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Research Article

A BI-OBJECTIVE MODELING FOR A CELLULAR MANUFACTURING SYSTEM DESIGN USING FUZZY GOAL PROGRAMMING UNDER UNCERTAINTY

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ABSTRACT
Cell formation problem is an important issue in designing cellular manufacturing systems. Most studies in this field in have been done in two-dimensional piece-machine matrix. Since the worker has an important role in getting things done, worker assigned to the cell is important for designing cellular manufacturing system to be more consistent with a competitive market environment. A mathematical a bi-objective model is presented for the problem of cell formation under conditions of uncertainty with regard to the worker in this thesis which involves aims to analyze the effectiveness of system measures to form optimize cell line production with minimal costs and exceptional elements in the cubic space of the worker-piece-machinery matrix. To demonstrate the performance and a better understanding of the proposed model, an illustrative example based on literature of Branch and Bound Method using Lingo software package through fuzzy goal programming technique has been resolved and the results are proposed.

***Keywords:** Cellular Manufacturing System, Cell Formation, Queuing Theory, Exceptional Elements in Cell Formation, Uncertainty and Fuzzy Goal Programming*

INTRODUCTION
In competitive environments, markets are heterogeneous and constantly changing. Production is appropriate based on a lie just under changing demand. Ability to design and operation of manufacturing firms that can rapidly and effectively adapt to technological change and market needs is very important in the success of any manufacturing organization. The manufacturing firms should be able to provide very high levels of elongation.
In order to maintain profitability, industry executives recognized cellular manufacturing system as an efficient production system. Therefore, many companies increasingly changed their production of plant production systems to cellular manufacturing system. This system has the advantages of workshop, flexibility and higher efficiency and lower production costs.
Cellular manufacturing system is an application of group technology in production and includes a series of processes on the same components (family components) by a set of machines or cell work and these series increase the competitiveness of the production system and decreases product life cycles and increases the ability to combine volume and average variety of product. Cellular manufacturing system design is called Cell Forming. Uncertainty exists about the time of the process and period between pieces entry. Random parameters can be described as continuous or discrete in unrealistic environments. If the information is specified, the uncertainty in the parameters will be used by discrete or continuous probability distribution. The scope of procedures for modeling is in a state of uncertainty such as: possible planning, queuing theory and etc (Saedi-Mehrabi and Ghezavati, 2009). The continuous probability distribution used to determine the uncertainty for the random parameters and queuing theory can be used in order to achieve the desired result.
Process of the probability distribution represents that the time gap between inputs are successful and output process (servicing process) is probability distribution, which represents the customer's service

time. We assume parts as the client and machines as server in this production environment. Meanwhile, the arrival rate is the number of inputs per unit of time and the service rate is the number of customers who have received services (Saedi-Mehrabi and Ghezavati, 2009).

In this study, the workers are considered to perform operations on machine parts within manufacturing cells. Furthermore, after forming cells which is allocating parts, machine and worker to the cell, some parts of the worker failing to allocate specific cells must be move to other cells to perform. This will cause the cost of transfers. This state that should least the costs is called exceptional elements. The model which is developed in this study offer costs forming cells as the target and number of exceptional elements to be considered as a secondary objective. Then, using fuzzy goal programming model will be solved and its effects can be analyzed.

Research Literature

Cellular Manufacturing System

Cellular manufacturing system is a producing philosophy of collaborative technologies that identifying and grouping of similar parts are used in production under the similar family name of parts and structural components (Selim, 1998). In cellular manufacturing, a family consisting of a collection of pieces either in size or shape or similar production processes (Groover, 1987). Also, a cell covers a set of other similar machines (for performance) that are placed in close distance from each other to produce a family of relative parts. In fact the cell production system by grouping machines into producing cells divides the whole process of production complex into several simpler processes. goally, each piece is produced within a cell and then material handling, process control, production planning and scheduling tasks becomes easier (Wemmerlov and John, 1997). Using machinery and equipment in the production of multifunctional cellular and response to changes in demand will make it possible to design components with minimal cost and time. In general it can be said cellular production is a production system which can be used for products with average volume and diversity.

