International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 4 Issue 4 || April 2015 || PP.01-04

Optimization of Assembly Line and Plant Layout in a Mass Production Industry-A Literature Survey

Parminder Singh*, Manjeet Singh**
*PG Scholar, **Associate Professor & Head
Department of Mechanical Engineering, Guru Gobind Singh College of Modern Technology
Chandigarh-Ludhiana Highway, Kharar, Sahibzada Ajit Singh Nagar, Punjab 140 301

ABSTRACT- *In the growing global competition, optimization is the key for survival of any business organization. Among different functions in an organization, optimization plays a vital role in minimizing the wastages which automatically result in productivity improvement. This can be done starting from stage of manufacturing processes, material handling and implementation of proper plant layout. This can be done by usage of suitable techniques augmented with fitting algorithms for decision making. Process optimization is the discipline of adjusting a process so as to optimize some specified set of parameters without violating constraints. The most common goals are minimizing cost, maximizing throughput and efficiency. This is one of the major quantitative tools in industrial decision making. This paper provides a comprehensive review of discrete event simulation publications with a particular focus on applications in manufacturing. The literature is classified into three general classes of manufacturing system design, manufacturing system operation, and simulation language/package development. The current review contributes to the literature in three significant ways: (1) It provides a wide coverage by reviewing papers; (2) It provides a detailed analysis of different aspects of the literature to identify research trends through innovative data mining approaches as well as insights derived from the review process; and (3) it updates and extends the existing classification schemes through identification and inclusion of recently emerged application areas and exclusion of obsolete categories. The results of the literature analysis are then used to make suggestions for future research.*

KEYWORDS- *Field of Research Process Optimization, Ranked Positional Weight Method (RPW) and Computerized Relative Allocation of Facilities Technique (CRAFT)*

I. INTRODUCTION

Facilities location is the study of the facility placement on a detailed plot of land with respect to suppliers and other facilities. Facilities design consists of the facility systems design such as structural, environmental, lighting/electrical and safety systems etc., the layout design and the handling systems design. In general the manufacturing plant Layout is a systematic arrangement of facilities which are essential for production of goods or delivery of services. The performance of any job depends on entity of facilitates like machine tool, work centre, manufacturing cell, machine shop, department, warehouse etc. in a facility layout. Usually the manufacturing system faces layout problems which are related to the location of facilities in a plant.

1.1. Importance of Plant Layout - The basic objective of the plant layout is to develop a facility layout that should be functionally better for the industry and cost savings. For functionally better industries the placing of necessary departments such as the operating and recovery rooms should be close together and keeping apart those departments which should not be together. Overall the Facility Layout includes the features of a layout which may not be immediately quantifiable, such as facilitating communication and improving staff safety.

1.2. Plant Layout Objectives - Generally the typical plant layout should possess the following objectives:

- Economic demands such as investments in equipment and material handling cost are to be minimized.
- Requirement of product design and volume is to be satisfied.
- Requisite of process equipment and capacity such as minimize overall production time; maintain flexibility of arrangement and operations are to be justified.
- Different types of material handling equipment are to be facilitated in the manufacturing process.
- The quality of work life provided for employee convenience, safety and comfort; facilitate the organizational structure must be the basic priority.
- Requirement of building and site constraints such as utilizing existing space most effectively

II. STUDIES ON ASSEMBLY LINE BALANCING

Shtub et al., 1989 pioneered in developing assembly lines for, "a cost efficient mass production of standardized products, designed to exploit a high specialization of labour and the associated learning effects." This resulted in extensive research in this field and many organizations adopted this method.

Mather et al., 1989 implemented "multipurpose machines with automated tools swaps that allow for a facultative production sequence of varying models at negligible setup times and costs. This makes efficient flow-line systems available for low volume assembly-to-order production and enables modern production strategies like mass customization. This in turn ensures that the thorough planning and implementation of assembly system will remain of high practical relevance in the foreseeable future."

Schoniger and Spingler et al., 1911 introduced general assembly Line balancing (GLAB), under the term assembly lines balancing (GLAB) various optimization models have been introduced and, which are aimed at supporting the decision maker in configuring efficient assembly systems.

Boysen et al., 2006 did experimental studies with real-world assembly systems and emphasized importance of multiple combinations and developed flexible assembly line balancing procedures which can deal with a lot of these extensions in a combined manner. Accordingly, by Identifying typical combinations of extensions which often arise jointly in real-world assembly systems, procedures were developed which exactly fit these requirements, while decreasing the required flexibility to a minimum.

