The Facility Layout Problem and Software Packages -A Review

Sugat Meshram[1#], Prof. R. S. Dalu[2#]
[1.] Sugat Meshram (Mtech student Production engineering)
[2.] Prof. R.S.Dalu Professor and Head of Department(Mechanical)
Government College of Engineering, Amravati, INDIA

Abstract— **Layout problems are found in several types of manufacturing systems. This paper deals with the illustration of software and methodology of solving layout problems using software. This paper illustrates two software i.e. Factory Layout Planner and Spiral. Typically, layout problems are related to the location of machines and departments in a plant. They are known to greatly impact the system performance. A few literature reviews papers are available, but they are restricted to certain specific aspects of these problems.**

Keywords—component; formatting; style; styling; insert (key words)

I. Introduction of layout

Flexible manufacturing systems (FMS) play a crucial role in modern complex production lines. Such systems generally consist of a group of machines capable of performing a number of different operations, interconnected through an automated parts-transportation and handling mechanism all operating under the hierarchical control of a common computer system. The layout of the machines has a significant impact to the material-handling cost, the time of processing, the throughput of the production system, and therefore affects the overall productivity of the FMS. The layout of machines in a FMS is typically determined by the type of material-handling device used such as material-handling robots, automated guided vehicles (AGVs), gantry robots, etc.

II. Factory Layout Planner

The Factory layout Planner described in this, wedge technologies to become a real new environment supporting the design lifecycle of a factory layout. The Factory Layout Planner (FLP) allows the multi-user, network-based visual creation and management of a factory layout: the design team can co-operate on the same layout both acting on a common multi-touch device and collaborating from different part of the world. Moreover, a key element in this revolution is the capability to provide an “adherent to reality” representation of manufacturing process, as gain highlighted in the “Manufacture Strategic Research Agenda”.

State of the art technology in layout design and simulation is represented by some huge software suites that aim to provide a comprehensive support from the product to the process design and management. The most important references are Dassault Systemes – Delmia V6 [DEL], and Siemens - Tecnomatix 9 [TEC], that support both layout design and simulation, and integrate tools for task programming and production process management; Visual Components [VIS] supports 3D components programming and assembly for an easy layout design and simulation. Some minor 3D configuration software tools have been recently developed for product variants management. These tools can be easily adapted to layout design but they don’t support any simulation of the plant and are not meant to be collaborative.

III. Client Application Showcase

The Factory Layout Planner is a client/server application that enables the collaborative development of a factory layout. There are three key features of the FLP: the 3D visual editing of the layout, the possibility to act on the same layout in a distributed environment, the ability to perform Discrete Events Simulation (DES) on the layout that the user is composing.

The collaboration on the layout can be both remote and local: while the first allow user distributed all over the world to cooperate in the layout creation, the latter allow users to act on the same device in the same time on a common model. The FLP aims to cover both the aspect of the collaboration issue, that is a more sensible issue in the nowadays global market; despite only the fist aspect of the collaboration is deeply described: the possibility to collaborate on a common layout, in the same time, over a network architecture. The architecture of this application is a two-level architecture with a fat client: the server is mainly a synchronization manager and a repository, while, on the client side, the most of the computation is performed: this enables the optimal usage of the computing resources. As an example, with this architecture it is possible to minimize the network data flow and exploit the hardware potentiality of the client (e.g. graphics card). Performance is a key factor when dealing with complex 3D model and real time requirements.
The following pictures shows the main user interface elements of the FLP.

Figure 1: Connect dialog

Figure 2: FLP client application

The user connects to a server using the dialog show in Figure 1 and can choose to create a new document or edit an existing one. The documents are stored on the central server and the application maintains an updated local copy. Once the connection to the server is established, the application also synchronizes its local copy of the catalogue of available equipments (templates) that are presented in the catalogue browser (left of the working area in Figure 2). This update is done in background, without blocking the usage of the application while the entire catalogue is downloaded. On the contrary, if some template is required to open an existing document, the download of such element is prioritized to ensure that the latest version of the resource is available.

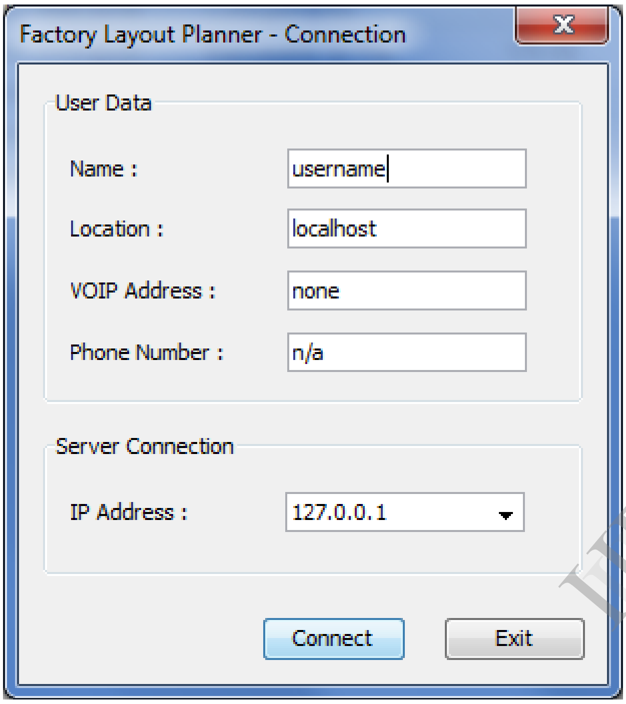

Figure 1: Connect dialog

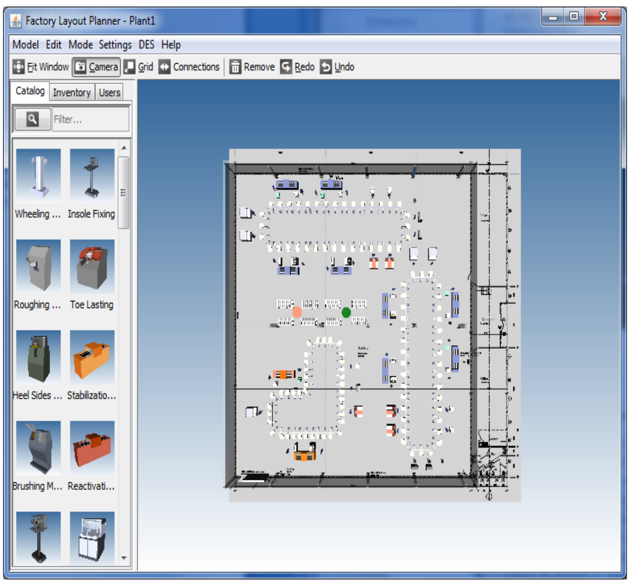

Figure 2: FLP client application

The catalogue is managed with drag & drop support: new objects can be added to the virtual scene simply dragging the icon from the catalogue to the 3D view. Properties of any element, its position and orientation, are all available by double clicking on the element itself.

Most of the application window is occupied by the 3D view of the layout. The user can interact with it using the mouse and the desired interaction mode:

• Camera: In this mode, the mouse is used to explore the layout: pan, zoom and rotate function are available for natural navigation in the 3D scene.

• Edit: This is the main mode used to modify the layout. The objects can be selected, grouped, moved, rotated and their properties viewed and edited. A snap grid can optionally be enabled to assist the positioning of the objects.

• Connection: When this mode is enabled, the user can connect objects to create logical relationship useful for the DES simulation. The available ports are shown and the user can connect then tracing lines from one port to the other.

IV. DATA STORAGE

The catalogue is a collection of different type components (machines, resources, operators…) used for the layout, described by a set of files. For each component the FLP stores:

• Image file (JPEG) used to visualize the component in the catalogue browser

• XML file defining objects relationships with frames1 and joints and referring to geometrical aspect (3D XML)

• VRML file to define the 3D appearance of the objects (such file format is usually easy exportable from any CAD system)

• Java class in a JAR file that describe the behavior of a component

• Properties file for DES parameters and ports. An important aspect of the data concerns naming. In fact the FLP can handle components without the need of knowing their details (the catalogue is dynamically extensible without changing the FLP); further the files building a component come from different independent sources (e.g. CAD system, XML editors, Java programming environment). For those reasons, it happens that the same item (port, frame or property) is cross referenced in more than one file.