The Issue of Designing Cellular Manufacturing System

Achieving the benefits of cellular manufacturing system depends on three changes in the following essential areas:

.. Change the arrangement and organization of production machinery and cellular manufacturing
.. Changing the ordering system of materials and controlling inventory.
.. Changing production planning system

(Wemmerlo and Hyer, 1986) stated first change as the structure of the system structure design and second and third changes as system operational characteristics design. They also mentioned selecting the components and grouping them into families and selecting pieces of equipment and processes of grouping them as production cells as two basic decisions of manufacturing cell production system designing phase. Identification and determination pieces families and machine groups in designing cellular manufacturing system is known as Manufacturing Cell Design or production cell manufacturing (Rajamani *et al.*, 1996). Goals must be specified for designing cellular manufacturing systems. Minimizing the cost and distance, Intercellular movements are among common goals. In addition to these costs, obtaining reliable answers to other costs have been considered in the design of the objective function including: handling costs between cells, intracellular handling movement costs, the costs of consumer devices, machine operating costs, material handling cost, the costs of sub-contracts, set-up costs, investment costs, and cost of transportation machines. Also factors such as flexibility, machinery, packing machinery within cells, the number of machines in production system designing should be considered in designing objective functions. In addition, the cell formation has constraints such as machine capacity, cell size, cell number, budget constraints, selection of the path or paths to process each piece, limited space, etc. which should be considered. In recent decades, useful studies have been done in cell production. The methods offer useful methods in the designing of cellular manufacturing systems (Paydar *et al.*, 2010)

The benefits of cellular manufacturing system can be achieved when it is properly designed. On the other hand, the problem of cellular manufacturing designing is a complex, a multi-criteria and multi-stage problem that is placed in the category of NP-hard problems (Ballakur, 1985) (Garey and Johnson, 1979).

As a result, it will not be easy. In the literature on cell production, terms cell formation (CF), Part family/machine cell (PF/MC) formation and designing producing cells refer to the problem of designing cellular manufacturing systems. The first and most important step in the design of a cellular manufacturing cell formation is called CF.

With regard to piece production data (including demand, producing and processing time) and available sources (including machines, Equipments, etc.), cellular system design can be produced in three main steps summarized as follows:

1- Determining family parts based on the similarity of piece manufacturing
2- Classifying machines in the form of producing cells
3- Allocating pieces family to producing cells

It should be noted that the above steps are not done necessarily sequentially and separately. Transposition may not follow the steps as listed. According to the formulations method used for manufacturing cell formation, they can be in different ways. For example, a family of parts and machinery cell can be determined with the family components allocation to the cells in combination. In this regard, (Ballakur and Steudel, 1987) propose three strategies to solve the problem of designing cellular manufacturing:

1. **Part-Family Identification (PFI) strategy**: In this strategy, Part-Family components are identified based on structural similarities. The machines grouped into cells with regard to families.
2. **Machine Groups Identification (MGI) strategy**: in this strategy machines are grouped based on similarities in the paths of manufacturing and the components are allocated to cells.
3. **Part families/machine Grouping (PF/MG) strategy**:

Setting the family pieces and forming pick-producing cells are solved simultaneously.

Benefits of Cell Producing

The advantages of mass manufacturing system for cellular production system appear over time. Therefore, the system is a logical choice for organizations that are based on time-based competitive production.

Over the past few decades, the use of these systems has increased among producers and many manufacturers of plant production environments use these systems and everyday overcome the construction of additional inventories, the long output (production), complex control tasks, planning and the others and create the areas for the implementation of production methods such as manufacturing and production and providing flexible systems (Askin and Standridge, 1993)

Several advantages result from the use of cellular manufacturing systems compared to other production systems which have been reported regarding its performance through simulation studies, analytical studies to determine the real-world applications (Song and Hitomi, 1992) (Mahdavi *et al*., 2012).

In accordance with practical experiments, analytical results and computer simulations, some of the most important benefits of cell production can be outlined as follows:

1. Reducing the Cost of Transportation

In the process of cell production system it is required for each piece as possible to be completed inside the cell. Therefore, the possible time and distance pieces move between cell-like is minimum (Kioon *et al.,* 2009) (Wemmerlöv and Hyer, 1989).

2. Reducing Set up Time

A producing cell was created to produce parts with the same shape and somewhat the same size. So, the fixtures of the same or similar parts can be used to keep most of parts. The use of these fixtures for the family of parts, tools and fixtures can reduce the time needed to replace tools and fixtures (Askin and Standridge, 1993) (Kioon *et al.,* 2009) (Suresh and Meredith, 1994).

3. Reducing Production Time

By reducing transportation time and construction time, the production process is significantly reduced.

4. Reducing Lot size

As the establishment of the cellular manufacturing system decreases, not only is it possible to use smaller size, it is even more economical. The smaller size even makes the flow of production smooth (Singh and Rajamaani, 1996) (Jeon and Leep, 2006).

5. Reducing the Amount of Work-In-Process and Finished Inventory

Due to the reduction of waiting times and shorter queues path, components and parts inventory levels in the process is kept at a low level (Askin and Standridge, 1993). They showed that half-holding time can reduce work-in-process inventories by 50%. In addition to reducing the amount of inventory in process, finished goods inventory is reduced and instead of storing the pieces after each other with high and fixed intervals or random time intervals, we can produce parts in small quantities or at fixed time intervals or Just-In-Time (JIT) production (Kioon *et al.,* 2009) (Panchalavarapu and Chankong, 2005).

6. Reducing the Output (Production) and Increased Production Rate

As a result of reduced inventory levels during construction, the required time for production and leaving the cell production system, unlike the plant production where the workshops and car parts are moved as a group, to perform the next operation, each piece will be transferred to the next machine immediately after the completion of an operation.

Thus substantially the waiting time reduces and the rate of production increases. This leads to a rapid response to the customer and deliver safer products (Wemmerlöv and Hyer, 1989) (Solimanpur *et al.*, 2004) (Schaller, 2007).

7. Reducing Space Requirements and Optimum Use of Space

A decrease in inventories process will decrease finished goods and packet size based on needed space. Also, due to the reduction in inventory levels during construction, it will consider the space available to add new machines that will be available for future expansion plans.

8. Allocation Concentration

Producing local and specialized cells that are assigned to the same parts which causes the allocation concentration.

9. Improving the Quality of Products

As the individual components can be moved between machines, feedback can be done quickly and if there is a problem in the production process, it can quickly be stopped (Kioon *et al.*, 2009) (Singh, 1993).

10. Better Control over the Entire Operation

In some production, some parts may be moved to other places. Consequently scheduling and controlling material flow will be difficult. But in cell production because the production processes in cells are divided to independent cells, controlling and timing will be more easily (Singh, 1993) (Solimanpur *et al.,* 2004) (Panchalavarapu and Chankong, 2005).

Hypotheses

1. The design of cellular manufacturing systems is possible under uncertain conditions (use of queuing theory) and by considering the worker.
2. Adopting optimized manufacturing cells with minimizing related costs and exceptional items is possible.
3. The use of a fuzzy goal programming affects optimal cell formation.

Mathematical Model

$$minimize\, Z_1 = \sum_{j=1}^{M} \{L_q . C_q\} \quad (1.1)$$

$$\text{minimize } Z_2 = \sum_{k=1}^{C} \left\{ \sum_{i=1}^{P}\sum_{j=1}^{M}\sum_{w=1}^{W} X_{ik}Y_{jk}Z_{wk} - \sum_{i=1}^{P}\sum_{j=1}^{M}\sum_{w=1}^{W} X_{ik}Y_{jk}Z_{wk}U_{ijwk} \right\} \quad (1.2)$$

$$+ \sum_{i=1}^{P}\sum_{j=1}^{M}\sum_{w=1}^{W}\sum_{k=1}^{C} \{X_{ik}Y_{jk}(1 - Z_{wk})U_{ijwk}\} \quad (2.2)$$

$$+ \quad \sum_{i=1}^{P}\sum_{j=1}^{M}\sum_{w=1}^{W}\sum_{k=1}^{C}\{2*(1-X_{ik})Y_{jk}(1-Z_{wk})U_{ijwk}\} \qquad (3.2)$$

$$+ \quad \sum_{i=1}^{P}\sum_{j=1}^{M}\sum_{w=1}^{W}\sum_{k=1}^{C}\{(1-X_{ik})Y_{jk}Z_{wk}U_{ijwk}\} \qquad (4.2)$$

Constraints

$$\rho_j - \sum_{k=1}^{C}\frac{\sum_{i=1}^{P}\sum_{w=1}^{W}\lambda_i\, r_{ijw}\, X_{ik}\, Y_{jk}}{\mu_j} = 0 \qquad \forall \ j; \qquad (3)$$

$$0 \le \rho_j \le 1 \qquad \forall \ j; \qquad (4)$$

$$\sum_{k=1}^{C} Y_{jk} = 1 \qquad \forall \ j; \qquad (5)$$

$$\sum_{k=1}^{C} Y_{jk} \le N_m \qquad \forall \ j \qquad (6)$$

$$\sum_{j=1}^{M} Y_{jk} \ge LM_k \qquad \forall \ k \qquad (7)$$

$$\sum_{i=1}^{P} X_{ik} \ge LP_k \qquad \forall \ k \qquad (8)$$

$$\sum_{w=1}^{W} Z_{wk} \ge LW_k \qquad \forall \ k \qquad (9)$$

$$\sum_{k=1}^{C}\sum_{w=1}^{W} U_{ijwk} = a_{ij} \qquad \forall \ i,j \qquad (10)$$

$$U_{ijwk} \le \qquad r_{ijw}Y_{jk} \qquad \forall \ i,j,w,k \qquad (11)$$

$$L_q = \sum_{j=1}^{M}\frac{\rho_j}{1-\rho_j} \qquad \forall \ j \qquad (12)$$

$$X_{ik}, Y_{jk}, Z_{wk}, U_{ijwk} \in \{0,1\} \qquad \forall \ i,j,w,k \qquad (13)$$

MATERIALS AND METHODS

The first step in the formulation of the present study is to identify and assess sources and references related to the design of integrated cellular manufacturing systems.

Since little research have been considered three areas of decision making: Cell forming (CF), Cell Layout (CL) and Cell Scheduling (CS), research method details are as follow:

1) With respect to the problem as fuzzy, after collecting basic information, expert opinion have been used and research literature about the types of variables, fuzzy parameters of goals and decisions' limitations were taken.
2) Buckley method was used to determine the specific weight of the effective goals of the model.
3) Lingo software is used to solve the model.

Data Analysis, Numerical Examples Solving, Primary Information

This example includes 6 pieces, 6 machines and 3 workers. For this example, three cells are considered. Table (1), (2) and (3) contains basic information about the instance.

In Tables (1) to (3) the allocation of a piece - machine, machine - worker and the worker - segment is displayed.

As the tables show, the variables are binary and are mentioned in the previous sections. Value 1 is meant to assign and value 0 means no attribution. For example, in Table (1) Part 1 has been assigned to the machine type 1. But this piece is dedicated to machine type 2.

Table 1: Primary data of example (allocation piece - machine matrix)

Parts	**Machines**					
	1	**2**	**3**	**4**	**5**	**6**
1	0	1	1	1	1	1
2	1	1	1	0	0	1
3	0	0	1	1	1	1
4	1	1	1	0	1	1
5	1	0	1	1	1	1
6	1	1	1	0	0	1

Table 2: Primary data of example (allocation worker - segment matrix)

Workers	**Parts**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	0	1	0	1
2	0	1	1	1	1	1
3	1	0	1	1	1	0

Table 3: Primary data of example (allocation machine - worker matrix)

Machines	**Workers**		
	1	**2**	**3**
1	1	0	1
2	1	1	0
3	1	0	1
4	1	0	1
5	1	1	1
6	1	0	1

As noted, 6 pieces are considered in the example that the mean arrival rate for each of the following sets of components is:

$$\lambda_1 = 0.58 \text{،} \lambda_2 = 0.65 \text{،} \lambda_3 = 0.88 \text{،} \lambda_4 = 0.89 \text{،} \lambda_5 = 0.75 \text{،} \lambda_6 = 0.83$$

In this example, the number of machines is 6 that the average service machinery or exit rate is as follows:

$$\mu_1 = 11 \text{،} \mu_2 = 10 \text{،} \mu_3 = 12 \text{،} \mu_4 = 13 \text{،} \mu_5 = 9 \text{،} \mu_6 = 14$$

The cost per unit of time that customers wait in line (cost per time unit) is intended as 250.

2. a bi-objective Problem Solving and Computational Results

To solve the problem in Lingo software as our model is a bi-objective, once the model is solved with the first objective function and once with the second objective function.

Table (4) shows the results of the first objective function and Table 5 shows the results of the second objective function. The values of the objective functions include:

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The first objective function :$Z_1 = 23.50179$ and $Z_2 = 502$
The second objective function :$Z_1 = 558.1001$ and $Z_2 = 21$

Description of Table (4): The first objective function for machine type 1 (j1) has the processing when the segment type 2 (i2) and worker type 1 (w1) are assigned to the cell1. So the machine type 1 will be processed when the device type 4, 5 and 6 and the worker 3 are assigned to cell 1.

Description of Table (5): The second objective function for machine type 1 (j1) has the processing when the segment type 2 (i2) and worker type 1 (w1) are assigned to the cell2. So the machine type 1 will be processed when the device type 4, 5 and 6 and the worker 3 are assigned to cell 2.

Other items for other machine are given in the table. As can be seen, according to the constraints (5), each machine is assigned to a cell.

Table 4: Results of the first objective function

first objective function		j_1	j_2	j_3	j_4	j_5	j_6
	w_1		1			3	
i_1	w_2						
	w_3			2	3		2
	w_1	1		2			2
i_2	w_2		1				
	w_3						
	w_1						
i_3	w_2					3	
	w_3			2	3		2
	w_1	1		2			2
i_4	w_2		1				
	w_3					3	
	w_1						
i_5	w_2					3	
	w_3	1		2	3		2
	w_1	1		2			2
i_6	w_2		1				
	w_3						

Table 5: Results of the second objective function

second objective function		j_1	j_2	j_3	j_4	j_5	j_6
i_1	w_1		3			1	
	w_2						
	w_3			1	1		2
i_2	w_1	2		1			2
	w_2		3				
	w_3						
i_3	w_1						
	w_2					1	
	w_3			1	1		2
i_4	w_1	2					2
	w_2		3				
	w_3			1		1	
i_5	w_1						
	w_2					1	
	w_3	2		1	1		2
i_6	w_1	2		1			2
	w_2		3				
	w_3						

For each of the first and the second target functions, length of queue (Lq) is calculated. The following calculations are given.
To calculate for the first objective function:

$\rho_1 = 1 - \frac{1}{te_1} = 1 - \frac{1}{1.421189} = 0.299$; $L_q = \frac{\rho_1}{1-\rho_1} = \frac{0.299}{1-0.299} = 0.426$

$\rho_2 = 1 - \frac{1}{te_2} = 1 - \frac{1}{1.310616} = 0.237$; $L_q = \frac{\rho_2}{1-\rho_2} = \frac{0.237}{1-0.237} = 0.310$

$\rho_3 = 1 - \frac{1}{te_3} = 1 - \frac{1}{1.498127} = 0.332$; $L_q = \frac{\rho_3}{1-\rho_3} = \frac{0.332}{1-0.332} = 0.499$

$\rho_4 = 1 - \frac{1}{te_4} = 1 - \frac{1}{1.273262} = 0.215$; $L_q = \frac{\rho_4}{1-\rho_4} = \frac{0.215}{1-0.215} = 0.273$

$\rho_5 = 1 - \frac{1}{te_5} = 1 - \frac{1}{1.525424} = 0.344$; $L_q = \frac{\rho_5}{1-\rho_5} = \frac{0.344}{1-0.344} = 0.524$

$\rho_6 = 1 - \frac{1}{te_6} = 1 - \frac{1}{1.203783} = 0.169$; $L_q = \frac{\rho_6}{1-\rho_6} = \frac{0.169}{1-0.169} = 0.203$

$$L_q = \sum_{j=1}^{M} \frac{\rho_j}{1-\rho_j} = 2.235$$

To calculate L_q for the second objective function:

$\rho_1 = 1 - \frac{1}{te_1} = 1 - \frac{1}{1.422244} = 0.297$; $L_q = \frac{\rho_1}{1-\rho_1} = \frac{0.297}{1-0.297} = 0.422$

$\rho_2 = 1 - \frac{1}{te_2} = 1 - \frac{1}{1.100616} = 0.091$; $L_q = \frac{\rho_2}{1-\rho_2} = \frac{0.091}{1-0.091} = 0.100$

$\rho_3 = 1 - \frac{1}{te_3} = 1 - \frac{1}{1.765527} = 0.434$; $L_q = \frac{\rho_3}{1-\rho_3} = \frac{0.434}{1-0.434} = 0.766$

$\rho_4 = 1 - \frac{1}{te_4} = 1 - \frac{1}{1.223218} = 0.182$; $L_q = \frac{\rho_4}{1-\rho_4} = \frac{0.182}{1-0.182} = 0.222$

$\rho_5 = 1 - \frac{1}{te_5} = 1 - \frac{1}{1.551221} = 0.355$; $L_q = \frac{\rho_5}{1-\rho_5} = \frac{0.355}{1-0.355} = 0.550$

$\rho_6 = 1 - \frac{1}{te_6} = 1 - \frac{1}{1.009783} = 0.009$; $L_q = \frac{\rho_6}{1-\rho_6} = \frac{0.009}{1-0.009} = 0.009$

$$L_q = \sum_{j=1}^{M} \frac{\rho_j}{1-\rho_j} = 2.069$$

3. Model Solving using Fuzzy Goal Programming

To generalize the view of the decision maker, the following functions are defined:
Min $Z_1 = 12$, $p_1 = 444$
Min $Z_2 = 111$, $p_2 = 1$
Considered values are replaced in the membership function:

$$\mu_{Z_1}(X) = \begin{cases} 1 & if \;\; Z_l(X) < 12 \\ 1 - \dfrac{Z_1(X) - 12}{444} & if \; 12 \le Z_l(X) \le 456 \\ 0 & if \; Z_l(X) > 456 \end{cases}$$

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$$\mu_{Z_2}(X) = \begin{cases} 1 & if \;\; Z_l(X) < 111 \\ 1 - \dfrac{Z_2(X) - 111}{1} & if \; 111 \le Z_l(X) \le 112 \\ 0 & if \; Z_l(X) > 112 \end{cases}$$

The optimal solution to (X^*) is maximized. Using the following mathematical programming in Lingo software, we have:

Max $\propto$

s.t.

$$\propto \le 1 - \frac{\mu_{Z_1}(X) - 12}{444}$$

$$\propto \le 1 - \frac{\mu_{Z_2}(X) - 111}{1}$$

$$0 \le \propto \le 1$$

After coding the maximum function in Lingo software, it is run and results were obtained through the software outputs. The results are given in Table (6).

Table 6: Results of the model using fuzzy goal programming

Fuzzy goal programming		**j_1**	**j_2**	**j_3**	**j_4**	**j_5**	**j_6**
i_1	w_1		1		2	2	
	w_2						
	w_3			3			3
i_2	w_1	1		3			3
	w_2		1				
	w_3						
i_3	w_1						
	w_2					2	
	w_3			3	2		3
i_4	w_1	1		3			3
	w_2		1				
	w_3					2	
i_5	w_1						
	w_2					2	
	w_3	1		3	2		3
i_6	w_1	1		3			3
	w_2		1				
	w_3						

Like the first and second objective functions, the Lq also calculated for fuzzy goal programming.
Calculating Lq for the model usig fuzzy goal programming:

$$\rho_1 = 1 - \frac{1}{te_1} = 1 - \frac{1}{1.078000} = 0.072 \quad ; \quad L_q = \frac{\rho_1}{1-\rho_1} = \frac{0.072}{1-0.072} = 0.077$$

$$\rho_2 = 1 - \frac{1}{te_2} = 1 - \frac{1}{1.300100} = 0.231 \quad ; \quad L_q = \frac{\rho_2}{1-\rho_2} = \frac{0.231}{1-0.231} = 0.300$$

$$\rho_3 = 1 - \frac{1}{te_3} = 1 - \frac{1}{1.050788} = 0.050 \quad ; \quad L_q = \frac{\rho_3}{1-\rho_3} = \frac{0.050}{1-0.050} = 0.052$$

$$\rho_4 = 1 - \frac{1}{te_4} = 1 - \frac{1}{1.740002} = 0.425 \quad ; \quad L_q = \frac{\rho_4}{1-\rho_4} = \frac{0.425}{1-0.425} = 0.739$$

$$\rho_5 = 1 - \frac{1}{te_5} = 1 - \frac{1}{1.203242} = 0.168 \quad ; \quad L_q = \frac{\rho_5}{1-\rho_5} = \frac{0.168}{1-0.168} = 0.201$$

$$\rho_6 = 1 - \frac{1}{te_6} = 1 - \frac{1}{1.043219} = 0.041 \quad ; \quad L_q = \frac{\rho_6}{1-\rho_6} = \frac{0.041}{1-0.041} = 0.042$$

$$L_q = \sum_{j=1}^{M} \frac{\rho_j}{1-\rho_j} = 1.411$$

Table (7) shows the comparison of the results of the fuzzy goal programming model with the first and the second objective functions of mathematical model.

Table 7: Comparison of the results of the first and second optimization objective functions and fuzzy goal programming

	Parts			Machines			Workers			L_q	Prob1	Prob 2	
	Cell 1	Cell 2	Cell 3	Cell 1	Cel l 2	Cel l 3	Cell 1	Cell 2	Cell 3				
Function 1	1,2,4,5,6	1,2,3,4,5, 6	1,3,4,5	1,2	3,6	4,5	1,2, 3	1,2, 3	1,2, 3	2.23 5	23.5017 9	502	0.974095 1
Function 2	1,2,3,4,5, 6	1,2,3,4,5, 6	1,2,4,5,6	3,4, 5	1,6	2	1,2, 3	1,3	1,2	2.06 9	558.100 1	21	
FGP	1,2,4,5,6	1,3,4,5	1,2,3,4,5, 6	1,2	4,5	3,6	1,2, 3	1,2, 3	1,3	1.41 1	23.5017 9	21	

