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Plant Layout Analysis by Computer Simulation for Electronic Manufacturing Service Plant

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***Abstract*—**In this research, computer simulation is used for Electronic Manufacturing Service (EMS) plant layout analysis. The current layout of this manufacturing plant is a process layout, which is not suitable due to the nature of an EMS that has high-volume and high-variety environment. Moreover, quick response and high flexibility are also needed. Then, cellular manufacturing layout design was determined for the selected group of products. Systematic layout planning (SLP) was used to analyze and design the possible cellular layouts for the factory. The cellular layout was selected based on the main criteria of the plant. Computer simulation was used to analyze and compare the performance of the proposed cellular layout and the current layout. It found that the proposed cellular layout can generate better performances than the current layout.

***Keywords*—**Layout, Electronic Manufacturing Service Plant (EMS), Computer Simulation, Cellular Manufacturing System (CMS).

I. Introduction

LAYOUT design and the flow of materials have a significant impact on performance of manufacturing system [1]. These can help to increase productivity, reduce work in process and inventory, short production lead time, streamlines the flow of materials, and reduce non-value added activities from the production process of waiting and transportation, which make the factory meet customers' requirement rapidly [2]. There are many types of layout designs in manufacturing system such as process layout, product layout and cellular layout. A process layout is suitable for a high degree of interdepartmental flow and little intradepartmental flow. It is proper for low-volume, high-variety environment. On the other hand, a product layout is used for high-volume, low-variety environment. A cellular layout is suggested for medium-volume and medium-variety environment [3], [4]. This kind of layout is also appropriate for both automated and non automated manufacturing systems. It can be designed based on Group Technology (GT) [5]. GT manufacturing offers several advantages which tend to improve productivity of a facility and reduce its operating costs, waiting time between process, machine setup time, distance and handling of work pieces, flow of materials between workstations. Several empirical studies confirmed these advantages [1], [2], [5], [6].

One of the effective methods for layout design was proposed by Muther, which is called Muther's systematic layout planning (SLP) [4]. This method presents layout planning step that can be used sequentially to develop new layout or improve existing layout [4]. However, it is difficult to evaluate the layout until that layout is implemented.

Simulation is a powerful modeling and analysis technique used to evaluate and improve dynamic systems of all types [7]. It was used to assess the performance of the production lines, sequencing and lot sizing [8]-[10]. It can also be used to evaluate the new layout before implementation.

In this research, a case study of an electronic manufacturing service (EMS), which currently uses process layout, is presented. EMS is a term used for companies that design, test, manufacture, distribute, and return/repair services for electronic components and original equipment manufacturers (OEMs). The business model for the EMS industry is to specialize in large economies of scale in manufacturing, raw materials procurement and pooling together resources, industrial design expertise as well as creating added value services such as warranty and repairs [11]. There are varieties of orders under vast customers. These mean EMS companies have many types of products to produce in different production routes and have large volume. So, the situation of existing plant is in a mess due to process layout. New layout for high-volume and high-variety environment is considered. Cellular layout is selected for implementation in one part of the current production plant due to the necessity of reduction of time, distance and flow within the manufacturing plant. Moreover, some of variety products can be grouped as group families. Then, SLP is applied for creating alternative layouts and the most appropriate one will be selected. Next, the best layout design is compared with the current layout by computer simulation.

II. Plant Layout Analysis

The case study factory needs to improve the current plant to cellular plant layout for increasing its flexibility. All of plant information is gathered and analyzed as shown in the following subsections.

A. Data Collection

The case study factory is an EMS industry which provides design, test, manufacture, distribute, return/repair services, and assemblies for electronic components and original equipment manufacturers (OEMs). There are a variety of products and demands which depend on customer demand, material, manufacturing process, and product life cycle. Fundamental data of the factory such as product data, manufacturing

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process data, flow process (routing), layout patterns, manufacturing facilities and relationship between each process are collected. The current factory layout can be shown in Fig. 1. Regarding to the results from the fundamental data, the product group, called "Charm" is selected to study, due to increasing of its demand. Two subgroups of products (P1-P8) can be formed by process flow analysis (PFA). The 1st group contains P1, P2, P3, P7, and P8 and the 2nd group contains P4, P5, and P6. Currently, the layout of the factory is a process layout. There are 17 major manufacturing processes for these two groups as shown in Table I. Relationship chart can be shown as in Fig. 2. Space for each process departments are shown in Table II.

