A Loop Material Flow System Design

H. Hojabri, A. Hojabri, A. A. Jaafari, L. N. Farahani

***Abstract*— one of the common approaches to transport material handling in industries is using of automated guided vehicle (AGV) systems. There are several types of AGV; one of them is single loop that all departments have a common boundary on perimeter of the loop. In this paper we proposed a decomposition algorithm to find single loop for facility layout.**

***Index Terms*—About four key words or phrases in alphabetical order, separated by commas.**

I. Introduction

One of the oldest activities done by industrial engineers is facilities planning. The term facilities planning can be divided into two parts: facility location and facility layout (Tompkins et al. 2003). Determining the most efficient arrangement of physical departments within a facility is defined as a facility layout problem (FLP) (Garey and Johnson 1973). Tompkins and White (1984) stated that 8% of the United States gross national product (GNP) has been spent on new facilities annually since 1955. Layout problems are known to be complex and are generally NP-Hard (Garey and Johnson 1973).

If the building size and shape are given, then the three principal and interdependent design decisions in the facility layout design problem are (Kim and Goetschalckx (2005)): (1) the determination of the shapes and locations of departments within the facility, which is called the conceptual block layout problem; (2) the determination of the locations of the input and output (I/O) points on the perimeter of each department; and (3) the design of the material flow paths or aisles that connect these I/O points.

Vehicle-based internal transport systems using automated guided vehicles (AGVs) are commonly used in facilities such as manufacturing plants, warehouses, distribution centers and transshipment terminals (Le-Anh and Koster 2006).
The design and control processes of an AGVS involve many issues. The main ones are: guide-path design, estimating the number of vehicles required (or determining vehicle requirements), vehicle scheduling, idle-vehicle positioning, battery management, and vehicle routing and deadlock resolution (Le-Anh and Koster 2006).

One of the AGVS guide path configurations proposed in the previous works includes a single-loop. In the literature it is proved that the problem of determining the shortest feasible loop is a NP-complete problem.
In fact, the loop must have the following specifications (Farahani et al. (2007)):

- The loop must cover at least one edge of each cell.
- The loop must not cross itself.
- The loop must be unidirectional.
- Each cell must have exactly one P station and one D station; they must be placed on the intersections.

There are many works on single loop design that we describe as follows:

Cheng and Gen (1998) presented a genetic algorithm (GA) approach to solving single loop design problem. They combined GA algorithm with a neighborhood search algorithm to have more efficiency. Mutation operator is implemented by neighborhood search algorithm to find a improved children.

Ho (2000) developed a strategy that not only can prevent the collision of vehicles but also can avoid the disadvantage of fixed-zone strategies. There are two methods in this paper, two procedures — Zone Adjustment Procedure and Zone Assistance Procedure. An SA algorithm is developed to find near-optimal zone-division designs

Gademann and Van de Vele (2000) addressed the problem of determining the home positions for m automated guided vehicles (AGVs) in a loop layout where n pickup points are positioned along the circumference (m<n). They showed for the unidirectional flow system, any regular function can be minimized in polynomial time.

Asef-Vaziri et al. (2001) developed an exact integer programming formulation to design a loop material flow system for unit load automated guided vehicles. The model simultaneously determines both the design of the unidirectional loop flow pattern and the location of the pickup and delivery stations. The objective is to minimize the total loaded-vehicle trip distances.
Potts and Whitehead (2001) considered combined scheduling and machine layout problems in a flexible manufacturing system (FMS). Three-phase integer programming models were derived. The first phase balanced the machine workload by assigning operations to machines. The second phase minimized inter-machine travel, while respecting the workload balance attained in the first phase. In the third phase, machines were assigned to positions in the loop layout so that the total number of circuits made by the products is minimized.

Bozer and Hsieh (2004) presented an analytical approach to approximate the expected waiting times for loads arriving at the loading stations in discrete-space, fixed-window, losed-loop conveyors. The expected waiting times are important for estimating the expected work-in-process (WIP) levels at individual loading stations (which can be used to facilitate buffer sizing) and to measure the overall performance of the conveyor loop.

