

A Multi-Objective Approach for The In-Plant Milk-Run in A Furniture Factory

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Abstract- Today, facility optimization is one of the most important decision for the firms while establishing a new factory. It is necessary to carry work-in-process products between the production lines in firms. Many firms use trains to carry these items. In this study, an application is made in a furniture manufacturing factory. Firstly, the routes which the train can use in the firm are created. The alternative routes are compared with each other. The routes contain all of the production lines in the factory. Our aim is to route the train with minimum distance and minimum amount of cargo carrying. In this study, one train is used in the firm. It is also necessary to use minimum train for carrying the work-in-process products. The optimal route is determined by using some of the methods in the literature for multi-objective models.

Keywords Facility logistic, In-plant Milk-Run, Multi-Objective Programming, Vehicle Routing Problem, Tow Train.

1. Introduction

In this study, one of the leading furniture suppliers of the world is investigating a cargo transportation route that can be integrated with the production line and the loading of these trains. It is aimed to develop this process with a systematic viewpoint. In the system studied, it is aimed to optimize the transportation of the materials in the production line between the units in the factory. Today, it is very important to minimize the time loss for factories. In order to be able to compete with the big companies in the sector, it is always necessary to carry out the best works. In this context, it is very important that the trains used in cargo transportation are used regularly on a certain route in a systematic manner with a minimum waiting time between units. In this study, appropriate routes are determined for trains owned by the company, and then a route to reach the whole point was determined with minimum distance in the most appropriate way. It is necessary to design the optimal route in a facility. The sequence and the time is very important. Next section literature review about this study is given. And in other sections, an application is made and the solution is compared with the current situation of the facility. Optimal route means, carrying the items with minimum distance and minimum time.

2. Literature Review

It is necessary to design the optimal route in a facility. The sequence and the time is very important. In this study, multi-objective approach is used for vehicle routing for a firm. In the literature, it is called in-plant milk-run when routing is planned in the firm. In Du et al.'s study, there is a milk-run application between suppliers and customers. Best fit algorithm and 2-exchange algorithm is used for vehicle-dispatching [1]. In Jafari-Eskandari et al.'s study, the milk-run between the supplier and the manufacturer has been studied. A model has been developed that takes account of the advantages and disadvantages of this method. First, a complex mathematical model has been developed. Then the robust optimization approach is used [2]. In Sadjadi et al.'s study, the milk-run is between the suppliers. A mixed number model has been established. However, a meta-intuition was needed because the computation time was too long. Then a genetic algorithm was used [3]. In Nemoto et al.'s study, the milk-run is between the suppliers. The milk-run application of an automobile company in Thailand is explained [4]. In Kovac's study, the milk-run is in stock within the firm. A mixed integer model has been developed. Solved with ILOG CPLEX [5]. In Brar et al.'s study, the literature review for the milk-run is made [6]. In Kilic et al's study, in-plant milk-run is made. 0-1 mixed

integer mathematical model has been developed [7]. In Arvidson’s study, the milk-run is between distribution center and customers. During the milk-run application, different routes (clockwise, counter clockwise) were compared and it was investigated which is better in terms of fuel consumption and time [8]. In Gyulai et al.’s study, a literature review is made for vehicle routing and milk-run [9]. In Ma et al.’s study, the milk-run is between the suppliers. A mutated ant colony algorithm is used [10]. In Hosseini et al.’s study, the milk-run is between the suppliers. The harmony search and annealing simulation algorithm is used [11]. In Hanson et al.’s study, the in-plant milk-run is made. A study has been made on how effective the unit load is in the factory supply [12]. In Novaes et al.’s study, the milk-run is between customers. The dynamic tooling procedure has been developed. Genetic algorithm is used [13]. In Lin et al.’s study, the milk-run is between suppliers. Greedy has developed a two-step heuristic algorithm, which is an intuitive and tabu search algorithm [14]. In Lin et al.’s study, the milk-run is between the suppliers. A two-step heuristic algorithm, greedy heuristic and annealing simulation algorithm, has been developed [15]. In Klenk et al.’s study, in-plant milk-run is made. Various strategies have been developed in order to make the ship better, and 4 different algorithms have been developed for these strategies [16]. In Korytkowski et al.’s study, the in-plant milk-run is made. A milk-run is simulation application was carried out in an assembly line [17]. In this study, an in-plant milk-run application is made by using multi-objective programming in. The difference from the literature is to obtain the route under these objectives.

3. In-Plant Milk-run

There are many types of problems in the literature for carrying the items from somewhere to the target place. In material flow system, items are transferred to the workstations from the warehouse or several supermarkets. And this transfer can be accomplished using tigger trains or forklifts. These trains show that transferring workstations in one trip of the train. This is called “in-plant milk-run” which will decrease the transportation costs [18]. This method is different from the other milk-run application because of the train’s capacity and the demand patterns. Just in time is very important for these problems.