TABLE I
PROCESSES OF PRODUCTS IN THE SCOPE OF THE STUDY

Product Name Process	P1	P2	P3	P4	P5	P6	P7	P8
1. Part preparation	1	1	1	1	1	1	1	1
2. SMT	1	1	1	1	1	1	1	1
3. AOI	1	1	1	1	1	1	1	1
4. 2nd	1	1	1	1	1	1	1	1
5. ICT	1	1	1	1	1	1	1	1
6. Masking	1	1	1	1	1	1	1	1
7. Coating	1	1	1	1	1	1	1	1
8. Unmasking	1	1	1	1	1	1	1	1
9. De-panel	1	1	1	1	1	1	1	1
10. Laser marking	1	1	1	1	1	1	1	1
11. TLA	1	1	1	1	1	1	1	1
12. Welding	1	1	1	1	1	1	1	1
13. FCT	1	1	1	1	1	1	1	1
14. Hipot test				1	1	1		
15. Thermal test	1	1	1	1	1	1	1	1
16. QA	1	1	1	1	1	1	1	1
17. Packing	1	1	1	1	1	1	1	1

The performance measures are determined by discussions with the company's management and by general layout guidelines. Criteria which are generally considered in layout design are flexibility involves variability and future of expansion, accessibility in material handling and operator paths, maintenance involves require space and tool movement, net present value and quality in production and product [1], [12], [13]. Criteria for the EMS industry that has been evaluated are "material handling", "layout characteristic", "cost" and "flexibility".

"Material handling" is an important topic of the overall facilities design that providing "right sequence". It can help eliminate non value added operation and reduce the variance of delivery time between elements. Work simplification can be provided and efficiency of material flow can be increased [4].

TABLE II
SPACE OF CURRENT LAYOUT, TOTAL 127.87 M^2

Process	Size (m^2)
1. Part preparation	3.24
2. Surface Mount Technology: SMT	32.88
3. Auto Optical Inspection: AOI	7.34
4. 2nd Assembly: 2nd	3.12
5. In Circuit Test: ICT	15.08
6. Masking	2.82
7. Coating	7.76
8. Unmasking	2.82
9. De-panel	3.10
10. Laser marking	3.02
11. Top Level Assembly: TLA	15.68
12. Welding	1.32
13. Functional Test: FCT	3.60
14. Hipot test	1.62
15. Thermal test	19.52
16. QA inspection: QA	2.19
17. Packing	2.76

"Layout characteristics" are styles or features of plant layout that can be visual. It is can be said that the plant layout is good or not with the visualization distance and a unity of production processes.

"Cost" is a very important criterion for top management decision. It has often been a more critical one. It includes an initial investment and operating cost.

Flexibility of plant layout is also a crucial criterion for the EMS plant because of the nature of EMS, which has to produce many types of products. Moreover, changes of product design often occur.

