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Corrections of costs to feasible solutions of economic lot scheduling problems

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Abstract

The paper considers the problem of choosing order quantities and a cyclic production pattern for several products that are produced in a common capacity constrained facility. The heuristic method from Segerstedt [Segerstedt, A. (1999). Lot sizes in a capacity constrained facility with available initial inventories. *International Journal of Production Economics, 59*, 469–475] is modified and improved. The method is compared with the heuristic technique according to Doll [Doll, C. L., & Whybark, D. C. (1973). An iterative procedure for the single-machine multi-product lot scheduling problem. *Management Science, 20*(1), 50–55; Goyal, S. K. (1975). Scheduling a single-machine multi-product system: A new approach. *International Journal of Production Research, 13*, 487–493]; the differences and similarities between the methods are illustrated in a common numerical example. It shows *that feasible* solutions can be found, both with our method and others; where the production can be scheduled during a time interval, the initial inventory level is the same as the final and the schedule can be repeated in a cyclic pattern without shortages. (This definition of feasibility differs from traditional.) However, it shows that the common approximation for the inventory holding costs $(\frac{q_i}{2}h_i(1-d_i/p_i))$ does not fit. The real inventory holding cost becomes different compared to the approximated that is used in the calculations. The real inventory holding cost depends on the chosen scheduling, which makes it difficult to find an optimal solution. Different solutions and extensions are discussed.

Keywords: Economic lot scheduling problem; Multi-products; Single machine; Capacity constrained

1. Introduction

The classical economic lot scheduling problem, ELSP, concerns scheduling the production of several different items consuming capacity on a single machine. The objective of the ELSP is to determine a production schedule that minimizes the sum of inventory holding costs and setup costs.

Constructing sensible and realistic schedules can be difficult and there are a number of methods to be found that try to determine a minimum cost production schedule. An upper bound on the optimum cost can be

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obtained from a common cycle that has capacity for the setup and the production of every item, so that each items is produced exactly once during each cycle (showed by Hanssmann (1962)). The common cycle approach, due to differences in demand rates, product cost, or setup cost will often not present an optimal solution to the original problem even though there are reported cases when this approach is successful, e.g. Galvin (1987) investigating metal work applications. Imbalances motivate the popular basic period approach, where the products are allowed to have different cycle times, which must be integer multiples of a basic period. High volume products are produced in every cycle or basic period and lower volume products are produced less frequently (every second cycle, or every forth cycle, etc.). Bomberger (1966) introduced the restrictive constraint that in some basic period all products may be produced. Therefore, the sum of the setup times and operations times of all item must be less than or equal to the basic period. This constraint is relaxed in the extended basic period approach, but the basic period must at least be long enough to cover the average setup times and processing times for all products. Bomberger (1966) presented a 10-item problem which has been used extensively in the literature since then. Doll and Whybark (1973) present an iterative procedure, which reaches the best known solution to the Bomberger problem. Elmaghraby (1978) presented an overview of earlier research and own contribution to the problem. Goyal (1973, 1975), Hsu (1983), Axsäter (1987), Dobson (1987, 1992), Gallego (1990), Zipkin (1991) and Bourland and Yano (1997) are all well-known references to this problem.

Lopez and Kingsman (1991) make a review and compare different solution methods; they argue that the "power-of-two", of the basic period, is a requirement for achieving schedule feasibility in practice. Yao and Elmaghraby (2001) also mean that power-of-two solutions seem to be a way to derive easy and effective heuristics. Segerstedt (1999) presented a heuristic method for this problem that has a slightly different formulation; no explicit common basic period, but during a common cycle (time period) the different items are produced with different frequencies restricted to "power-of-two". Segerstedt (2004) shows that this heuristic can also be extended to several machines and multi-level production.

Since the methods by Doll and Whybark (1973), Goyal (1975) and Segerstedt (1999) find solutions to the Bomberger problem that coincide with each other, one purpose of this paper is to describe and compare the different procedures. First the recursion procedure from Segerstedt (1999) is modified, which is a second purpose with this paper; because the original procedure sometimes may restrain the differentiation of the frequencies between the produced items and there are problems where the original heuristic cannot find improvements, but the modification can. Thereafter this modified method and the heuristic methods of Doll & Whybark and Goyal are illustrated with the same small numerical example. The production during the calculated cycle time is planned and schedules for which item to produce when, and of what quantity for avoiding shortages are created. It shows that the real inventory holding cost becomes different compared to the approximated that is used in the calculations.

This is a third purpose with this paper and to show that this is still a feasible and sensible solution. The real inventory holding cost depends on the chosen scheduling, which makes it difficult to find an optimal solution. Different possible solutions and extensions are discussed.

2. Common assumptions and a test example

The different methods described in this article paper have all the following assumptions:

- Only one product can be produced at a time.
- Product setup costs and setup times are independent of production order.
- Product demand rates are deterministic and constant over time.
- The production rate for each item is deterministic and constant.
- The inventory holding costs are determined on the value of stock held.
- Backorders are not allowed.

We consider N different items which are produced on a capacity constrained machine and introduce the following notations: