Proceedings of the International MultiConference of Engineers and Computer Scientists 2010 Vol III,
IMECS 2010, March 17 - 19, 2010, Hong Kong

An Approach for Facility Layout Problem

V. R. Golmohammadi, A. A. Jaafari, M. Bakhshayeshi Baygi, E. Esfanji, M. Rahimi

***Abstract*—In facility layout, when departments have rectilinear shape, are called block layout. One type of block layout is bay structure layout wherein departments are located in parallel rows or columns. In this paper we show if layout with k bay is infeasible then layout with $k'; k' > k$ is infeasible.**

***Index Terms*—Facility Design, Facility Layout, Flexible Bay-Structured Layout.**

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). Layout problems are known to be complex and are generally NP-Hard (Garey and Johnson 1973).

For U.S. manufacturers, between 20% to 50% of total operating expenses are spent on material handling and an appropriate facilities design can reduce these costs by at least 10% to 30% (Meller and Gau 1996). Dr. James A. Tompkins, one of the seminal researchers in the field, recently wrote, "Since 1955, approximately 8 percent of the U.S. GNP has been spent annually on new facilities. In addition, existing facilities must be continually modified.These issues represent more than $250 billion per year attributed to the design of facility systems, layouts, handling systems, and facilities locations..." (Tompkins 1997).

In a typical layout design, each cell is represented by a rectilinear, but not necessarily a convex polygon. The set of the fully packed adjacent polygons is known as a block layout (Zanjirani et al. 2007). In many researches, shapes of departments are assumed to be as a block layout (Lee et al. 2008, Kelachankuttu et al. 2007, Liu and Meller 2007, Castillo et al. 2005, Castillo and Westerlund 2005). The two most general mechanisms in the literature for constructing such layouts are the flexible bay and the slicing tree (Arapoglu et al. 2001). In bay-structured layout, departments are located in vertical columns or horizontal rows, bay, (see **Fig.1**). If numbers of bays are flexible in design of layout, layout calls flexible bay layout and fixing number of bays, layout calls fixed bay layout. In this paper we show if layout with k bay is infeasible then layout with $k'; k' > k$ is infeasible. First we describe problem in section II, then computational results are indicated in section III and at last conclusions are discussed.

V. R. Golmohammadi, A. Jaafari, M. Bakhshayeshi Baygi and M. Rahimi are with the Department of Industrial Engineering, Amirkabir University, Tehran, Iran (e-mail: ardestani.amir@aut.ac.ir, ardestanijaafari.amir@yahoo.com).
E. Sfanji is with Department of Industrial Engineering, Islamic Azad University, Tehran, Iran eesfanji@yahoo.com

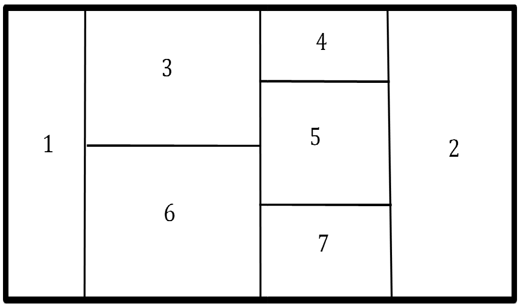

Figure 1. Bay-structured layout

II. Bay structured-layout definition

Konak et al. (2006) formulate facility layout problem using bay structure. Here, we describe notations and assumptions of it:

A. Parameters

n	Number of departments,
W	Width of the facility along the x-axis,
H	Length of the facility along the y-axis,
B	Maximum number of parallel bays,
a_i	Area requirement of department i,
α_i	Aspect ratio of department i,
l_i^{max}	Maximum permissible side length of department i
l_i^{min}	Minimum permissible side length of department i
f_{ij}	Amount of material flow between departments i and j,

B. Variables

$$z_{ik} = \begin{cases} 1, & \text{If department } i \text{ is assigned to bay } k \\ 0, & \text{Otherwise} \end{cases}$$

$$r_{ij} = \begin{cases} 1, & \text{If department } i \text{ is above department } j \text{ in the same bay} \\ 0, & \text{Otherwise} \end{cases}$$

$$\delta_k = \begin{cases} 1, & \text{If bay } k \text{ is occupied} \\ 0, & \text{Otherwise} \end{cases}$$

w_k	Width (the length in the x-axis direction) of bay k,
l_i^y	Height (the length in the y-axis direction) of department i,
h_{ik}	Height of department i in bay k,

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

(o_i^x, o_i^y) Coordinates of the centered of department i,

d_{ij}^x Distance between the centered of departments i and j in the x-axis direction,

d_{ij}^y Distance between the centered of departments i and j in the y-axis direction.

Objective function of their model is:

$$\min \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} f_{ij}\left(d_{ij}^x + d_{ij}^y\right)$$

C. Assumptions

- The coordinates of the southwest corner of the facility are (0, 0).
- In the model description, without loss of generality, the long side of the facility is along the x-axis direction, and bays are assumed to run vertically.
- If a department is assigned to a bay, the bay must be completely filled. The formulation can solve problems with $\sum_i^N a_i \leq (W \times H)$ by allowing empty space in the far west and/or east sides of the facility.
- If the aspect ratio is specified to control departmental shapes, then $l_i^{min} = \sqrt{a_i/\alpha_i}$ and $l_i^{max} = min\{H, \sqrt{a_i \alpha_i}\}$.

D. Modification of Model

In Konak et al. (2006) model, δ_k define number of bays and number of bays in optimal layout is calculated after solving model. In this paper, it is assumed that number of bays is fixed before running problem and instead of single solving model with variable number of bays; we solve problem n times with number of bays ranging between$[1, n]$.

III. Computational results

We run test problems sizing between$[5,8]$. For each size we generate 5 test problems as follows.