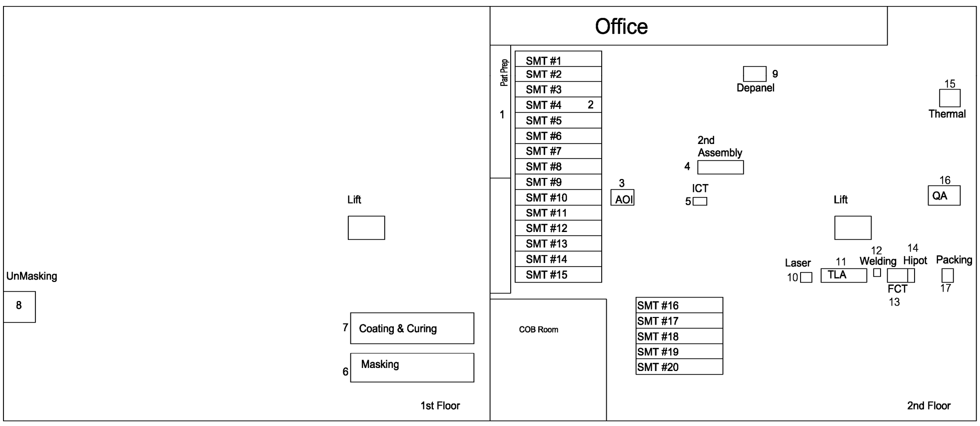

Fig. 1 The existing layout for case study

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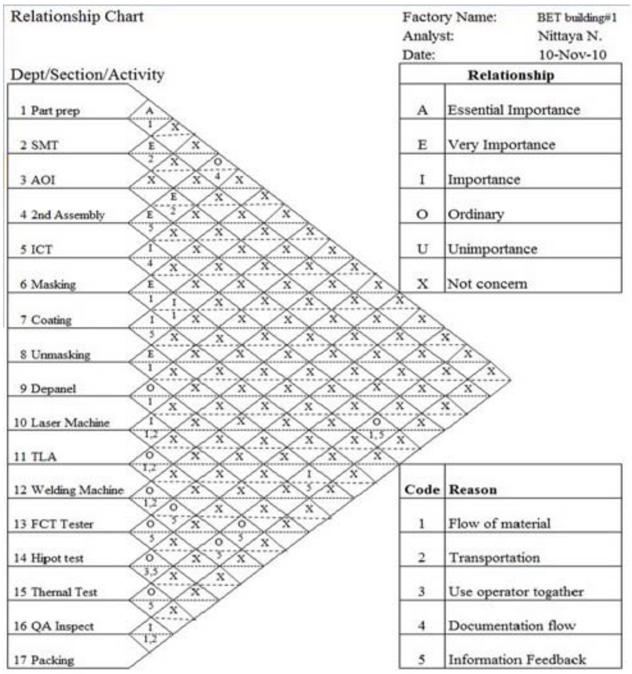

Fig. 2 The relationship chart

B. Layout Alternatives Generation and Selection

Alternative layouts are generated based on the existing layout and some significant limitations that executives need to pay attention. Twenty four types of block layouts are generated. However, there are limitations that some designs may not appropriate. These limitations are availability of space, utilities support, work environment, affect on other products and investment cost. So, factory layout based on cellular layout is designed and selected by using the analytic hierarchy process (AHP) [14]. The selected layout is shown in Fig. 3. In the proposed cellular layout, two cells of the two product groups have been moved to the second floor. The operational sequences of parts in each group are indicated using different styles of numbers. The 1st product group uses Roman numerals and the 2nd product group uses Arabic numerals.

III. Performance Analysis by Computer Simulation

Standard times of all processes are measured and calculated. Independence, homogeneity, stationarity, and goodness of fit are tested for all processing times and can be shown in Table III Independence is checked by using scatter plots and run tests. Homogeneity can be tested by visually inspect the distribution to see if it is more than one mode. Stationarity is to examine that the data should not change with time. The goodness of fit is tested by Kolmogorov-Smirnov [7]. These data are used in simulation models. Two models are constructed. The first model is the existing plant model for evaluating the current performance as shown in Fig. 4. The second model is the proposed model based on cellular layout as shown in Fig. 5. The existing model is verified by checking programming code, checking the output, watching animation and tracing and debugging. Moreover, validation is done by comparing the real quantity of products that can be produced with the simulation results at 0.05 significance level.

The objective of the simulations is for comparing the performance of existing layout and proposed cellular plant layout. Performance measures are throughput rate, facility utilization, and average time in the system. The simulation models are run 30 times. Each time has been running for 102 days (Calculating at 0.05 significance level). Assume 100% of yield.