In this paper, we presented a decomposition approach to design single loop for block layout. The remainder of paper is organized as follows: in section II, we develop a decomposition algorithm, in section III computational result is illustrated, in section IV conclusions is discussed.

II. Algorithm

The decomposition algorithm is as follows:

H. Hojabri, A. Hojabri, A. A. Jaafari, L. N. Farahani are with Industrial Engineering Department at Amirkabir University of Technology, Tehran, Iran. (e-mail: h.hojabri1986@gmail.com).

ISBN: 978-988-18210-5-8
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

- Locate all departments in loop.
- Select a department randomly and withdraw it from the loop.
- If loop is infeasible go to step 2 else if there is not any department in the loop go to step 1.
- Stop.

To more comprehending of algorithm we exemplify a case as Figure 1 showed.

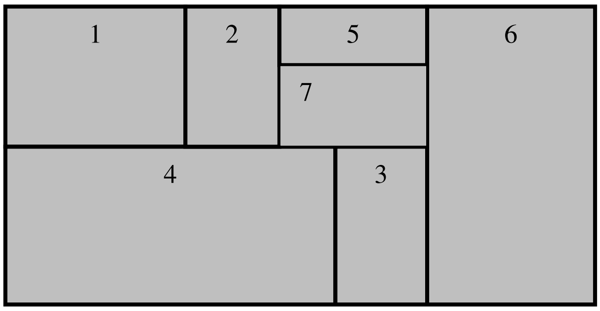

Figure 1.a. all departments is in loop.

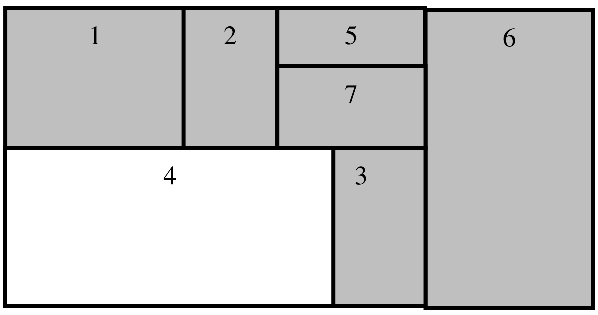

Figure 1.a. department 4 is withdraw randomly

III. Computational Results

We run test problems sizing with rang of 5 to 60 departments in a PC with 3.4 GHz CPU and 1.00 GB RAM. Table 1. shows computational results. Our algorithm can be use as a initial solution of meta heuristic algorithm, since it take less than a second even large sizes..

IV. Conclusions

One of the common approaches to transport material handling in industries is using of automated guided vehicle (AGV) systems. There are several types of AGV; one of them is single loop that all departments have a common boundary on perimeter of the loop. In this paper we proposed a decomposition algorithm to find single loop for facility layout. We show efficiency of our algorithm respect to exact approach. Our algorithm can be use as a initial solution of meta heuristic algorithm, since it take less than a second even large sizes.

Table 1. Computational results

Size	Algorithm		Exact
5	Time	Value	Value
5	0.04	28.40	22.36
5	0.83	25.71	21.02
5	0.97	55.94	43.17
5	0.62	8.37	6.74
10	0.21	43.73	34.55
10	0.37	7.02	5.45
10	0.84	22.45	18.34
10	0.08	31.05	25.42
10	0.99	61.97	47.94
20	0.42	29.97	22.27
20	0.77	53.18	38.65
20	0.30	30.79	25.16
20	0.51	40.90	32.83
20	0.95	24.07	19.77
20	0.09	27.68	21.95
30	0.08	26.84	21.85
30	0.78	48.36	35.47
30	0.72	54.85	43.26
30	0.16	12.74	10.06
30	0.59	55.50	40.35
30	0.38	58.47	44.62
40	0.76	54.70	42.58
40	0.83	17.69	12.70
50	0.71	32.73	24.96
50	0.98	42.20	32.22
60	0.56	56.46	45.36
60	0.95	49.61	40.04

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ISBN: 978-988-18210-5-8
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)