This requires a consistent naming within a template. For example: a new component "roughing machine" has a specific parameter "roughing-level". Defining this parameter as a property in the properties XML file enables the FLP to show the parameter in a dialog and let the used change its value. The same parameter is used in the Java class defining the behavior of the component during DES simulation. Finally all the files mentioned above are listed in a catalogue.xml with the version used by client: this technique allows discovering the user local copy is synchronized with the server one. Thus for each item it is specified the template name, a label, the URL of the 3D XML, the URL of the preview image, the URL of the properties file, the template category, a description, the version number and a list of URLs of required resources. The XML of the catalogue is validated against XSD [XSD04] (catalogue.xsd) to ensure the data to be coherent with the data model used by the FLP. The FLP uses a XML file for each factory layout. This file contains all the instances of objects that are in the layout. Those objects are described by an identifier (ID), a reference template name, the properties values, a position and all the connections to other objects.

V. DISCRETE EVENT SIMULATION (DES)

The FLP can run DES simulation on a layout. Besides the layout and connections, to perform a DES simulation the FLP needs also a production plan and the operation flows. Both are stored in XML files: while the first contains the plan in term of product codes and quantities, the second contains the sequence of operations needed by each product. This information is used to construct a complete DES model: the approach is to be as much as possible independent from the simulation execution library.

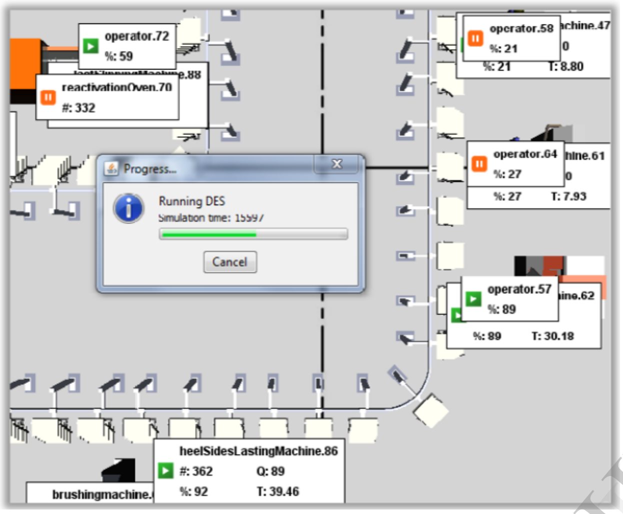

Figure 3: A running DES simulation

Thus topic has presented an innovative tool for the factory layout planning. The capability to support a collaborative editing of the layout (possibly distributed) in a 3D environment, and the integrated DES possibilities, makes FLP to be an high value adding tool for cost-effective and rapid creation, management and use of the Next generation factory. Topic highlights how all the efforts in the design and development of this tool went in the direction of creating a comfortable environment for the layout designer and his team.

VI. A HIERARCHICAL AHP/DEA METHODOLOGY FOR THE FACILITIES LAYOUT DESIGN PROBLEM

Layout design often has a significant impact on the performance of a manufacturing or service industry system and is usually a multiple-objective problem. Neither an algorithmic nor a procedural layout design methodology is usually effective in solving a practical design problem. This topic proposed a hierarchical analytic hierarchy process (AHP) and data envelopment analysis (DEA) approach to solve a plant layout design problem. A computer-aided layout-planning tool was used to generate a considerable numbers of layout alternatives as well as to generate quantitative decision making unit (DMU) outputs.