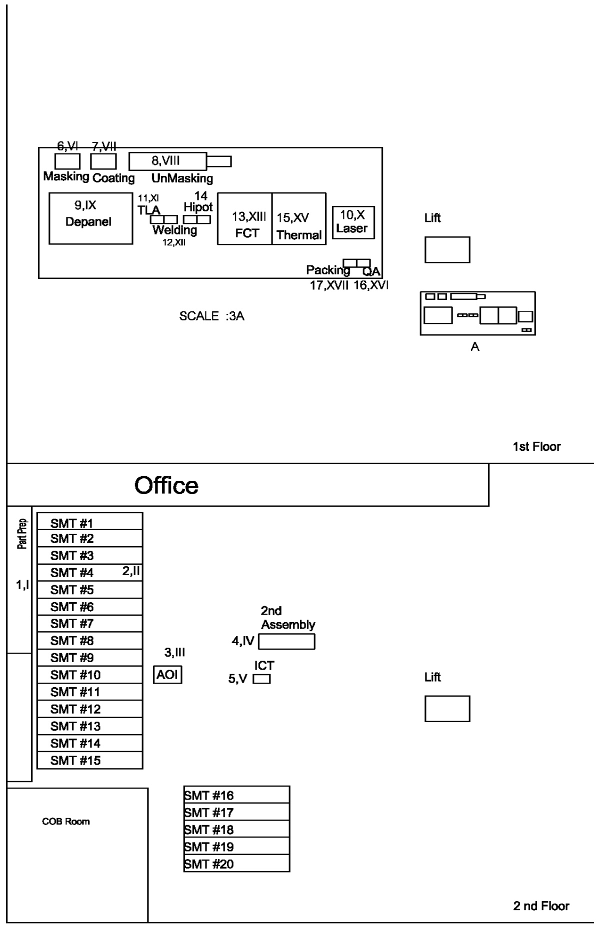

Fig. 3 Proposed cellular layout

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TABLE III
PROCESSES OF PRODUCTS IN THE SCOPE OF THE STUDY

st.	type of job	std. time	test of independence	test of homogeneity	test of stationarity	Goodness test	P-value	Parameter
1	stamp PCB& prepare part	0.190	√	√	√	Inverse gaussian	0.992	(0.,52.5,0.188)
2	SMT	2.257	√	√	√	Weibull	0.938	(2.,26.9,0.262)
3	AOI (Bottom side)	0.384	√	√	√	LogLogistic	0.921	(0.,78.4,0.383)
4	SMT	2.314	√	√	√	Weibull	0.896	(2.,33.,0.321)
5	AOI (Top side)	0.339	√	√	√	Weibull	0.988	(0.32,2.22,2.33e-002)
6	2nd Assembly	0.843	√	√	√	Johnson SB	0.952	(0.827,3.08e-002,-0.275,0.664)
7	ICT	0.407	√	√	√	Normal	0.834	(0.446,9.04e-003)
8	QA Inspection	0.437	√	√	√	Gamma	0.938	(0.172,144,1.99e-003)
9	Masking	0.910	√	√	√	Inverse Weibull	0.924	0.,113,1.)
10	Coating 1&2	2.811	√	√	√	Inverse Weibull	0.938	(2.,99.6,1.13)
11	Unmarking	0.459	√	√	√	Weibull	0.938	(0.516,6.32,5.82e-002)
12	QA Inspection	0.456	√	√	√	Pearson 5	0.973	(0.,1.71e+003,852)
13	Depanel	0.399	√	√	√	Inverse Weibull	0.936	(0.,27.6,2.56)
14	Laser	0.401	√	√	√	Lognormal	0.959	(0.,-0.91,0.139)
15	Assembly	0.982	√	√	√	Weibull	0.936	(0.,110,0.99)
16	Welding	0.425	√	√	√	Gamma	0.927	(0.,2.86e+003,1.49e-004)
17	FCT	6.905	√	√	√	Lognormal	0.887	(5.,-1.45,4.84e-002)
18	Hipot test	0.343	√	√	√	Weibull	0.97	(0.,27.2,0.352)
19	Thermal test	5.502	√	√	√	Inverse Weibull	0.972	(5.,54.6,2.02)
20	QA Inspection	0.456	√	√	√	Pearson 5	0.945	(0.,1.71e+003,352)
21	Packing	0.984	√	√	√	Pearson 5	0.891	(0.,1.36e+004,1.34e+004)
	total standard time	28.204						

