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Analysis and Modeling of Flexible Manufacturing System

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Abstract: ***The analysis and modeling of the flexible manufacturing system (FMS) consists of the planning of the system and the optimization of the FMS objectives. The flexible programming problems of the FMS (Flexible Manufacturing System) become extremely complex when it comes to taking into account frequent deviations in the design of the pieces of incoming jobs. This research focuses on efficiently programming the various incoming jobs in the system and maximizing the utilization and performance of the system, with machines equipped with different tools and tool magazines, but with multiple machines that can be assigned to a single operation. Jobs have been scheduled according to the shortest processing time (SPT) rule. The shortest time programming rule (SPT) is simple, fast and generally a superior rule in terms of minimizing the completion time through the system to minimize the average number of jobs in the system, generally lower stocks in process (less load congestion) and downstream downtime (increased resource utilization). The simulation is better than the experiment with the real system because the system does not yet exist and the system experiments are expensive, time consuming and too dangerous.***

Keywords: FMS, Taguchi philosophy, optimization, Genetic algorithm, Scheduling of jobs, simulation

1. Introduction

In today's competitive global market, manufacturers must change their operations to ensure a better and faster response to customer needs. The main objective of any manufacturing industry is to achieve a high level of productivity and flexibility that can only be achieved in a computer-integrated manufacturing environment. A Flexible Manufacturing System (FMS) is an integrated, computer-controlled configuration in which there is some flexibility that allows the system to respond to changes, whether anticipated or unexpected. FMS consists of three main systems. Work machines that are often automated CNC machines are connected by a material handling system (MHS) to optimize the workflow and the central control computer that controls the movement of the material and the flow of the machine. An FMS is modeled as a collection of workstations and Automated Guided Vehicles (AGVs). It is designed to increase system utilization and system performance and to reduce the average work in process stocks. Many factors affect both the use of the system and the performance of the system in this search system. The performance of the system has been optimized taking into account the factors.

1.1. Flexible manufacturing system

A system consisting of many programmable machine tools connected by an automated handling system and able to produce a wide variety of items. An FMS is a large, complex and expensive fabrication in which teams run all the machines that complete the process so that many industries cannot pay for the traditional FMS, so the smaller versions tend to call up cells. Manufacturing. Flexible Today, two or more CNC machines are considered a flexible manufacturing cell (FMC) and two or more cells are considered a Flexible Manufacturing System (FMS).

"The flexible manufacturing system is a computer-controlled manufacturing system in which the numerically controlled machines are interconnected by a handling system and a main computer controlling the CNC machines and the handling system.

The main objective of any manufacturing industry is to achieve a high level of performance, flexibility and system utilization. The use of the system calculated as a percentage of the available hours (number of machines available for production multiplied by the number of working hours), can be increased by modifying the design of the installation, reducing the transfer time between two stations and yield, defined as the number of pieces produced by the last machine of a manufacturing system for a certain period of time. As the number of pieces increases, the performance also increases and also increases the use of the system. The flexible manufacturing system includes the following components.

Work station: The workstation includes of machines which is digitally controlled by a computer that performs many operations in a group of parts. SGF also consist other workstations, such as control stations, sheet metal press and assembly work.

Automated material handling and storage system: the work pieces and parts of prefabricated parts between processing stations are transferred by many times automated material processing systems. Many automated handling devices are used in a flexible production system, such as conveyors, an automated vehicle, etc. There are two types of management systems.

Primary handling system: establishes the basic layout of the FMS which is responsible for moving the blanks between the stations of the system.

Secondary handling system: consists of automatic pallet changers transfer devices and similar mechanisms located at the workstations in the FMS.

Computer Control System: It is used to control the activities of the processing stations and the material handling system in the FMS.

1.2. Flexible manufacturing system layouts

The flexible production system has different designs depending on the location of the machine and the flow of parts. According to the part flow and the location of the machine, the scheme of the flexible production system is discussed below.

1.2.1. In-line FMS layout

The machines and the handling system are arranged in a straight line. The pieces move from one work station to another in a well-defined sequence, with work always moving in one direction and no return. Operation similar to a transfer line, except that the system contains a greater variety of parts. The routing flexibility can be increased by installing a linear transfer system with bidirectional flow, here, a secondary treatment system is provided at each work station to separate most of the main line. Material handling equipment used: online transfer system; a rail-guided vehicle system or conveyor system.

