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Int. J. Production Economics 73 (2001) 123–135

international journal of
production economics

www.elsevier.com/locate/dsw

Regime-change management under post-mass production

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Accepted 17 October 2000

Abstract

This paper considers the implications of optimum production planning for facilities where capacity is a tight processing constraint. In this environment, there are benefits to incorporating workload smoothing within the production planning process and this approach to production planning has been addressed in the literature. No attention, however, has been given to the transition between regimes. Stock incompatibilities arise between adjacent regime plans as a function of the active regime-change drivers and the timing of the regime change. The procedures of this paper, therefore, optimise the stock outcomes of regime change with respect to its timing. To highlight the stock effect, processing within regimes is assumed to have JIT properties and the facility is assumed to be single stage, in line with trends in the globalisation of production. The method is applied to an example where regime change is driven by the combined influences of demand shifts, product innovation, and process innovation. The example demonstrates the scope for significant cost savings from managing the regime change when capacity is tight, and illustrates the simplicity of the method. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Production planning; Batch manufacturing; JIT; Processing regimes; Transitory planning

1. Introduction

Post-mass production is the result of a pursuit of market share through an increase in variety across product lines. Processing plant and equipment is shared between the increased number of goods that are produced in batches, rather than being dedicated as in mass production. The demand for parts processing comes from the assembly shop which operates to match the shifting demand for end products. For example, a snack food processing facility which produces extruded- and chip-type snacks, may produce dozens of end-products of different materials, flavours, and salt contents, as well as combinations of these.

Under post-mass production, processing regimes are used to provide stable processing environments with consequent gains in processing efficiency. This paper focuses on processing regimes for facilities, where capacity is a tight regime constraint that rewards workload smoothing at the planning stage. As usual, changes in regime are a response to developments in market demand and technical progress that are outside regime tolerances. Considerable attention has been devoted in the literature to optimising the processing strategy for a given regime, and to optimising the regime tolerance settings to achieve a balance between processing efficiency, on

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0925-5273/01/$ - see front matter
PII: S0925-5273(00)00163-8

the one hand, and the speed of response to external developments, on the other. In the context of tight capacity constraints, the transition from one regime to the next also offers opportunities for performance optimisation, but this has received little attention in the literature. In this paper, *regime-change management* refers to the management of stock surpluses and shortages through optimising the timing of regime change.

The focus of this paper is on the management of regime changes induced by process innovation, product innovation, and demand shifts. It is shown that in the absence of regime change management, the expected outcome is either an avoidable accumulation of stock to be carried for the duration of the new regime, or an infeasible regime change involving shortages of assembly feed stock. The properties of regime change are developed in Section 4. Two aspects of regime-change management are analysed – transitory planning and regime-change timing. In Section 5 a transitory plan is defined to avoid shortages for assembly, and the properties of transitory plans are established. In Section 6, the stock implications of transitory plans are optimised with respect to the timing of the regime change. Regime-change management is shown to avoid unnecessarily burdening the facility with excess stocks over the new regime.

The motivation of this paper is the enduring focus of the production systems literature on steady state properties with the result that, as noted by Gopalan et al. [1, p. 18], "little effort has been devoted to the study of systems during their transient period". While regimes in JIT systems have attracted considerable interest, for example in Miltenburg [2], the impact of changes in JIT regimes, and their management, have not. As a case in point, the concept of Post-mass production, introduced by Womack [3], has received great attention in the literature with respect to optimum within-regime production, but little with respect to optimum transitory behaviour between regimes. The intended outcome of the current paper is to promote the general development of transitory strategies. In Section 2 the paper describes a production planning method that provides superior workload profiles in an environment where capacity restrictions are tight. Subsequent sections then develop procedures to manage regime changes in this environment in order to improve inventory outcomes.

2. The basic model: Within-regime planning

To highlight the stock effect, processing within regimes is assumed to operate under JIT processing planning. The model presented below places JIT production in a specific Post-mass production context based on regimes. The processing parameters that define a regime are the set of parts, processing times, batch sizes, and assembly demands. Processing is single stage, which exposes policy properties more starkly and corresponds to trends under the globalisation of production.

The processing shop is assumed to operate under within-regime processing planning based on a production planning matrix

$$\underset{(n \times T)}{\boldsymbol{Y}} = \{y_{i\tau}\}, \tag{1}$$

where n is the number of parts, T is the planning horizon and

$$y_{i\tau} = \begin{cases} 1 & \text{if processing of the } i\text{th part is planned for period } \tau, \\ 0 & \text{otherwise.} \end{cases}$$

Processing planning must satisfy both soft capacity constraints

$$\sum_{i=1}^{n} t_i y_{i\tau} P + x_\tau, \text{ for } \tau = 1, 2, 3, \ldots, T, \tag{2}$$

where t_i is processing time, inclusive of set-up, per batch of part i (hours), P is processing capacity per period (hours), x_τ is overtime processing during processing period τ; and, flow conservation equations

$$I_{i\tau} + r_i y_{i,\tau-1} - d_i = I_{i,\tau+1},$$
$$\text{for} \quad i = 1, 2, 3, \ldots, n, \ \tau = 1, 2, 3, \ldots, T, \tag{3}$$

where d_i is the demand rate for part I, r_i is the batch size for part i, and $I_{i\tau}$ is the opening stock of part i in period τ.

Overtime processing in (2) enables nominal capacity to be exceeded and, as indicated in (3), processed batches become available to satisfy assembly demand one period after processing. Further, all