Hans-Walter Lorenz et. 2009 wrote paper on "Assembly line balancing: Which model to use when?, which discusses the importance of Assembly line balancing in the industrial production of high quality standardized commodities. Due to high capital requirements when installing or redesigning a line, configuration planning is of great relevance for practitioners. This paper structures the vast field of assembly line balancing according to characteristics practical setting and highlights relevant model extensions which are required to reflect real world problems."

III. STUDIES ON PLANT LAYOUT OPTIMIZATION

Koopman and Benckman et al., 1957 were the first to model the problem of locating plants with material flow between them. They modeled this problem as a quadratic assignment problem (QAP). Lawler et al., 1963 proved that the above integer programming problem and the QAP are equivalent. Hillier et al., 1963 developed a heuristic algorithm which is based on a move desirability table. This table consisted of values (based on a given initial layout) which represented the cost changes that would result by moving a facility from its current location to an adjacent location. The move desirability table is scanned and the maximum value is selected. Buffa et al., 1964 developed CRAFT method, the principle involved in CRAFT is so popular that it has been modified frequently. Burkard et al., 1973 proposed an optimal algorithm for solving the QAP based on the reduction of a square matrix.

Love and Wong et al., 1976 proposed a simple integer programming formulation for the QAP in which :(:) the locations are given as points on a two dimensional plane (ii) transportation costs are proportional to weighted rectangular distances. Kaufman et al., 1978 developed mixed integer program which has the smallest number of variables and constraints amongst all integer programming formulations of the QAP. Rosenblatt et al., 1979 developed a model which minimizes the transportation cost of material and maximize a closeness rating measure. Dutta and Sahu et al., 1982 developed heuristic algorithm to solve plant layout problems. Yookkasemwong et al., 1991 studied the, "production process for Cable box to form metal. The problem was that the work could not be finished within 8 hours. The problem was then studied from data collection, the actual time load, improper plant layout, and the duration of the process. The principle of systematic Layout Planning (SPL) was adapted to reduce the waste and arrange the repeated steps, resulting in changes in plant layout and staff workload. The impact of improper plant layout on the manufacturing process for valve and metal parts production was studied."Sucharitkul et al., 1999 studied the "possibility of plant layout and installing aluminum foundry. As for the layout of plant, it was done in accordance with the steps in Systematic Layout Planning."Yujie et al., 2005 studied the general plane of long yards using Systematic Layout Planning (SPL) which the best layout showed the good workflow and practical significance. W. Wiyaratn, and A. Watanapa et al., 2009 wrote journal on Improvement Plant Layout Using Systematic Layout Planning (SPL) for Increased Productivity In this case study, amount of equipments and tools in iron production were studied. The detailed study of the plant layout such as operation process chart, flow of material and activity relationship chart was investigated. The new plant layout was designed and compared with the present plant layout. The SLP method showed that new plant layout significantly decrease the distance of material flow from billet cutting process until keeping in ware house. M. Khoshnevisan et al., 2010 wrote paper on "Optimal Plant Layout design for Process focused Systems "In this paper a semi-heuristic optimization algorithm for designing optimal plant layouts in process-focused manufacturing/service facilities was proposed. The proposed algorithm marries the well-known CRAFT (Computerized Relative Allocation of Facilities Technique) with the Hungarian assignment algorithm.

IV. CRAFT ALGORITHM APPROACH (METHODOLOGY)

Computerized Relative Allocation of Facilities Technique (CRAFT) was proposed in 1964 by Buffa et al, and it is also called as computerized heuristic algorithm which takes inputs of the load matrix of interdepartmental flow and transaction costs with a representation of a block layout. The existing layout or new facility or any initial arbitrary layout is considered as a block layout. Now, the algorithm computes the department allocations and estimate the cost incurred on the layout which is observed as initial travelling cost of the layout. The impact on a cost measure for two-way or three-way swapping in the location of the facilities would be computed by the governing algorithm. The basic goal of the algorithm is to minimize total cost (TC) function. Input to develop the JAVA program Input required for applying CRAFT algorithm Number of departments = 12. Initial layout of the machine shop is taken from the AUTOCAD Diagram. Cost matrix = 1 rupee.

Steps in the development of layout:

Step 1. Get the required information such as inputs, data required for optimization and selecting the Algorithm for optimization.

Step 2. Draw a layout diagram which acts as the initial layout for the algorithm in design software like AUTO CAD.

Step 3. Convert the line diagram into a STEP file format.

Step 4. Calculate the relation between machines in the initial layout.

Step 5. Calculate the distance between the machines in the layout using available information in STEPfile.

Step 6. Calculate the Part flow matrix, which used as input to the CRAFT Algorithm.