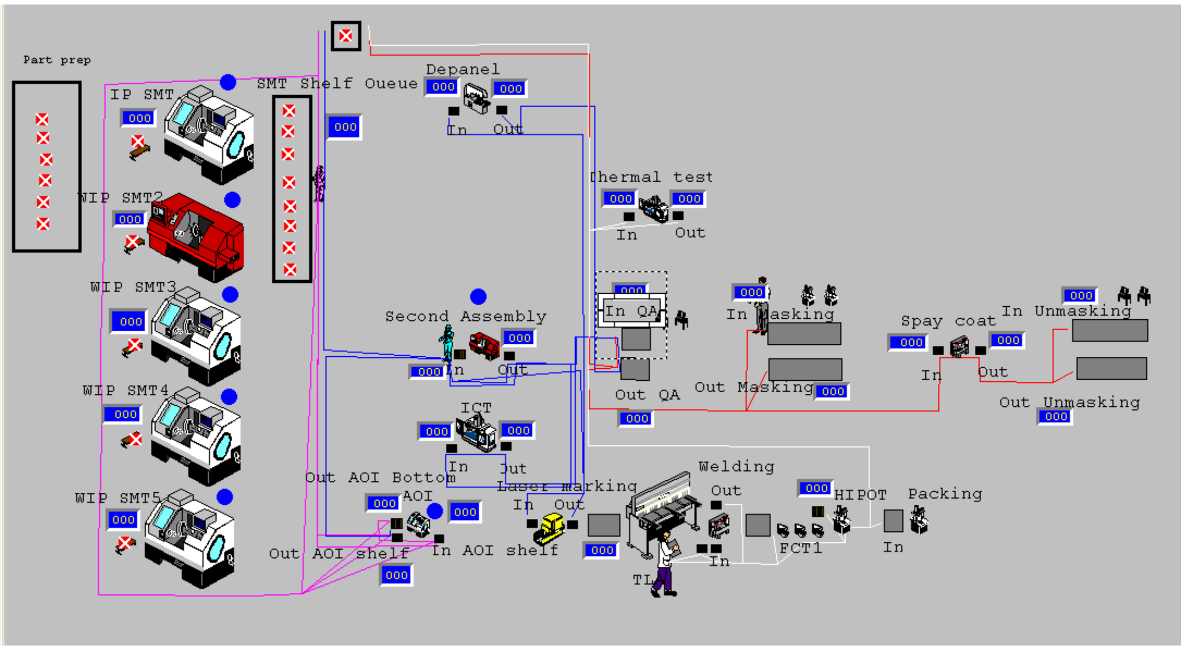

Fig. 4 Current layout

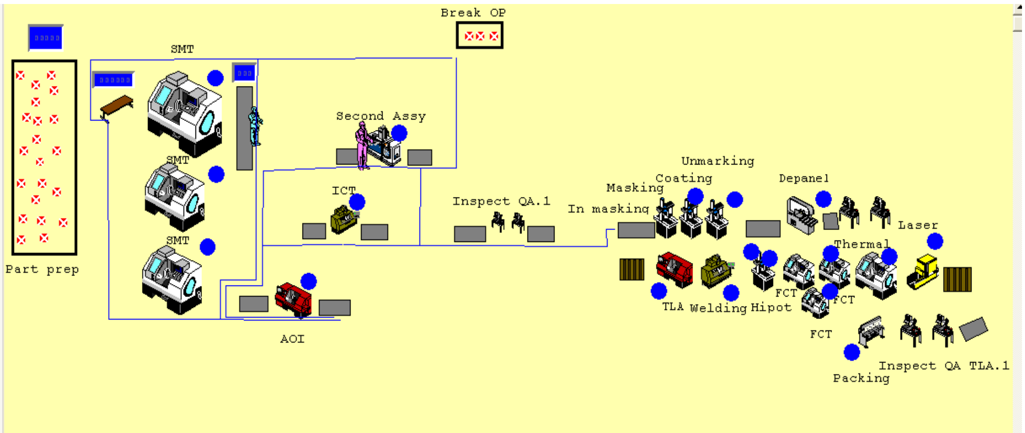

Fig. 5 Proposed cellular layout

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After simulating for 102, we found that the total output from existing plant is 17,920 pieces (175 pieces per day or 5,255 pieces per month), but the total output of the proposed cellular layout can produce up to 22,720 pieces (231 pieces per day or 6,941 pieces per month). The total throughput improves 27% as shown in Table IV.

Table V shows that the average utilization of the proposed plant is better than the current layout due to increasing of utilization. Utilization of TLA, Welding and FCT stations are extremely increased due to reducing of travel distance.

From the result of simulations, the average time in the system of parts produced in the current plant is higher than parts produced in the cellular layout as shown in Table VI.

The proposed cellular layout can improve productivity, utilization and the average time of parts of the system as shown in Table VII. In the cellular layout, the total moving distance of parts is reduced, so parts can be produced faster than the current layout. Parts are grouped in families, then flexibility of using production line and utilization is increased.

TABLE IV
COMPARISON OF THROUGHPUT BETWEEN CURRENT LAYOUT AND PROPOSED LAYOUT