A. *Introduction of Packages*

Algorithmic approaches usually simplify both design constraints and objectives in order to reach a surrogate objective function, the solution of which can then be obtained. The majority of the existing literature reports on algorithmic approaches (Heragu, 1997). Algorithmic approaches can generate layout alternatives efficiently, particularly, when commercial software is available, e.g., Spiral_ (Goetschalckx, 1992) and LayOPT_ (Bozer et al., 1994). However, the resulting quantitative results often do not capture all of the design objectives. Procedural approaches can incorporate both qualitative and quantitative objectives in the design process (Muther, 1973). The success of a procedural approach implementation is dependent on the generation of quality design alternatives, often provided by an experienced designer. Thus, such an approach may be subjective and may generate an inferior solution due to a lack of a sound scientific foundation. Accordingly, both possible subjectivity and inefficiency hinder the adoption of a procedural approach to solve a layout design problem

VII. PROPOSED METHODOLOGY

A. *Data collection*

Data collection should include characteristics of products, quantities, routing, support, and time considerations, in order to assure the validity of the input data at the design stage. The design objectives usually include both quantitative and qualitative criteria. The outputs of this stage become the inputs for the proposed hierarchical analysis procedure.

B. *Layout alternative generation*

This step adopts a computer-aided layout planning tool, e.g., (Spiral_, 1999), ALDEP (Seehof and Evans, 1967), BLOCPLAN (Donaghey and Pire, 1990), etc., to efficiently investigate a large number of design alternatives. When only few alternatives are evaluated, the final solution may be trapped in a local optimum and may be inferior. A computer-aided tool can quickly provide quantitative performance measures that become parts of the DMU outputs.

Available floor space ¼ 99.25 m (width) _ 27.00 m (length)

No. Department name Size (m2)

1 Wafer sawing	89.21
2 Die bond	181.51
3 Wire bond	577.38
4 Molding	599.57
5 Dejunk/trimming and curing	183.71
6 Electro deflash/solder platting	500.13
7 Marking	199.94
8 Forming and singulation	186.40
9 Lead scanning/inspection	110.78
10 Packaging	51.09

Table no: 1

VIII. DATA COLLECTION

The IC packaging process is divided into 10 departments in A-company existing layout. The material flow is from departments 1 to 10 sequentially, regardless of product type. The departmental sizes and the existing layout design are shown in Table 1 and Fig. 4. The performance measures are determined by the discussions with A-company management and by general layout guidelines. They are: flow distance, adjacency score, shape ratio, flexibility, accessibility, and maintenance.

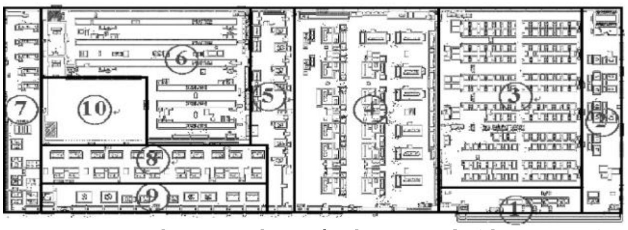

Figure 4: The existing layout for the case study (alternative 18)

IX. LAYOUT ALTERNATIVE GENERATION

Spiral_ (1999) was used for layout generation. Flow routing was converted to a form to chart, which together with departmental sizes then became the input to Spiral. Spiral generated a layout alternative based on its embedded algorithm. We then choose its improvement algorithm, three-way pair wise interchange, to generate a large number of alternatives ranking by flow distance in ascending order. Since the sample size in terms of the number of layout alternatives is large, the final solution is not sensitive to the sample generation process. In addition, Spiral has warranted the solution quality at least for one evaluation criterion for those selected design alternatives. Since there were six output measures, the number of DMUs should be more than 12. A preliminary study selected 17 alternatives for further evaluation as shown. Note that alternative 18 is A-company's current layout. The quantitative measures for those design alternatives are shown in Table 2.