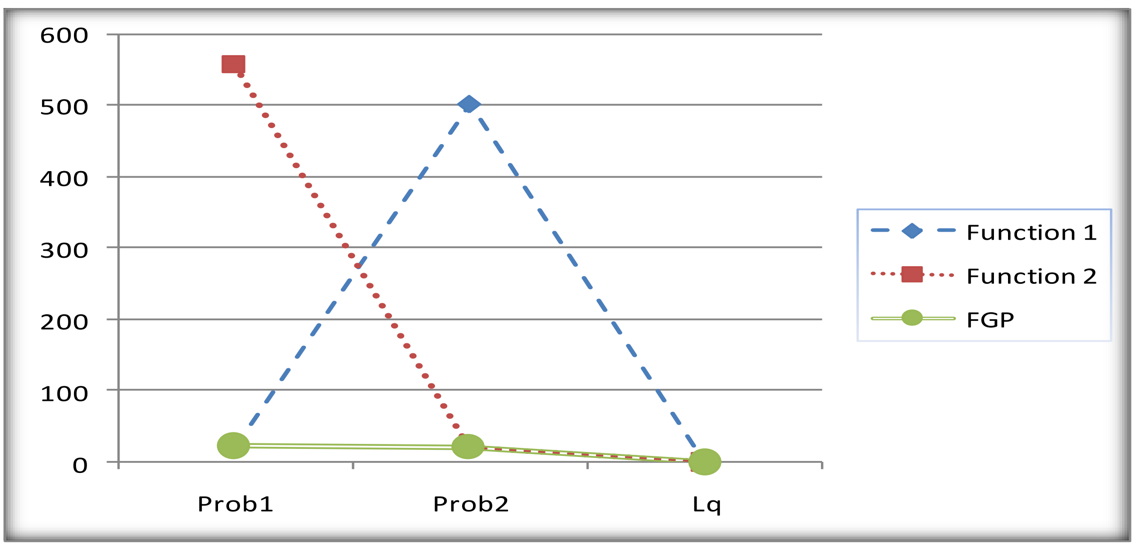

Figure 1: Diagram of optimum problem

Function is 2.235 and for the second function the value is 2.069. After solving the fuzzy goal programming model as a bi-objective, the queue length has been reduced to 1.411. For question, the optimum value of the first objective function is 23.50179 and for the second objective function, the value is 588.1001. By solving the model and applying fuzzy goal programming, its minimum value at each target separately is not exceeded 23.50179. The optimal value obtained through a bi-objective problem, final optimum level is 23.50179.

Similarly, the optimal values of the first and second objective functions, respectively, are 502 and 21 for Article 2. The model after being solved by fuzzy goal programming calculated 21 as optimal value.
Figure 1 shows depict of the first and second objective functions and also the fuzzy goal programming function. As is evident in this chart, the function of fuzzy goal programming considerably reduces queue length and the costs and also the number of exceptional elements or remains constant by adding a second goal and no increase has been observed.

RESULTS AND DISCUSSION

Conclusion

In this study, a new mathematical model for solving cell formation based on three-dimensional matrix of machine- piece- worker is proposed that represents square of the allocation in cellular manufacturing system. In addition, the new concept of exceptional elements discussed interpretation of the intracellular components and workers for the corresponding processing on machines. The proposed method minimizes the total number of exceptional elements and voids in the cellular manufacturing system. The costs associated with the formation of the cell are substantially improved and queue length in cell production system is not increased.
Before examining the results, this study suggests the research main advantages:
1. Using the known parameters in production systems to provide an integrated model.
2. Substantially reduction in the cost and length of the queue at any moment.
3. Substantially reduction in voids and exceptional elements in each cell
4. Simultaneous determination of voids and exceptional elements and reduction of the cost of the queue length per unit time.
5. The designed model with the worker in terms of uncertainty

The results can be summarized as follows:
1. The design of cellular manufacturing systems under uncertainty using queuing theory and considering the worker is possible.
2. Optimized Forming producing cells by minimizing the costs and minimal exceptional items is possible.
3. Fuzzy goal programming has a good effect to optimize the shape of the cells and lead to better optimization of the shape.
4. Fuzzy goal programming can be a practical way to achieve an optimal solution in terms of the features of decisive.

According to the results, one can realize the importance of using the model.

Recommendations

1. due to the increasing variety of products and industries movement toward the use of cellular manufacturing, in order to enjoy the benefits of it, using conventional methods in solving problems related to cellular manufacturing do not have good performance and using innovative methods can be considered.
2. Using innovative methods such as simulated annealing, genetic algorithms, neural networks, etc., to solve model problems with the real proposed size
3. Considering the sequence of operations for cell forming problem (CFP) which can improve application solutions from the model.
4. Giving the layout of machines to calculate the cost of inventory.
5. Providing s model to determine cell formation in a dynamic environment

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