Step 7. The initial layout cost is calculated using Part flow matrix, distance matrix.

Step 8. The optimization of cost for initial layout is done by the replacement of the machines.

Step 9. The final result of the program is a layout with optimized cost.

V. RESULT

In this paper the layout cost is calculated by taking the distance matrix and flow matrix. The distance matrix is obtained by converting the layout diagram into STEP File format which is taken as input to java program and output is obtained as distance matrix. The initial layout is now optimized in order to reduce the layout cost which is done by replacements of machines in a proper sequence such that the distance matrix is altering every time and due to this the layout cost is changed.

VI. CONCLUSION

Traditionally, the Quadratic Assignment Problem (QAP) model has been used for layout problems. The QAP was introduced by Koopmans and Beckman in 1957 for modeling the problem of locating interacting plants of equal areas. The QAP has been widely applied in various applications such as urban planning, control panel layout and wiring design and also stated that the QAP is a special case of the facility layout problem due to the assumptions that all departments have equal areas and locations are fixed with a known priority. The well-known Construction algorithms like CORELAP (Computerized Relationship Layout Planning) and ALDEP (Automated Layout Design Program) produce the solution initio without requiring any starting layout. Improvement algorithms, such as CRAFT and COFAD (Computerized Facilities Design), were used to start with an initial layout and try to improve it with exchanging facility. Hybrid approaches provides both construction phase and final improvement of arranging facilities. In order to minimize material handling cost a genetic algorithm methodology was adopted for solving quadratic assignment problems. An improved genetic algorithm was proposed to solve the unidirectional loop layout in order to optimize the facilities in workshop. A standards-oriented form-feature extraction system was developed which is known as STEP File format and it is very easy to extract the AutoCAD diagram into step file format. Presented a model which is mainly projected to extract the geometric information of rotational parts from STEP file, and this information is use to recognize the features. A generalized Java code is used to extract the data from STEP file and to recognize the features.

REFERENCES

[1] Armour, F. C. and E. S. Buffa, "A Heuristic Algorithm and Simulation Approach to Relative Location of Facilities," Management Science, 10, 294-309, 1963.

[2] Askin R. G. & Standri ge, C. R. (1993). Modeling and analysis of manufacturing systems; John Wiley and Sons Inc, ISBN 0-471-51418-7

[3] Benjaafar, S. and M. Sheikhzadeh, Design of Stochastic Plant Layouts," IIE Transactions, in press.

[4] Baybars, L. (1986).A survey of exact algorithms for the simple assembly line balancing problems. Management science, Vol. 32, No.8, (August, 1986).

[5] Becker C. and Scholl, A.(2004).A survey on problems and methods in generalized assembly line balancing , European Journal of Operations Research, in Press.

[6] Boysen, N., Fliedner, M. & Scholl, A. (2006). A classification of assembly line balancing problems. European journal of operational research, Elsevier, Vol 183, No. 2 (December, 2007)

[7] Buzacott, J. A. and J. G. Shantikumar, Stochastic Models of manufacturing Systems.

[8] Falkenauer, E. and Delchambre, A.(1992).A Genetic Algorithm for Bin Packing and Line Balancing, Proceedings of the 1992 IEEE International Conference on Robotics.