We generate area of departments; departmental material flows randomly between $[1,10]$ and $[1,100]$with density of 20% repetitively. Each test problem is run with aspect ratio of $1, 3$. It is assumed that facility has square shape.

Table.1. illustrate results of solving problems. For each department with various aspect ratio, it can be shown when layout with k bay is infeasible then layout with $k^{'}; k^{'} > k$ is also infeasible.

IV. Conclusion

This is paper is claimed according to computational results when layout with k bay is infeasible then layout with $k^{'}; k^{'} > k$ is also infeasible. These cause noticeable reduction of runtime. For example when $n = 8$ and in layout with $k = 5$ bays, if in layout with $k = 5$ bay there is no feasible solution, in layouts with $k = 6,7$ and8 there wouldn't be any feasible solution, too.

References

[1] Tompkins JA, White JA, Bozer YA, Tanchoco JMA (2003) Facilities planning, 3rd edn. Wiley, Chichester.

[2] Garey M. R, Johnson D. S, Computers and intractability: A guide to the theory of NP-completeness, WH Freeman, (1979) New York.

[3] Meller R. D, Gau K. Y, The facility layout problem: recent and emerging trends and perspectives, Journal of Manufacturing Systems, 15 (1996) 351-366.

[4] Tompkins, J. A., "Facilities planning: a vision for the 21st century," IIE Solutions, August (1997) 18-19.

[5] Zanjirani Farahani R, Pourakbar M, Miandoabchi E, Developing exact and Tabu search algorithms for simultaneously determining AGV loop and P/D stations in single loop systems, International Journal of Production Research, 45 (2007) 5199-5222.

[6] Lee M. L, Kim J. G, Kim Y. D, Linear programming and Lagrangian relaxation heuristics for designing a material flow network on a block layout, International Journal of Production Research, 2008, 1–18, iFirst.

[7] Kelachankuttu H, Batta R, Nagi R, Contour line construction for a new rectangular facility in an existing layout with rectangular departments, European Journal of Operational Research 180 (2007) 149–162.

[8] Liu Q, Meller R. D, A sequence-pair representation and MIP-model-based heuristic for the facility layout problem with rectangular departments, IIE Transactions, 39 (2007) 377–394.

[9] Castillo I, Westerlund J, Emet S, Westerlund T, Optimization of block layout design problems with unequal areas: A Comparison of MILP and MINLP optimization methods, Computers and Chemical Engineering 30 (2005) 54–69.

[10] Castillo I, Westerlund T, An ε-accurate model for optimal unequal-area block layout design, Computers & Operations Research 32 (2005) 429–447.

[11] Arapoglu R. A, Norman B. A, Smith A. E, Locating input and output points in facilities design-A comparison of constructive, evolutionary, and exact methods, IEEE Transactions on Evolutionary Computation, 3 (2001) 192-203.

*: inf means there is no feasible solution and fea means there is a feasible solution

Table 1. computational result

size	Num of problem	Alfa α	1	2	3	4	5
5	1	1	inf	inf	inf	inf	inf
5	2	3	inf	fea	inf	inf	inf
5	3	1	inf	inf	inf	inf	inf
5	4	3	inf	fea	fea	inf	inf
5	5	1	inf	inf	inf	inf	inf
5	6	3	inf	fea	inf	inf	inf
5	7	1	inf	inf	inf	inf	inf
5	8	3	inf	fea	inf	inf	inf
5	9	1	inf	inf	inf	inf	inf
5	10	3	inf	fea	inf	inf	inf

size	Num of problem	Alfa α	1	2	3	4	5	6
6	11	1	1	2	3	4	5	6
6	12	1	inf	inf	inf	inf	inf	inf
6	13	3	inf	fea	fea	inf	inf	inf
6	14	1	inf	inf	inf	inf	inf	inf
6	15	3	inf	fea	fea	inf	inf	inf
6	16	1	inf	inf	inf	inf	inf	inf
6	17	3	inf	fea	fea	inf	inf	inf
6	18	1	inf	inf	inf	inf	inf	inf
6	19	3	inf	fea	fea	inf	inf	inf
6	20	1	inf	inf	inf	inf	inf	inf

Continue of Table 1

size	Num of problem	Alfa α	1	2	3	4	5	6	7
7	21	1	inf	inf	inf	inf	inf	inf	inf
7	22	3	inf	fea	fea	inf	inf	inf	inf
7	23	1	inf	inf	inf	inf	inf	inf	inf
7	24	3	inf	fea	inf	inf	inf	inf	inf
7	25	1	inf	inf	inf	inf	inf	inf	inf
7	26	3	inf	fea	fea	inf	inf	inf	inf
7	27	1	inf	inf	inf	inf	inf	inf	inf
7	28	3	inf	fea	inf	inf	inf	inf	inf
7	29	1	inf	inf	inf	inf	inf	inf	inf
7	30	3	inf	fea	fea	inf	inf	inf	inf

Continue of Table 1

size	Num of problem	Alfa α	1	2	3	4	5	6	7	8
8	31	1	inf	inf	inf	inf	inf	inf	inf	inf
8	32	3	inf	fea	fea	fea	inf	inf	inf	inf
8	33	1	inf	inf	inf	inf	inf	inf	inf	inf
8	34	3	inf	fea	fea	inf	inf	inf	inf	inf
8	35	1	inf	fea	inf	inf	inf	inf	inf	inf
8	36	3	inf	fea	fea	inf	inf	inf	inf	inf
8	37	1	inf	fea	fea	inf	inf	inf	inf	inf
8	38	3	inf	fea	inf	inf	inf	inf	inf	inf
8	39	1	inf	inf	inf	inf	inf	inf	inf	inf
8	40	3	inf	fea	fea	inf	inf	inf	inf	inf

Continue of Table 1