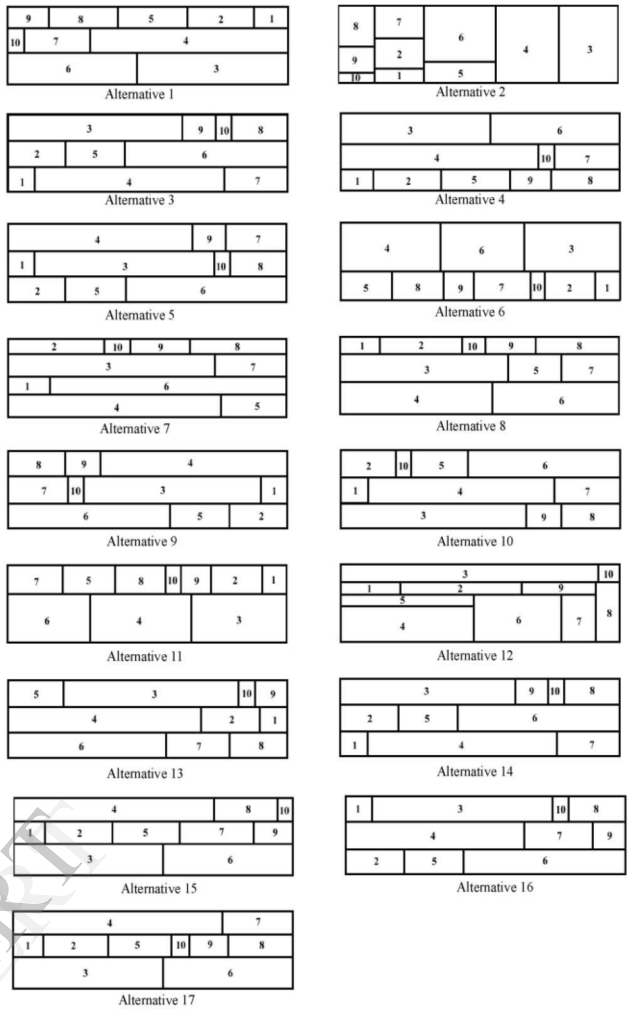

Figure 5: Layout alternatives from Spiral.

Quantitative measures for layout alternatives

DMU No:	Distance (m)	Adjacency	Shape ratio
1	185.95	8	8.280
2	207.37	9	3.750
3	206.38	8	7.850
4	189.66	8	8.280
5	211.46	8	7.710
6	264.07	5	2.070
7	228.00	8	14.000
8	185.59	9	6.250
9	185.85	9	7.850
10	236.15	8	7.850
11	183.18	8	2.000
12	204.18	8	13.300
13	225.26	8	8.140
14	202.82	8	8.000
15	170.14	9	8.280
16	216.38	9	7.710
17	179.80	8	10.300
18	5.75	10	10.160

Table no: 2

X. DEA FOR FINAL DESIGN

The modified BCC model was solved by efficiency analysis software, Frontier Analyst_ (1998). The resulting efficiency measures are shown in Table 3.

Qualitative measures for layout alternatives

DMU No:	Flexibility	Accessibility	Maintenance
1	0.0494	0.0294	0.0130
2	0.0494	0.0147	0.0519
3	0.0370	0.0147	0.0519
4	0.0370	0.0147	0.0519
5	0.0617	0.0147	0.0390
6	0.0494	0.0147	0.0519
7	0.0247	0.0735	0.0649
8	0.0370	0.0441	0.0390
9	0.0741	0.0441	0.0519
10	0.0741	0.0588	0.0649
11	0.0864	0.1029	0.0909
12	0.0370	0.0588	0.0260
13	0.0247	0.0735	0.0519
14	0.0247	0.0588	0.0519
15	0.0864	0.1176	0.1169
16	0.0741	0.0735	0.0519
17	0.0988	0.1324	0.0909
18	0.0741	0.0588	0.0390

Table no: 3

XI. FINAL EFFICIENCY SCORES

DMU No:	Efficiency score
1	91.69
2	98.45
3	86.39
4	89.94
5	86.44
6	96.62
7	80.77
8	96.51
9	95.69
10	87.44
11*	100.00
12	85.72
13	86.29
14	86.66
15*	100.00
16	96.74
17	94.63
18*	100.00

Table no: 4

The results showed that alternatives 11, 15, and 18 were the performance frontiers. They are equally viable candidates of the final design. A company existing layout (DMU no. 18) was considered to be efficient.

