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Layout Planning of Mass Customization Systems by Using Data Clustering Techniques

(Case Study: Company of Shoae Beton Shargh)

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Abstract: Layout planning of machinery and equipment is fundamental problem in each plant. The aim of layout method of machinery and equipment and offices is layout planning of manufacturing machines and stations, offices in different parts of manufacturing and service organizations. If all of products are the same, factory layout planning will be relatively easy; the problem starts when products are various and each will have its manufacturing process. Nowadays the concept of customization manufacture or mass customization replace to traditional methods of mass production. In order to overcome the complexity of custom manufacturing that potentially to be created in system of manufacturing, can used way for making cell to divide small and manageable parts. In layout of cell is usually used production flow analysis technique for cell classification; this paper presented a methodology based on clustering processes for layout planning of different products. The steps proposed of this methodology is presented that focuses on the data conversion with the most information algorithms to establishment of equipment and based on to calculate similarity coefficient, manufacturing cells are formed.

Keywords: Layout Planning, Mass Customization, Data Clustering.

I. INTRODUCTION

Nowadays market has special position that further complexity is added each day. There are complex demands and specific needs of design to achieve the standard framework makes it very difficult. In order to achieve the needs of the market, following the pattern of cell design has great importance [2]. Using a cellular strategy to produce all types of products and fast delivery to customers is an integral part of contemporary management thinking [3]. Cellular system has layout capabilities, divisions and different use and can be easily extended. Create multiple products by using limited resources creates stiff competition in the manufacture of goods. If a company seeks to rationalize manufacturing facilities and to produce various products at low prices, should consider ways to make cells [4]. Nowadays the custom manufacturing and or mass customization replace traditional mass production techniques [5]. Mass customization, mass production of goods and services are customized for each individual. The goal of mass customization production is producing goods and services with sufficient diversity; in this case each customer can buy a customized product that its cost is close to the cost of mass-produced products. In other words, mass customization will give exactly product that the customer needs it, and at a cost that s/he wants, when s/he wants [6].

Place of research is Shoae Beton Shargh Company. The main issue of research is new layout and installation of production lines and machines in defined place in firm position space. In this paper, by using clustering techniques offers specific methodology for automated layout planning of machinery and equipment manufacturing based routing of each product. When the products are not detectable as mass and production volume is low and variety of products is very high, one of the problems in the production system is the allocation of products to manufacturing cell in a group technologies. Research methodology allowed the identification of appropriate layout planning for each product, regardless of the production volume. Information needed to implement the methodology obtained from routing information in production of product and it doesn't need for information gap, cycle time, flow rate, and other resources

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that their collection is consuming and expensive. Thus after basic concepts in theoretical framework explain the problem and its solution; accordingly algorithm is proposed to solve such problems.

II. 2. THEORETICAL FRAMEWORK

a. Mass Customization

Mass customization predicted as Future Shock by Alvin Toffler in 1970 and in 1987 was marked by Stan Davis as complete future. Mass customization is a new way of competing commercial and method to identify and to complete the wants and Critical needs of individual customers, with regard to efficiency, effectiveness and low cost [7]. Mass customization is performed in four steps. One of competitiveness challenges of companies producing customized products in a mass scale is creating a range of solutions (figure 1).

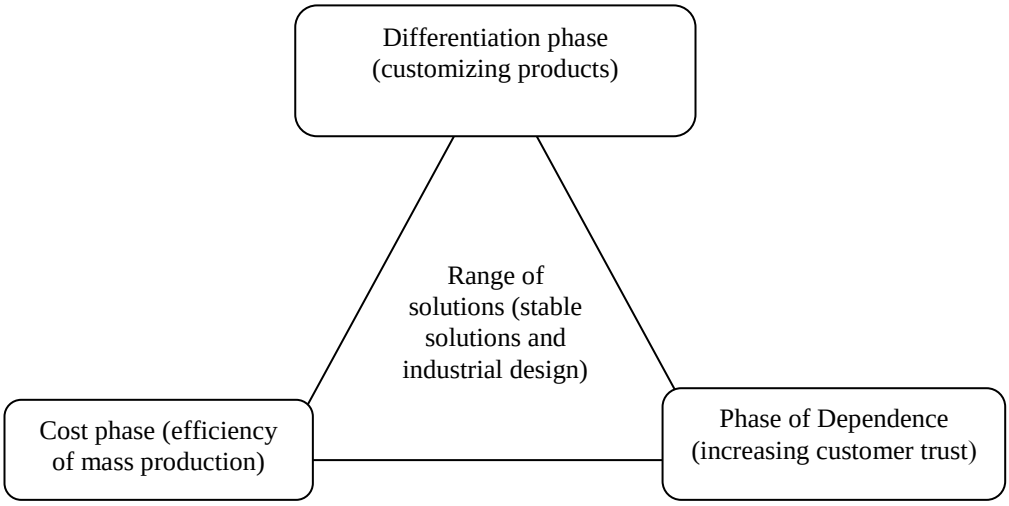

Fig1: The four step of mass customization (Tezcanli, 2006)

To achieve such a system needs to change manufacturing processes and especially change in the design of flexible processes. When all the products are the same, layout planning is relatively easy, the problem starts when products are different and each one will have its own manufacturing process. A family of products, the amount of variation in the final products depends on customer's choose options. In level of production, such diversity requires a very complex control operation and manufacturing. When want to create diverse sets with different numbers of different products, layout of the equipment and machines and how the transport materials or transport equipment will be one of the main concerns and issues [9].

b. Plant Facility Layout

Facilities may be a machine tool, center service, cell manufacturing, machine workshop, department, store and each part. Facility layout is an arrangement and order of everything that is necessary to produce goods or provide the services [9]. In fact aim of this study is facility layout to minimize delays in material handling, supply flexibility, more efficient use of space and labor and to increase employee morale. Proper facility layout has an impact in overall operational efficiency and can even reduce50 percent of operating expenses and also can increase amount of an organization's products and services [10].

c. Similar Criteria for the Combined Scale [11]

To measure the similarity between two objects or between two clusters, we use a general similarity coefficient that First, by Gower (1971) were presented. General coefficient of Gower for dissimilarity of two objects X and Y are as follows:

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$$S_G(X,Y) = \frac{\sum_{k=1}^{d} \alpha(X_k,Y_k) S(X_k,Y_k)}{\sum_{k=1}^{d} \alpha(X_k,Y_k)}$$

In this relation, d the number of indexes, $S_G(X,Y)$ Similar between two objects in terms of K and α (X_k , Y_k) is factor of zero and one that indicates whether component K is valid factor for calculating or not (If two objects in terms of K, have been data, α (X_k , Y_k)=1 and if have lost at least one of data, Zero value obtain α (X_k , Y_k)=0

For a variety of indicators $S_G(X,Y)$can be calculated as follows:

For quantitative indicators (ratio and interval): $R_k$is Changes range of K index.$S_G(X,Y) = 1 - \frac{|X_k - Y_k|}{R_k}$

For the indicators with the two values: if amount of two objects were harmonized in terms indicators examined, $S_G(X,Y) = 1$ and otherwise it will be $S_G(X,Y) = o$

For a nominal or categorical indicators: like the previous case, if two objects in terms of indicators examined have been the same status (X_k=Y_k) in this state $S_G(X,Y) = 1$ and otherwise $S_G(X,Y) = o$

d. The Center of Gravity Method [12]

Above relationships is as same as method gravity or center of gravity in mathematical localization model that by using geographic coordinates of objects search best place to facilitate layout or new facilities by using geographic coordinates located facilities and the number of traffic between them and any traffic costs (their weight). Generally objective function of layout model is: $F(X) = \sum_{i=1}^{n} W_i\, d(X,P_i)$. This function is depends distance variables of new facility with existing facilities and the cost of moving between them which should be minimum. d is the distance between the new facility and the existing facility that can be linear or nonlinear. W_i is Cost of traffic or weight moving. The geographical coordinates of layout location of the current equipment with coordinates [a_i , b_i] And X is Layout location of the new facility with coordinate of [x, y].If distance be as the Euclid in this case:

$$Minf(x,y) = \sum_{i=1}^{n} W_i \sqrt{(x - a_i)^2 + (y - b_i)^2}$$

$$\frac{\partial f(x)}{\partial x} = o \quad \rightarrow \quad x^* = \frac{\sum_{i=1}^{n} W_i\, a_i}{\sum_{i=1}^{n} W_i}$$

$$\frac{\partial f(x)}{\partial y} = o \quad \rightarrow \quad y^* = \frac{\sum_{i=1}^{n} W_i\, b_i}{\sum_{i=1}^{n} W_i}$$

III. 3. STATEMENT OF THE PROBLEM

Company Shoae Beton Shargh use mass Customization systems and it produces products with minimum numbers, but a great variety based on customer order. This Company has Established machines (M_1 , M_2……..M_n) that each collection is dedicated to making a series of products. Each production process is unique to one product family and is different with other production process; there isn't also mass production and each family has its own custom product that are low number but diverse. To illustrate the problem, consider only part that makes the product family of lamp base. List of products and production processes in these families is presented in (Table 1).

Table 1: List of products and their production processes

Product Name	*Product Code*	*Manufacturing process*		
Fancy lamp base	*b1025*	M_3	M_5	
Short lamp base	*b1026*	M_2	M_4	
Long lamp base	*b1027*	M_1	M_2	M_4
Two-way lamp base	*b1028*	M_3	M_5	
Classic lamp base	*b1029*	*M1*	*M4*	
lamp base of all tools	*b1030*	M_5		

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As can see, some of the products from one machine pass in their manufacturing processes. B1025 product in a stage of its production of the machine 5 (M_5) passes and B1028 product in a stage of its production of the machine 5 (M_5) passes. Thus, relevant information can be extracted to provide a layout planning.
It is clear that if number of products be high, to get an overview of information will be difficult; in opinion of investigator in such cases the use of clustering algorithms (cluster analysis) is desirable. Cluster analysis is an attempt that observations in each cluster (group) have been most similar together in terms of variables of interest and observations of each group has been maximum distance from other groups' observations [11].

IV. LAYOUT METHOD OF MANUFACTURING CELLS BY USING CLUSTERING TECHNIQUES

In a method that is introduced, layout is built based on categorizing the pieces of the product family. First process is classified and similar processes are in one group. Then for each group, a cell is considered. This method combines the benefits of the product deployment and workshop by using data clustering techniques that that technique of industrial cell layout planning is easier and less costly; because is not requiring information the flow of material or the direction and acts based on path of product manufacturing.

a. Family Members Identify of Products

To identify members of a product family based on the similarity of the products should be considered the criteria. In opinion of researchers in a group technology [GT] can use separate algorithms matrix of clustering data that are known to non-hierarchical methods and methods of oriented center because these techniques are used to problems that the number of objects or numbers index or both are high. [11].
This research has focused on methods of data clustering. Clustering (also called segmentation) population divides into smaller sub-populations with similar behavior based on a standard predefined. Clustering based on maximum uniformity will be in each cluster and the most non-uniformity among clusters [13]. For using the data clustering method, in first step of data (Table 1) based on the similarity of use of the machine was converted and were modified that is Led to the formation Table 2.

Table 2: convert of data in term of similarity for clustering

Product Code	*The production process*				
	M1	*M2*	*M3*	*M4*	*M5*
b1025	*0*	*0*	*1*	*0*	*1*
b1026	*0*	*1*	*0*	*1*	*0*
b1027	*1*	*1*	*0*	*1*	*0*
b1028	*0*	*0*	*1*	*0*	*1*
b1029	*1*	*0*	*0*	*1*	*0*
b1030	*0*	*0*	*0*	*0*	*1*

1) This table is composed based on the similarity of a passing each group of products machine and based on the principles of clustering for quality measures that the similarity with the number (1) and dissimilarity of number (0) coded. Accordingly, we could calculate the similarity coefficient because by using it obtained the adjacency matrix and create the clusters (primary cells). Calculations was performed based on similar relations from general similarity coefficient in reference [14]

$$S_{ij} = \frac{x_{ij}}{(x_{ij}+x_{jj})}$$

X_{ij} is number of products that pass both machines and is number of products that only passing one machine. About machine 1 and 2 (M_{12}), $X_{ij} = 1$ and $X_{jj} = 2$

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Based on Gower general similarity coefficient, because the data are not lost, always $\alpha(M_1,M_2) = 1$ and as a result, $S(M_1,M_2) = 1$ because 3 product pass these two machines, thus $\sum_{k=1}^{d} \alpha(M_1,M_2) = 3$

$S_{12} = \frac{1}{1+2} = 0.33$, $S_{13} = \frac{0}{0+4} = 0, S_{14} = \frac{2}{2+1} = 0.67$, ……

Table 3: Similarity coefficients calculated

Machinery	M_{12}	M_{13}	M_{14}	M_{15}	M_{23}	M_{24}	M_{25}	M_{34}	M_{35}	M_{45}
S	0.33	0	0.67	0	0	0.67	0	0	0.67	0

The number of calculations is equal $\frac{n(n-1)}{2} = \frac{5(5-1)}{2} = 10$ that in the table 3 summarizes because the adjacency matrix (table) is formed.

Table 4: adjacency matrix of similarity coefficients

	M1	M2	M3	M4	M5
M1	1	0.33	0	0.67	0
M2		1	0	0.67	0
M3			1	0	0.67
M4				1	0
M5					1

Based on the similarity matrix was done primitive clustering mechanisms (Table 5); and based on machines clustering were defined clustering of products, and family of products (Table 6). In this way machine (1 and 2), (1, 4), (2, 4) and (3, 5) which has a similarity coefficient that can be deployed side by side and machinery (1, 3), (1, 5), (2, 3), (2, 5), (3, 4) and (4 and 5) should not be deployed together. This concept formed the basis of the relationship diagram between activities (Activity Relationship Chart) or ARC that expresses the importance of each machine in the side of other… .

Table 5: Proposed cell of machinery

Clusters (cells) 1	M_1 , M_2 ,M_4
Cluster (family) 1	b1025,b1028,b1030
Clusters (cells) 2	M_3 , M_5
Cluster (family) 2	b1026,b1027,b1029

Based on primitive machining cells can also deal with clustering of products.

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Table 6: Recommended Product Family

b1025	b1026	b1027	b1028	b1029	b1030
M_3 - Cell 2	M_2 – Cell 1	M_1 –Cell 1	M_3 – Cell 2	M_1 – Cell 1	M_5 – Cell 2
M_5 -Cell 2	M_4 -Cell 1	M_2 -Cell 1	M5 - Cell 2	M_4 – Cell 1	
		M_4 -Cell 1			

Assuming producing cells (Table 5) are valid [11]; in this case, the right Layout of primary cells circulating products among the cells was analyzed.
thus the distance between machines, material flow rate and material handling costs and also the relationship between human and machine for production support or maintenance and repairs, were analyzed from different angles; so instead of moving of products from one machine to another machine (Table 1), cell-to-cell movement (Table 7) were studied to establish the most appropriate machinery.

With the integration of Table 1, 4 and 5, the following results were observed:

Table 7: The process of manufacturing machine-cell

In this way overall layout planning of machinery in an assembly line based on group technology can be consider as a table (7):

Table 7: Proposed Layout Plan

M_1	M_2	M_4	M_3	M_5

b. Recognition of Manufacturing Processes Related and Making Cell

In the first stage all equipment belonging to specific cells and its cells were placed next to each other. So it considering the arrangement associated with each product within each cell, the displacement was consistent with cost minimization. The main goal is identifying the relevant production processes per cell (Tables 8 and 9) the separation and machinery deployed in the right place.

Table 8: Production process each product in the cell (1)

Cells 1	*Product Code*	*Production Process*		
List of products	*b1026*	M_2	M_4	
	b1027	M_1	M_2	M_4
	b1029	M_1	M_4	

Table 9: Production process each product in the cell (2)

Cells 1	*Product Code*	*Production Process*	
List of products	*b1025*	M_3	M_5
	b1028	M_3	M_5
	b1030	M_5	

b1025	b1026	b1027	b1028	b1029	b1030
Cell 2 - M_3	Cell 1 – M_2	Cell 1 –M_1	Cell 2 – M_3	Cell 1 – M_1	Cell 2 – M_5
Cell 2 -M_5	Cell 1 -M_4	Cell 1 -M_2	Cell 2 - M5	Cell 1 – M_4	
		Cell 1 -M_4			

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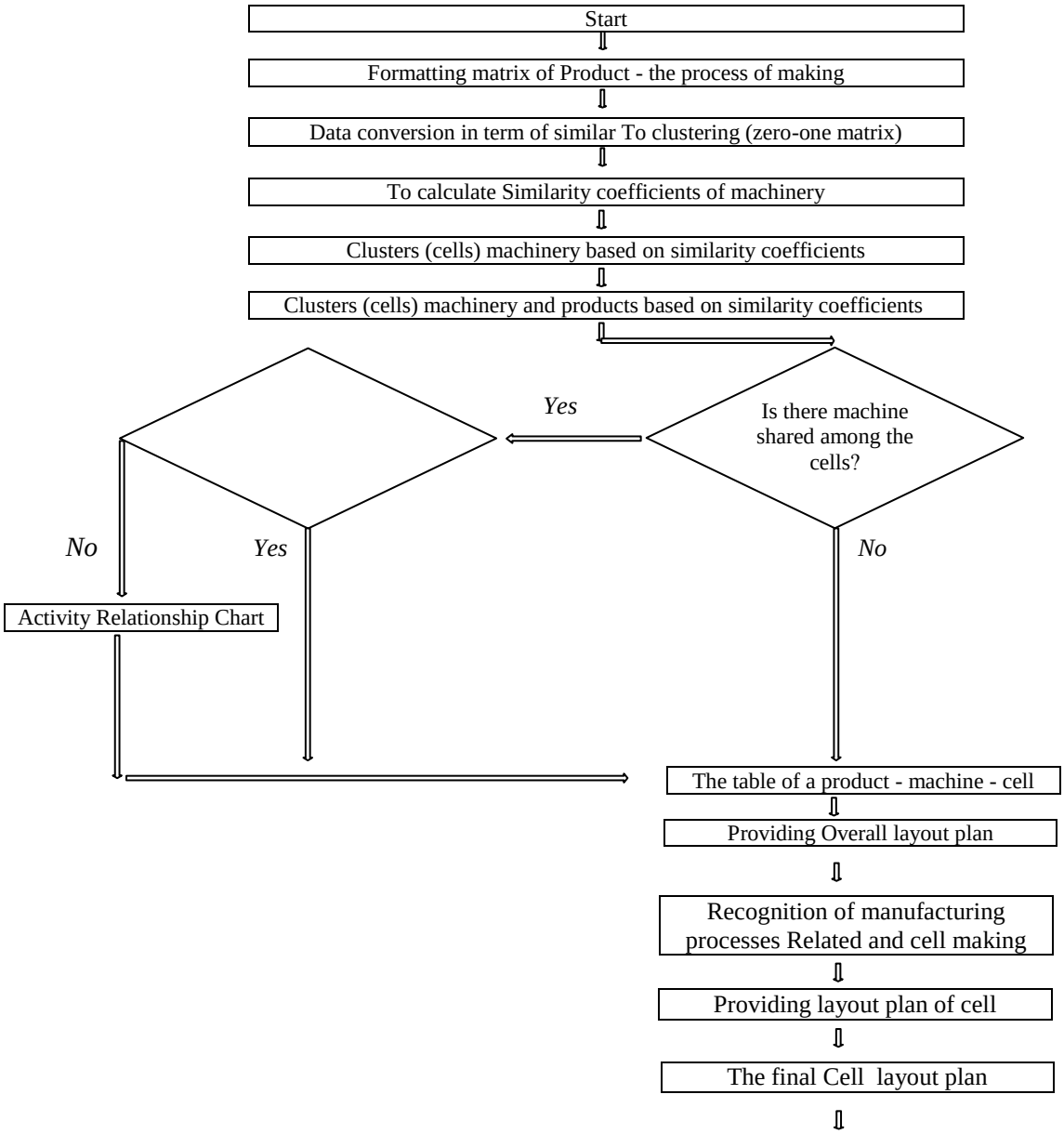
As a result, layout by the straight line (without moving return) and was performed in 2 cells that related product family also identified. Care must be that each cell be intended machinery required for the manufacture of products. In some cases, a couple of family of products need to basic machine for their products. In such cases, managers must analyze the cost - benefit, or a separate machine for each cell establish or share a machine between two cells that In this case is created limit and will need to schedule production.

