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Int. J. Production Economics 102 (2006) 317–332

international journal of production economics

www.elsevier.com/locate/ijpe

A flow-network approach for equilibrium of material requirements planning

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Received 12 February 2003; accepted 7 April 2005
Available online 13 June 2005

Abstract

Material requirements planning (MRP) has been a very popular and widely used multi-level inventory control method since 1970s. Recent developments in computer and information technology accelerate and facilitate the calculations necessary for MRP, but MRP is simply a system to open and trace the production/purchasing orders under pre-determined lead-time and lot size constraints. It does not directly include any optimization feature. In this article, an approach, which consists of the Flow Network with Side Constraints, is discussed in order to optimize the material flows in MRP problems. Additionally, an example case is given in order to show the applicability of the flow network formulation to APS. The model of the example case is solved and the computational results are given.

Keywords: Material requirements planning (MRP); Flow network; Optimization; Side constraints

1. Introduction

Inventory management is one of the most important functions of a production system. A production system or a manufacturing company has two types of inventory as defined by Plossl (1994) and Orlicky (1975). While the first type—manufacturing inventory—consists of raw materials, semi-finished component parts, finished component parts, sub-assemblies, component parts in process and sub-assemblies in process, the second one—the distribution inventory—is made up of completed products in warehouses and completed products in transit. The main goal of a company is to obtain profit by meeting costumers' demands completely and on time. To meet demands completely and on time requires a good inventory management supporting the production planning and keeping inventories under control. According to Orlicky (1975), inventory management is based on one of the two different approaches: (1) stock

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doi:10.1016/j.ijpe.2005.04.002

replenishment or statistical inventory control which is based on monitoring inventory levels according to the policy preferred in order to eliminate the probability of being shortage by statistically analyzing the consumption rates (2) material requirements planning (MRP) which is a method based on planning the requirements according to the master production schedule (MPS) which is prepared depending on customers' demands. Two basic data are necessary for MRP: (1) the MPS, and (2) Bill of materials (BOM).

MPS is a plan showing the product which will be produced when and in what quantity based on forecasting or received customer orders. BOM shows which sub-component or raw material is used for which product and in what quantity. Required material quantities are calculated by hierarchically multiplying the production quantities in MPS by unit usage coefficients in BOM.

2. Current state of literature for MRP

Rondeau and Litteral (2001) give a brief summary about the historical improvements of manufacturing planning and control systems. Segerstedt (1996) presents formulas, which are used for calculations of MRP. Formulation is discussed in detail and a flow chart for the method is given. However, the formulation given has no optimization property. Chu (1995) intensifies on aggregate optimality. The objective for the model is to maximize the total (potential) profit. An LP model has been developed subject to the restrictions on the supply, the total demand and the labor resource. Plenert (1999) compares MRP with just in time (JIT), optimized production technology (OPT)/theory of constraints (TOC) and bottleneck allocation methodology (BAM), and claims its strength in job shops. The incorrect uses of MRP system are also discussed. According to the author, the basic abuses of the MRP environment is the lead time which is a kind of non productive time made up of elements like queue time, waiting time, transfer time, etc. Euwe and Wortmann (1997) discuss the deficiencies of MRP in issues like flexibility in lot sizes, product structures' capacity constraints and alternative plans. They also define 'vision statements' for the future planning systems in order to overcome such difficulties. Van Donselaar and Gubbels (2002) compare MRP and line requirements planning (LRP) for planning orders. Their research basically focuses on minimizing the system inventory and system nervousness. They also discuss and propose LRP technique to achieve their goals. Zijm (2000) discusses a framework emphasizing the integration of technological and logistics planning, capacity planning and materials coordination issues. He also classifies advances in manufacturing practice in three different fields: hardware automation, design and process planning and manufacturing planning and control systems, and then, adds system complexity reduction as a fourth impact factor. Zijm (2000) also emphasizes that OR models are being integrated in planning systems of some software manufacturers. Clark (2003) proposes three mixed integer programming models in his study.

The network flow models can be solved more efficiently and faster than those developed in general linear form. McBride (1985) develops an algorithm, discusses it in details and gives computational comparisons of the code of his program called "EMNET" with "MINOS" of IBM. He finds that network approach and solution is about five times faster than MINOS. Ali et al. (1988) define an algorithm for network problems, which have side constraints to assure some arcs having equal flow and give computational results of their code "EQFLO" by comparing "MSPX" of IBM. Mathies and Mevert (1998) give some additional computational results from the literature while discussing their algorithms. Glover et al. (1992) give some applications of the pure flow networks to the inventory problems as the examples for the dynamic network models. They apply the pure flow network approach to the multi-period inventory problems. They also extend their models to include backorders, multi-products and multi-plants. However, they did not take the multi-level hierarchical product tree and lead times into consideration.

Yenisey (1998) gives a primitive study for the network optimization of MRP. However, that study has some deficiencies to express all the aspects of an MRP system. Hence, an improved optimization model, based on pure flow network with side constraints formulation, is developed in this research. Since, the given