from their goals and are called out of balance. The cause of this situation could be temporary equipment downtime, a low staffing level at certain production area, improper job release into the factory, sudden change in demand, or combinations of these causes. Such a WIP profile will not only create temporary bottlenecks, or "popping constraints," which in turn result in inconsistent throughput, but it will also invalidate most production plans generated by the mid or long-term production planning systems. Manufacturing environments characterized by long cycle times, fluctuating demand, and complex production processes routinely experience these types of WIP imbalances are in need of a good short-term production planning system.

The objective of this study is to develop an understanding of the effectiveness of different short-term manufacturing rules under different factory conditions. By different factory conditions we mean different relationships of the actual WIP profile to the WIP goals. With this knowledge, factories will be able to adjust their manufacturing rules to cope with sudden changes in the manufacturing environment. A planning horizon of 24 hours is especially of interest, which corresponds to the industry practice of providing daily updates to production plans to workers. In such an environment, a production

Table 1
Different Levels of Manufacturing Plans (Arnold 1996)

	Horizon	Focus	Inputs	Level of Detail	Term of Measurement
Strategic Business Plan	> 2 years	1. Product lines 2. Markets	Analyses from marketing, finance, production, and engineering groups	Very low	Dollars
Production Plan Sales & Operations Plan (S&OP)	6 ~ 18 months	1. Plan for major product groups 2. Desired inventory level 3. Resources required for each period 4. Availability of resources	Strategic business plan	Low	Units
Master Production Schedule (MPS)	3 ~ 18 months depending on manufacturing and purchasing lead times	Plan for individual end items	S&OP, sales orders, inventory, demand forecast, existing capacity	Medium	Units
Material Requirements Plan (MRP)	3 ~ 18 months depending on manufacturing and purchasing lead times	"When and what items are required to make each end item."	MPS	High	Units
Production Activity Control & Purchasing (PAC)	1 day ~ 1 month	1. Flows of materials in/out of factory 2. Flows of work through factory	Individual components, workstations, orders	Very high	Units

plan must be quickly generated every 24 hours, reflecting the current factory's conditions, including WIP, demand, and equipment/staffing capacity.

Review of Related Work

Much effort has been dedicated to making decisions for different levels of production planning. For long-term production planning, a hierarchical planning approach is widely accepted (Uszoy, Lee, and Martin-Vega 1992). This class of planning systems, called infinite-capacity models, assumes constant throughput regardless of equipment utilization (Vollmann, Berry, and Whyback 1988), and has been widely used in many mid to long-term production-planning problems, such as MRP, MPS, and S&OP. Finite-capacity systems, on the other hand, model the relationship between process time and workload. These systems find their applications also in mid to long-term production planning, typically for refining an MRP-type production plan. For example, Hung and Leachman (1996) propose a production-planning methodology based on iterative simulation and linear programming. An industrial implementation (Leachman et al. 1996) of that linear programming finite-capacity model has been accomplished. Liao et al. (1996) propose a linear programming approach utilizing Lagrange relaxation and decomposition techniques. Another approach, proposed by Horiguchi et al. (2001), is based on forward scheduling for

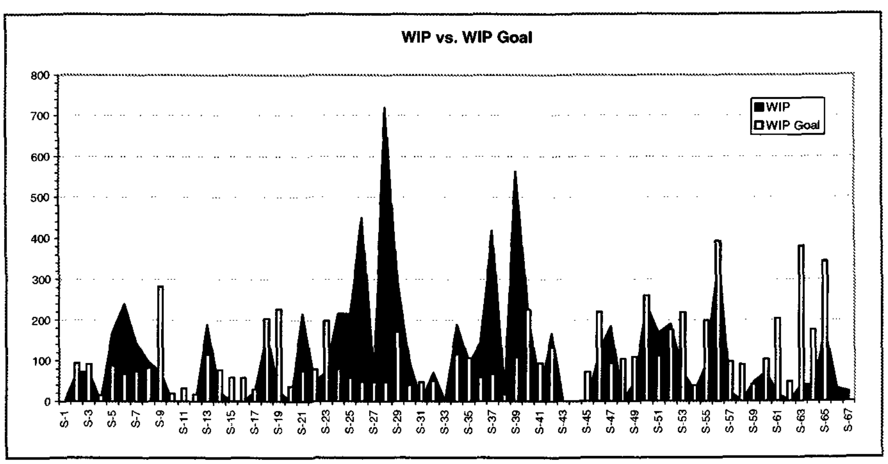

Figure 1
WIP vs. WIP Goals at Operation Level (Chen, Dabbas, and Cochran 2001)