[9] Falkenauer, E. and Delchambre, A.(1992).A Genetic Algorithm for Bin Packing and Line Balancing', Proceedings of the 1992 IEEE I nternational Conference on Robotics and Automation, May 10-15, 1992, Nice, France. IEEE Computer Society Press, Los Alamitos.
[10] Falkenauer, E. (1997)'A Grouping Genetic Algorithm for Line Balancing with Resource Dependent Task Times', Proceedings of the fourth International Conference on neural Information Processing (ICONIP'97), University of Otago, Dunedin, New Zealand, November 24-28, 1997. pp 464-468.Conference proceedings.
[11] Falkenauer, E. (1998) Genetic Algorithms and Grouping Problems, John Wiley & Sons, Chichester, UK Book.
Fu, M. C. and B. K. Kaku, "Minimizing Work-in-Process and Material handling in the facilities Layout Problem," IIE Transactions, 29, 1, 29-36, 1997.
[12] Fu, M. C. and B. K. Kaku, "Minimizing Work-in-Process and material Handling in the Facilities Layout Problem," Technical Report TR 95-41, University of Maryland, College Park, Institute for Systems Research, 1995.
Foulds, L. R., "Techniques for Facilities Layout: Deciding which Pairs of Activities Should be Adjacent," Management Science, 29, 12, 1414-1426, 1983.
[13] Garey M. R. and Johnson D. S.(1979) Computers and intractability-A Guide to the Theory of NP-Completeness, W.H. Freeman Co., San Francisco, USA Book.
[14] Gu, L., Hennequin, S., Sava, A., & Xie, X.(2007).Assembly line balancing problem solved by estimation of distribution, Proceedings of the 3rd Annual IEEE conference on automation science and engineering scottsdale, AZ, USA.
[15] Johnson, M. E. and M. L. Brandeau, "An Analytic Model for Design and Analysis of Single Vehicle Asynchronous Material Handling System," Transportation Science, 28, 4, 337-353, 1994.
[16] Johnson, M. E. and M. L. Brandeau, "Stochastic Modeling for Automated Material Handling System Design and Control," Transportation Science, 30, 4, 330-350, 1996.
[17] Johnson, M. E. and M. L. Brandeau, "An Analytic Model for Design of a Multivehicle Automated Guided Vehicle System," Management Science, 39, 12, 1477-1489, 1993.
[18] Kouvelis, P. and A. S. Kiran, "The Plant Layout Problem in Automated Manufacturing System," Annals of Operations Research, 26397-412, 1990.
[19] Kusiak A. and S. S. Heragu, "The Facility Layout Problem," European Journal of Operational Research, 27, 229-251, 1987.
[20] Li, W. And J. M. Smith, Stochastic quadratic Assignment Problems in "Quadratic Assignment and Related Problems," Editors: P. Pardalos and H. Wolkowicz, American Mathematical Society , DIMACS Series in Discrete Mathematics, 221-236, 1994.
[21] Little, J. D. C., "A Proof of the Queuing Formula L=1W," Operations Research, 9, 383-387, 1961.
Meller, R. And K. Y. Gau, "The Facility Layout Problem: Recent and Emerging Trends and Perspectives," Journal of Manufacturing Systems, 15, 5, 351-366, 1966.
[22] Papadopoulos, H. T; Heavey, C. & Browne, J.(1993). "Queuing Theory in Manufacturing Systems Analysis and Design"; Chapman & Hall, ISBN 0412387204, London, UK
[23] Pardalos, P. And H. Wolkowicz (Editors), Quadratic Assignment and Related Problems, American Mathematical Society, DIMACS Series in Discrete Mathematics, 221-236, 1994.
[24] Thonemann, U. W. And M. L. Brandeau, "Designing a Single Vehicle Automated Guided Vehicle System with Multiple Load Capacity," Transportation Science, 30, 4, 330-350, 1996.
[25] Ponnambalam, S. G., Aravindan, P. & Naidu, G.M. (1999).A Comparative evaluation of assembly line balancing heuristics. International journal of advanced manufacturing technology, Vol.15, No. 8 (July 1999), pp. (577-586), ISSN:0268-3768
[26] Rekiek, B. & Delchambre, A.(2006). Assembly line design, the balancing of mixed-model hybrid assembly lines using genetic algorithm; Springer series in advance manufacturing, ISBN-10:1846281121, Cardiff, UK
[27] Rubinovitz, J. & Levitin, G.(1995).Genetic algorithm for assembly line balancing , International Journal of Production Economics, Elsevier, Vol.41, No.1-3 (October, 1995), pp(343-354), ISSN 0925-5273
[28] Sabuncuoglu, I., Erel, E. & Tanyer, M.(1998).Assembly line balancing using genetic algorithms. Journal of intelligent manufacturing, Vol.11, No. 3(June, 2000), pp.(295-310), ISSN:0956-5515.
[29] (1993).Data of assembly line balancing problems. Retrieved from http://www.wiwi.uni-jena.de/Entscheidung/alb/, last accessed: 07 February 2008
[30] Scholl, A. (1999). Balancing and sequencing of assembly lines, Second edition, Heidelberg: Physica, 318s, DM98, 00, ISBN:3790811807.
[31] Suresh, G. & Sahu, S. (1994).Stochastic assembly line balancing using simulated annealing, International journal of production research, Vol. 32, No.8, pp.(1801-1810), ISSN:1366-588X(electronic)0020-7543(paper).
[32] Tasan, S. O. & Tunali, S.(2006). A review of current application of genetic algorithms in assembly line balancing, Journal of intelligent manufacturing, Vol.19, No. 1 (February, 2008), pp. (49-69), ISSN:0956-5515.
[33] Vilarinho, P. M. & Simaria, A.S. (2006).ANTBAL: An ant colony optimization algorithm for balancing mixed-model assembly lines with parallel workstations, International journal of production research, Vol 44, Issue 2.