V. ALGORITHM TO LAYOUT OF MASS CUSTOMIZATION PROCESSES WITH CLUSTERING METHOD

According to what was described, algorithm to problem solution of layout of mass customization processes (Figure 1) is proposed:



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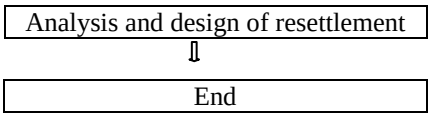

Fig 2: the proposed algorithm of layout planning by clustering method

VI. CONCLUSION

For classification of cells, manufacturing processes in group technology is usually used the method of production flow analysis. In this paper by using clustering techniques offers a methodology for automated layout planning of machinery and equipment manufacturing based routing of each product. When the products are not detectable as mass and large and production volume is low and variety of products is very high, one of the problems of production system is associated of products for manufacturing cells in group technology. The methodology of this study allowed the identification of appropriate layout planning for each product, regardless of the production volume. Information needed to implement the methodology can be obtained routing information of product and doesn't the need for information flow rate, cycle time, and other resources of time consuming and costly.

Important to note is review of layout planning process. It is possible that new cells cover the old cells. The distinction cause the proposed algorithm is automatic layout of new facilities and automatic membership for new products in family of products. This paper is underlying to investigate other clustering methods in the layout planning and based on can use to make fuzzy cell and providing layout planning with information related to start-up costs and prepare

REFERENCES

[1]www.shoaeshargh.com

[2]Strong, M.B, *Toolsand metrics for evaluating modular products based on strategic objectives*, Brigham Young University, Master Thesis,2003.

[3]Sanchez, R, *Fitting together a modular approach*, *Manufacturing Engineer*, 81 (5),2002.

[4]Tezcanli, E., *An analytical survey on customization at modular systems in the context of industrial design*, Master Thesis,2006.

[5]Erixon, G, *Modular function deployment (A method for product modularization)*, KTH, Stockholm, Doctoral Thesis,1998.

[6]Duray, R. and Milligan, G. W, *Improving customer satisfaction through mass customization* (*Quality Progress)*, 32 (8), 1999.

[7] Pine, B.J, *Mass customization: the new frontier in business competition*, Harvard Business School Press, Cambridge, MA,1993.

[8] E. J. Phillips , *Manufacturing plant layout – Fundamentals and fine points of optimum facility design*, Society of Manufacturing Engineers,1997.

[9]Heragu, S.S. and Kusiak, A., *Efficient Models for Facility Layout Problem*, European Journal of Operational Research, 53(1),1991.

[10]Tompkins,J.A., & Reed,J.R., *An Applied Model for The Facilities Design Problem*. International Journal of Production Research, 14, 1976.

[11] Moemeni,M,the data clustering, moalef,Tehran, Iran,2011.

[12] Soufi,M, Quantitative techniques in management of plant and planning of industrial units, Elijah culture, Iran,2009.

[13] C. Westphal, C. and T. Blaxton, *Data Mining Solutions*, John Wiley, New York,1998.

[14]*Cellular Manufacturing Systems* – Lecture Series 8 IE 3265 POM R. R. Lindeke, PhD Spring, 2005.