XII. CONCLUSION

This paper focus on the few software packages with their illustration and examples. A brief investigation can be done for any type of layouts using the available packages and also there is the growing market for the software related to layout design . Thus topic has presented an innovative tool for the factory layout planning. Few software mention in this paper are widely used for facilities problems and construction.

XIII. REFERENCES

1. Fuller, R.B. (1982): Synergetic: Explorations in the geometry of thinking.EJ Apple white, Macmillan Pub Co (Ed.)
2. European Commission, MANUFUTURE – a vision for 2020, November 2004
3. Bathelt, J., Boër, C.R., Chryssolouris, G., Constantinescu, C., Dépincé, P., Pappas, M., Pedrazzoli.
4. Rovere, D., Westkämper, E. (2007): High Value Adding Virtual Reality Tools for Networked Customer- Driven Factory. Proceedings of the 4th International Conference on Digital Enterprise Technology, pp. 347-352. September 19-21, Bath,United Kingdom. Maropoulos, Paul (Ed.), CIRP u.a
5. Boër, C.R, Jönsson, A., Pedrazzoli, P., Sacco, M., (2006): Virtual Factory Framework: key enabler for future manufacturing. Digital enterprise technology: perspectives and future challenges, pp 83-90, Springer, 1
6. F. Howell, R. Mcnab, “simjava: A Discrete Event Simulation Library for Java”, In International Conference on Web-Based Modeling and Simulation, 1998, pp 51—56.
7. XML Schema, W3C Recommendation 28 October 2004, [RMI]
8. J. Postel, J. Reynolds, File Transfer Protocol, Request for Comments number 959, Internet Engineering Task Force, October 1985, http://www.ietf.org/rfc/rfc959.txt
9. DELMIA Digital Manufacturing & Production, [TEC] Siemens Tecnomatix9,
10. Apple, J.M., 1997.Plant Layout and Material Handling, 3rd ed. Wiley, New York.
11. Banker, R.D., Charnes, A., Cooper, W.W., 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science 30 (9), 1078–1092.
12. Bozer, Y.A., Meller, R.D., Erlebacher, S.J., 1994.An improved- type layout algorithm for single and multiple-floor facilities. Management Science 40 (7), 918–932.
13. Bowlin, W.F., 1987.Evaluating the efficiency of US air force real-property maintenance activities. Journal of Operational Research Society 38, 127–135.
14. Cambron, K.E., Evans, G.W., 1991.Layout design using the analytic hierarchy process. Computers and Industrial Engineering 20 (2), 211–229.
15. Carmone, F.J., Kara, A., Zanakis, S.H., 1997.A Monte Carlo investigation of incomplete pairwise comparison matrices in AHP. European Journal of Operational Research 102, 538–553.
16. Charnes, A., Cooper, W.W., Rhodes, E., 1978.Measuring the efficiency of decision making units. European Journal of Operational Research 2, 429–444.
17. Donaghey, C.E., Pire, V.F., 1990.Solving the facility layout problem with BLOCPLAN Industrial Engineering Department.
18. Donegan, H.A., Dodd, F.J., 1991.A note on Saaty_s random indexes.Mathematical and Computer Modeling 15 (10), 135–137.
19. Finan, J.S., Hurley, W.J., 1999.Transitive calibration of the AHP verbal Scale. European Journal of Operational Research 112, 367–372.
20. Foulds, L.R., Partovi, F.Y., 1998. Integrating the analytic hierarchy process and graph theory to model facilitates layout. Annals of Operations Research 82, 435–451.
21. Frontier Analyst user_s manual 1998. Banxia Software,Glasgow, Scotland.
22. Goetschalckx, M., 1992. An interactive layout heuristic based on hexagonal adjacency graphs. European Journal of Operational Research 63, 304–321.
23. Harker, P.T., 1987.Incomplete pairwise comparisons in theanalytic hierarchy process. Mathematical Modeling 9 (11), 837–848.