Design and development of an internal milk-run material supply system in automotive industry.

Dipteshkumar Patel¹, Dr. M.B.Patel²

¹Research Scholar, GTU Ahmadabad
²Retired Professor, GTU Ahmadabad

Abstract

Material handling is one of the most crucial issues that should be taken into account for eliminating waste and reducing the cost. The purpose of this paper is to develop a mathematical model and a heuristic approach, which will be helpful to construct the routes and determine the service period for the design of an internal milk-run material supply system. The material supply by this system occurs on a just-in-time basis from a central warehouse to several stations of an assembly line. Milk-run material supply system is the round trips are either goods collected from several suppliers and transported to one customer, or goods collected from one supplier and transported to several customers. Besides, the heuristic approach intends to construct routes based on an initial service period value and attempts to improve the solution by considering different period values. Furthermore the scheduling of the vehicles will be calculated based on necessity of the raw materials and routes. The most suitable solution will be decided on the basis of the least total material handling and inventory holding cost. The objective of the mathematical model is the minimization of the total material handling and inventory holding cost. These saving could be either use for reduction of the product cost, which will boost up the sales or to lift the company profit margin.

Keywords: Milk run material supply, JIT

1. Introduction

Milk-run supply system can be classified into external milk-run system and internal milk-run system. Internal milk-run systems are those that deliver parts to the customers inside of the plant. Application of milk-run distribution systems in plants is to standardize the material handling system and eliminates the waste. If a good material handling system design is accomplished, it is claimed that the cost will decrease between 10% and 30% [2]. In a typical industry, material handling composes the 25% of the workers, 55% of the factory area, and 87% of the production time [3]. The objectives of the lean logistics are the delivery of the right mix of products at the right time to the right place, and carry out these activities, effectively [1]. Assembly lines must satisfy the customer demand neither late nor early, because early production incurs inventory holding cost and late production causes either lost sales or backlog. Therefore, parts supply to the point of use in the assembly line must be also achieved just-in-time (JIT). Otherwise, either time losses may occur due to disorganized and insufficient material supply to the assembly line, or excess inventory accumulates. JIT material delivery to the internal customers is usually achieved by means of the pull production control that employs Kanban. Pull production control mechanism is based on replacement of a predefined level of buffer stock of parts needed for an operation. Whenever a workstation starts consuming parts from a container, it detaches the Kanban attached to it and posts it into a Kanban post or puts into the order box, which is an order of a container of parts. The Kanban are collected frequently by the material handling staff, and the material requirements are satisfied by the supplier of each station of the line. The exact number of parts must be delivered to prevent inventory holding. Today, assembly lines usually require many types of components at different stages of assembly operations simultaneously. The need to move small quantities of large number of items within the plant with short and predictable lead times without increasing transportation costs resulted in development of milk-run material delivery systems [1]. Milk-run delivery system picks up and delivers containers of parts along the fixed routes each comprised of a predetermined set of stock points of the stations of an assembly line, based on a schedule. Therefore, integration of pull production control with the milk-run part supply system for the assembly lines is beneficial. The contribution of this research will be development of a mathematical model and a heuristic approach where the routes are constructed and the service period is determined for the design of an internal milk-run material supply system that works on just-in-time basis. Both of the techniques consider the total material handling and inventory holding cost. Especially, in cases of large real-life problems, the route construction algorithm (heuristic approach) is beneficial.

2. Literature review

During the review of JIT parts supply of materials studies, papers of two inter-related topics were reviewed: Kanban or pull production control papers and milk-run material supply papers. Kumar and Panneerselvam [6] made a critical review of Kanban papers and examined the papers about single-card and two-card Kanban systems, blocking mechanisms coupled with the buffer capacities, and measure of performance. In addition, Junior and Filho [7] focused on special cases or variations of the Kanban systems developed to overcome the problems occurring due to the unfavourable conditions of
use. The authors reported that most of the proposed systems follow the original Kanban logic. In addition, Hao and Shen [8] reviewed the studies considering Kanban systems and concluded that these relevant papers did not consider the material handling issues at the shop floor level, though it affects the system performance considerably [8]. In contrast to the Kanban literature, there exists a limited literature on milk-run material supply system, based on the pull philosophy. This type of papers about milk-run material supply systems can be divided into two groups: internal and external milk-run. Internal milk-run systems are those that deliver parts to the customers inside of the plant. Vaidyanathan et al. [4] analysed the JITVRP (just-in-time vehicle routing problem) and emphasized the unique characteristic of this problem. JITVRP requires that the quantity to be delivered at each of the demand nodes is a function of the route taken by the vehicle assigned to serve that node. The authors developed a non-linear mathematical model for this problem, relaxed it by making some assumptions and proposed a linear model that attempts to determine the lower bound for the number of vehicles required [4]. Moreover, a two-stage heuristic algorithm was proposed in this paper, for the solution of the problem. Satoglu et al. [15] explained JIT periodic material supply system for assembly line. They approached heuristic and mathematical method for routing. However, the researchers did not attempt scheduling of the vehicles in their research.

