ELSEVIER

Int. J. Production Economics 74 (2001) 49–61

international journal of production economics

www.elsevier.com/locate/dsw

The finite horizon economic lot sizing problem in job shops: the multiple cycle approach

J. Ouenniche[a,b,*], J.W.M. Bertrand[b]

[a]Faculty of Business Administration, Lakehead University, 955 Oliver Road, Thunder Bay, Ont, Canada P4B-SE1
[b]Department of Operations Planning and Control, Faculty of Technology Management, Eindhoven University of Technology, P.O. Box 513, Paviljoen H12, 5600 MB, Eindhoven, Netherlands

Abstract

This paper addresses the multi-product, finite horizon, static demand, sequencing, lot sizing and scheduling problem in a job shop environment where the planning horizon length is finite and fixed by management. The objective pursued is to minimize the sum of setup costs, and work-in-process and finished products inventory holding costs while demand is fulfilled without backlogging. We propose a new and efficient cyclic scheduling solution framework, called the multiple cycle (MC) method, based on the assumption that the cycle time of each product is an integer multiple of a basic period. This method relies on a decomposition approach which decomposes the problem into an assignment sub-problem, a sequencing sub-problem and a lot sizing and scheduling sub-problem. To evaluate its performance, the MC method was compared to the common cycle method and numerical results show that it performs better, as expected. However, the magnitude of improvement varies between 4% and 8% depending on the structure of the problems.

Keywords: Sequencing; Lot sizing; Cyclic scheduling; Job shop

1. Introduction and problem definition

This paper addresses the problem of making sequencing, lot sizing and scheduling decisions for several products, say n, manufactured through a job shop where all parameters are deterministic and constant over a given planning horizon length, say H, which is assumed to be fixed by management. The objective pursued is to minimize the sum of setup costs, work-in-process (WIP) inventory holding costs and finished products inventory holding costs while a given demand is fulfilled without backlogging. We consider a job shop with m machines and assume that there is only one machine of each type and that each product i has a unique serial route through the shop which will be indicated by an ordered subset of machines and denoted by $\rho(i,.)$; in other words, we assume that routing decisions have been made and, based on some criteria, a unique serial route has been chosen for each product. In addition, we assume that preemption is not allowed. To solve this problem, we assume that the cycle time of each product i, say T_i, is an integer multiple, say m_i, of a basic period F; that is, $T_i = m_i F$ for all i. In addition, we require that the basic period F be such that the planning horizon H is an integer multiple of the global cycle

* Corresponding author. Tel.: +1-807-343-8525; fax: +1-807-343-8443.
E-mail address: jamal.ouenniche@lakeheadu.ca (J. Ouenniche).

0925-5273/01/$ - see front matter
PII: S0925-5273(01)00106-2

Parameters

n	: number of products
m	: number of machines, also called stages
i	: product index
j	: machine/stage index
μ_i	: number of machines on the route of product i
n_j	: number of products to be processed by machine j
n_j^k	: number of products that require processing by machine j in basic period k
$\rho(i, .)$	: route of product i through the shop
$\rho(i, j)$	: j^{th} machine on the route of product i
r_i	: demand rate of product i
p_{ij}	: production rate of product i on machine j
t_{ij}	: set-up time of product i on machine j
s_i	: sum of set-up costs of product i through its route
h_{ij}	: inventory holding cost per unit of product i per unit of time between machine j and its consecutive machine
h_i	: inventory holding cost per unit of end product i per unit of time
H	: length of the planning horizon

Decision variables

T_i	: length of the time interval between two successive runs of product i, called the cycle time of product i
F	: basic period (when we assume that the global cycle is divided into a number of basic periods)
m_i	: time multiple of product i (when we assume that T_i is m_i times F)
M	: $LCM\{m_i\}_{i=1,\ldots,n}$
MF	: global cycle length
σ_j^k	: processing order of products requiring machine j in basic period k
$\sigma_j^k(i)$	: i^{th} product in the sequence σ_j^k
π_{ij}	: processing time of product i on machine j
d_{ij}	: processing start time of product i on machine j

Fig. 1. Basic notation.

MF, that is, $H = \xi MF$ where ξ is an integer and M denotes the least common multiple (LCM) of m_i's. This problem can be formulated as a mixed non-linear program that simultaneously determines all the relevant decisions. However, for large or even medium size instances, the solution of this model may require a prohibitive amount of computational time. Consequently, in this paper, we propose a solution method, called the multiple cycle (MC) method, which decomposes the problem into three sub-problems; namely, an assignment sub-problem, a sequencing sub-problem and a lot sizing and scheduling sub-problem. The first two sub-problems are solved using heuristics while the third sub-problem is solved to optimality. Throughout this paper, we will use the notation given in Fig. 1.

To the best of our knowledge, the only contribution to this problem is reported in Ouenniche and Boctor [1]. Recall that the classical job shop problem has attracted the attention of many researchers (e.g., [3–10]). This problem consists of determining, for a given set of non-splittable jobs, the execution sequences and the starting dates so as to optimize some objective function. However, this problem is quite different from the one considered in this paper, as the classical job shop problem does not deal with lot sizing issues. Attention has also been paid