4. Application

In this study, an application is made in a furniture manufacturing factory. In this factory, there is a problem for carrying the items from one cell to another cell in the factory. The tigger train is used to carry the items. In this study an optimal route for the train is obtained by using multi-objective mathematical programming. To solve the multi-objective problems, there are many methods presented in the literature. In this study, ϵ -Constraint Scalarization Method, Weighted-Sum Scalarization and The Augmented Weighted Thebycheff Scalarization Method is compared for this problem. The best of these method is used. There are 6 cells in the factory in this study. The demands of these cells are given below in Table 1.

Table 1. Results for the weighted sum method

| <i>Solutions</i> | <i>Objective (F₁,F₂)</i> | <i>Route</i> |
|------------------|--|---------------|
| 1-8 | 520,350 | 1-5-3-4-6-2-1 |
| 9-16 | 450,390 | 1-5-3-4-6-2-1 |
| 16-20 | 420,470 | 1-5-4-3-2-6-1 |
| 21 | 420,550 | 1-6-2-3-4-5-1 |

5. Mathematical Model

In this study, the mathematical model has two objectives. These are; minimizing of total carrying distance and minimizing the amount of cargo carrying. The second objective means that some packages contain more than the target cell needs. So only demand of the cells can be carried by the train. The mathematical model for this problem is given below.

5.1. Notations

i, j : Transportation node index, $i=1,2,3,\dots,6$ and $j=1,2,3,\dots,6$ cell nodes and $i, j=1$ is delivery center or depot node.

d_{ij} : Carrying distance from node i to node j .

R : A set of intermediate nodes.

u_i : It has any real value of node i .

l_{ij} : Carrying amount of item from the way i to node j .

5.2. Objective Functions

$$\min F1 = \sum_{i=1}^6 \sum_{j=1}^6 d_{ij} x_{ij} \tag{1}$$

$$\min F2 = \sum_{i=1}^6 \sum_{j=1}^6 l_{ij} x_{ij} \tag{2}$$

5.3. Constraints

$$\sum_{i=0}^{N_k} x_{ij} = 1 \quad \forall j=1,2,\dots,6 \tag{3}$$

$$\sum_{j=0}^{N_k} x_{ij} = 1 \quad \forall i=1,2,\dots,6 \tag{4}$$

$$u_i - u_j + n. x_{ij} \leq n - 1 \quad \forall i \neq j \in R \tag{5}$$

The equations (1) and (2) are the objective functions of the mathematical model. (3) and (4) constraints are pacified to visit each node at least once. Equation (5) denotes the sub-tour elimination constraint. This type of sub-tour elimination constraints, using Gomory cutting planes approach developed by Miller, Tucker and Zemlin in 1960[19]. These constraints took the tour of the state model to inhibit the formation of approximately (n^2-3n+2) lead to the addition of one constraint [20]. In particular, the use of this Miller, Tucker and Zemlin constraints in oversized model is much easier and routing problems is one of the constraints to improved well-received tour blocking.

6. Computational Results

In this study, there are two objective functions. Firstly, combining these objectives process is made. Three of leading methods in the literature applied. These methods are; The

Weighted-Sum Scalarization Method, The ϵ -Constraint Scalarization Method and The Augmented Weighted Tchebycheff Scalarization Method. For the weighted-sum scalarization method, the mathematical model is solved and the results are given in Table 1.

Second method to combine the objectives is the epsilon-constraint method. In the epsilon-constraint method, one of the objective function is written as a constraint. According to this situation, objective function and constraints have to be written below. Epsilon values are changing between 350-430. The results for the epsilon-constraint method is given in Table 2.

Table 2. Results for the epsilon-constraint method

| <i>Solutions</i> | <i>Objective (F₁,F₂)</i> | <i>Route</i> |
|------------------|--|---------------|
| 1-8 | 420,550 | 1-6-2-3-4-5-1 |
| 9-16 | 420,470 | 1-5-4-3-2-6-1 |
| 17-19 | 420,550 | 1-6-2-3-4-5-1 |
| 20-21 | 420,470 | 1-5-4-3-2-6-1 |

The augmented weighted tchebycheff function method is based on the minimization of distance from ideal point. The results for the augmented weighted tchebycheff function method is given in Table3.

Table 3. Results for the augmented weighted tchebycheff function method

| <i>Solutions</i> | <i>Objective (F₁,F₂)</i> | <i>Route</i> |
|------------------|--|---------------|
| 1-3 | 520,350 | 1-5-3-4-6-2-1 |
| 4 | 490,380 | 1-5-2-6-4-3-1 |
| 5-11 | 450,390 | 1-5-6-4-3-2-1 |
| 12-21 | 420,470 | 1-5-4-3-2-6-1 |

6. Conclusion

In this study, a multi-objective mathematical is created for the in-plant milk-run problem. The objectives of the problem are combined by three of leading methods in the literature. Then it is examined which method is more effective. According to the results that calculated by GAMS 24.7.1 program, the most efficient scalarization method for the in-plant milk-run problem is 'Augmented Weighted Tchebycheff Scalarization Method.'. It has the pare to efficient point more in many place number of these places are higher than the other methods have. The optimal point for both objective function is (F₁=420, F₂=470). And also optimal route for this in-plant milk-run is determined. The route must be 1-5-4-3-2-6-1.

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