Domingo et al. [9] explained a real implementation of milk-run material supply system that serves a lean assembly line. They followed a practical approach. First, the stock points where pickups and deliveries were determined. Then, the sequence of operations was defined and alternative routings were determined. The stock points with high demand rates and those with lower demand rates were included in two separate routings. Then, the pickup and delivery schedule were developed. However, the researchers did not attempt to make an optimal milk-run delivery system design. Alvarez et al. [10] presented a case study of the redesign of an assembly line by using lean production tools. To reduce lead time and excessive stocks and improve material flow within the manufacturing system, Kanban-based production control and a milk-run material handling system were implemented. The authors realized that the design of Kanban production control system is insufficient without implementing an appropriate material handling vehicle [10]. Boysen and Bock [11] considered scheduling JIT part supply to a mixed-model assembly line where assembly line and the warehouse are at different factory floors. The authors used dynamic programming and then simulated annealing for the solution of the problem. Hao and Shen [8] developed a prototype software system that integrates discrete event simulation with agent-based simulation technique to evaluate the performance of a Kanban-based milk-run system serving an assembly line. In addition, Costa et al. [12] analysed the milk-run material delivery system of an electronics company using the simulation technique. In addition, Nemoto et al. [16] explained JIT external milk-run applications of the Toyota automobile assembly factories located in Thailand.

Some studies considered time windows and VRPSPD (vehicle routing problem simultaneous pick-up and delivery). Angelelli and Mansini [13] formulated a mixed-integer non-linear model of the VRP (vehicle routing problem) with time windows and simultaneous pickup and delivery. The term of “time windows” means that the material handling vehicle's pickup and delivery service at a supplier must be started and completed between the predefined time points. Ohlman, Fry, and Thomas [14] considered the VRP with time windows and split deliveries, where orders are picked up from a network of suppliers and delivered to the depot of a lean (JIT) production system. The authors divided the problem into two phases: the routing phase and the scheduling phase. Similarly, Chuah and Yingling [5] developed a non-linear mathematical model of the VRP with time windows and considered high-frequency and small-quantity deliveries from suppliers to a JIT assembly plant. Based on this review, it can be also deduced that there are only a few internal milk-run system studies in the literature. It has been observed that many manufacturing companies around the world aim to implement milk-run approach inside their production systems. Thus, there is a considerable requirement of studies that intend to design internal milk-run systems. Therefore, the contribution of this research will be significant to both the industry and the literature.

3. Conclusion

The research can be carried out by two different methods called mathematical model and heuristic approach. The delivery of the parts to the station of assembly line will be based on JIT. Considering a central warehouse, where vehicle will pick up the full containers of components and deliver them to the buffer stock area. Once assembly line will start to consume these components from a container, it will issue a Kanban card, in other word indication of the requirement of another container. The vehicle will collect the requirement from the unit specified by Kanban and deliver the full container to the buffer stock area. The vehicles delivery will be on JIT basis, neither late nor early. The mathematical model will be used to calculate the requirement of number of vehicles and period of the routes. Although the mathematical model is non-linear due to continuous demand of each station [4] and it is not precise for the large scale problem. Therefore it will be inevitable to use heuristic approach and compare them to reach at an optimal solution. In this method an algorithm (Route construction algorithm) will be developed. It will be helpful to calculate the feasible route and scheduling of vehicles.
During the design of a milk-run material supply system the routing of vehicle, period of the delivery and pick up service will be determined. The objective of this model is to construct the route, scheduling of vehicles and to determine the service period that ultimately minimizes the total material handling and inventory holding cost.

Reference