part name	throughput	
	current layout	proposed layout
P4626	1120	1120
P4627	1760	1760
P4628	4000	4000
P4632	1120	1600
P4633	1120	6080
P4629	2560	2400
P4630	4160	4480
P4631	2080	1280
total	17920	22720
total run time	102.3 days	98.1 days
throughput per day	175.17	231.37
throughput per month	5255.13	6941.21

TABLE V
COMPARISON OF UTILIZATION BETWEEN CURRENT LAYOUT AND PROPOSED LAYOUT

st.	Location name	Capacity	Utilization	
			current layout	proposed layout
1	SMT	5	38.79%	39.41%
2	AOI	1	48.22%	50.57%
3	ICT	1	24.46%	26.04%
4	Second Assy	1	24.28%	25.37%
5	Inspect QA PCB	2	12.18%	23.42%
6	Masking	1	95.13%	94.56%
7	Coating	1	94.97%	96.16%
8	Unmarking	1	19.06%	19.99%
9	Depanel	1	19.25%	20.15%
10	QA Inspect_Coat	2	9.53%	23.42%
11	TLA	1	38.52%	94.94%
12	Welding	1	20.32%	94.90%
13	Hpot	1	4.80%	28.73%
14	FCT	3	57.65%	94.89%
15	Thermal	1	94.85%	95.65%
16	Laser	1	10.42%	19.54%
17	Inspect QA TLA	2	5.34%	10.42%
18	Packing	1	21.09%	21.41%
	average utilization		34.48%	47.18%

TABLE VI
COMPARISON OF AVERAGE TIME IN SYSTEM BETWEEN EXISTING PLANT AND PROPOSED PLANT

part name	average time in system	
	current layout	proposed layout
P4626	87,075.30	17,269.92
P4627	73,589.76	25,588.81
P4628	85,859.60	42,202.09
P4632	101,007.60	58,354.58
P4633	126,798.89	80,503.21
P4629	130,034.18	104,955.86
P4630	108,493.98	124,788.97
P4631	115,436.33	141,402.27
average time	103,536.96	74,383.21

TABLE VII
COMPARISON OF ALL PERFORMANCE MEASURES BETWEEN EXISTING PLANT AND PROPOSED PLANT

Performance measure	Existing	Proposed	% improved
Productivity (Piece/day)	175	231	27%
Utilization	34.48%	47.18%	37%
Average time in the system (minute)	103,536	74,383	28%
Total moving distance for product group 1, 2 (meter)	870, 885	625, 637	28%, 28%

IV. CONCLUSION

Computer simulation is used for Electronic Manufacturing Service (EMS) plant layout analysis in this research. The current layout of this manufacturing plant is a process layout, which is not suitable for EMS. So, cellular manufacturing layouts were designed for the selected group of products. All of plant data are gathered and analyzed to improve the possible cellular layouts for the factory. The best cellular layout was selected based on the main criteria of the plant. Computer simulation is used to analyze and compare the performance of the proposed cellular layout and the current layout. It found that the proposed cellular layout can generate better productivity, utilization and average time in system of parts than the current layout.

REFERENCES

[1] T. Yang and C. Kuo, “A hierarchical AHP/DEA Methodology for the Facilities Layout Design Problem,” *European Journal of Operational Research*, vol. 147, pp. 128-136, May. 2003.

[2] H. Kaebernick, M. Bazargan-Lari, and G. Arndt, “An Integrated Approach to the Design of Cellular Manufacturing,” *CIRP Annals - Manufacturing Technology*, vol. 45, pp. 421-425, 1996.

[3] A. Wirabhuana, H. Haron, and M. R. Imtihan, “Simulation and Re-engineering of Truck Assembly Line,” in *the Second Asia International Conf. on Modelling & Simulation*, 2008, pp. 783-787.

[4] J. A. Tompkins et al., *Facilities Planning*. New Jersey: John Wiley & Sons, 2003, ch. 6.

[5] S. A. Irani, *Handbook of Cellular Manufacturing Systems*. New York: John Wiley & Sons, 1999, pp. 25-130.

[6] N. Singh, and D. Rajamani, *Cellular Manufacturing Systems.* London: Chapman & Hall, 1996, ch. 1.

[7] C. Harrell, B.K. Ghosh and R.O. Bowden, *Simulation using Promodel*, Singapore: McGraw Hill, 2003.

[8] S. H. Melouk, N.K. Freeman, D. Miller, M. Dunning, Simulation Optimization-Based Decision Support Tool for Steel Manufacturing. *International Journal of Production Economics*, 2013, vol. 141, pp.269-276.

[9] S. P. Padhi, S.M. Wagner, T.T. Niranjan and V. Aggarwal, A Simulation-Based Methodology to Analyse Production line Disruptions, *International Journal of Production Research*, 2013, Vol. 51, No. 6, pp. 1885-1897.

[10] M. Kampf and P. Kochel, Simulation-Based Sequencing and Lot Size Optimization for a Production and Inventory System with Multiple Items, International Journal of Economics, 2006, Vol. 104, pp.191-200.

[11] Wikipedia foundation Inc., (2011, January 1), Electronics Manufacturing Services Available: http://en.wikipedia.org/wiki/Electronics_manufacturing_services.

[12] T. Ertay, D. Ruan, and U. R. Tuzkaya, “Integrating Data Envelopment Analysis and Analytic Hierarchy for the Facility Layout Design in Manufacturing Systems,” *Information Sciences*, vol. 176, pp. 237-262, February. 2006.

[13] A.A. Aguilar-Lasserre, M.A. Bautista Bautista, A.Ponsich and M.A. Gonzalez Huerta, “An AHP-Based Decision-Making Tool for the Solution of Multiproduct Batch Plant Design Problem under Imprecise Demand”, *Computer & Operations Research*, vol. 36, pp. 711-736, 2009.

[14] N Ngampak and B. Phruksaphanrat, Cellular Manufacturing Layout Design and Selection: A Case Study of Electronic Manufacturing Service Plant, *Proceedings of International MultiConference of Engineers and Computer Scientists*, Vol. II, IEMCS, March 16-18, 2011, Hong Kong.

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