1.2.2. Loop FMS layout

Workstations are organized in a loop that is served by a looped parts handling system. In parts usually flow in one direction around the loop with the capability to stop and be transferred to any station.

1.2.3. Ladder FMS layout

This includes of a loop with rungs upon which workstations are located. The rungs increase the number of possible ways of getting from one machine to the next, and obviate the need for a secondary material handling system. It reduces average travel distance and minimizes congestion in the handling system, thereby reducing transport time between stations.

1.2.4. Rectangular FMS layout

Each station has secondary handling equipment so that part can be brought-to and transferred from the station work head to the material handling loop. Load/unload stations are usually located at one end of the loop.

1.2.5. Open field FMS layout

It includes of several loops and stairs, and may also include sidings. This design is typically used to process a large family of parts, although the number of different types of machines can be limited, and parts are typically routed to different workstations whichever is available first.

1.2.6. Robot centered FMS layout

This layout uses one or more robots as the material handling system.

1.3. Sequencing of jobs

The machines are organized in a typical design in a specific FMS environment. All works will be dealt with, they have different operations. Depending on their processing time, due dates are scheduled to minimize time. The following rules are selected from many of the existing priority program rules to get a better sequence.

First-Come, First-Serve (FCFS) – The first job that comes in the first service (local rule). It's simple, fast, "right" for the customer and the disadvantage of this rule is that the smaller effect is measured by traditional performance measures because the abusive resources of the flows imply a long-term expectation of the others and include the date Due to work and remaining work (past information) .

Shortest Processing Time (SPT) – The job is the shortest running time in the service (local rule). The advantages of this sequence rule are simple, fast, usually a better rule in terms of minimizing time completed in the system, minimizing the number of jobs in the system, generally processing a lower inventory (less congestion in system). Workshop) and downtime (greater use of resources), and delays and disadvantages of work on an average, ignore information about due date and waiting, and waiting for long-term jobs (diversity). I'm waiting for work).

Earliest Due Date (EDD) - the work with the nearest expiration date is put into service first (local rule) and is simple, fast, generally works well in relation to the expiration date, but if it is not because the rule does not take into account the work process . A high priority for late work and ignores the content of the remaining work.

Critical Ratio (CR) Rule – sort the activities for the remaining time up to the expiration date divided by the total remaining processing time (global rule). Work with the lowest ratio between expiration dates and processing time first enters service. The report consists of (Expiration Date-Present) / Remaining Purchase Time in which the remaining purchase time refers to: queue, configuration, execution, wait, and transfer times in current and descendant work centers. Recognizes the work due date and the remaining work (incorporates the following information) but in this sequence, expired jobs have high priority, not counting the number of remaining transactions

Slack Per Operation – it is a global rule, where the priority of the work is determined as (Slack of Restaining Operations), it recognizes the date of expiry of the work and the remaining work (integrates the information downstream)

Least Changeover Cost (Next Best rule) - Work sequences based on cost or time of installation (local rule). It's simple, fast; usually it works well in this regard the costs of setting up. Does not take into account the time of the work process, the end time and the remaining work.

1.4. Simulation modeling

"Modeling" - is the process of developing a real model of the system and experimenting with that model in order to understand the behavior of the system or evaluate various strategies (within the limits imposed by the criteria or set of criteria) to work the system "definition was given RE Shannon, we simulate and .. Do not experiment with the system in the real world, because the system does not exist yet, and experiments with the system are expensive, a lot of time, too dangerous. Experimentation with the system is suitable. The system is defined as. Group of objects, which combine a regular interaction or interdependence to obtain a universal system, which does not change over time, is static and the other, which changes over time - it is a dynamic system consists of following elements:

- **Object:** The object is an object of interest for the system.
- **Attribute:** An attribute is an object property. A particular object can handle many attributes.
- **Activity:** The activity represents a certain period of time
- **The state of the system:** It is defined as a set of variables necessary to describe the system at any time, with respect to the objectives of the study.
- **Event:** An event is defined as an instant event that can change the state of the system
- **System progress:** System progress is studied after system state changes.

Simulation is a powerful method for solving problems. It can be used to experiment with systems that do not already exist, or with existing systems without actually changing the actual system; and therefore it offers a reduction in value in terms of time, cost and risk associated with system modeling, design of experiments and games for scenario analysis. Although simulation analysis is limited in some ways, its popularity as an aid to decision-making increases in direct proportion to the possibilities and availability of modern high-speed digital computers. Computer simulations assume the role of traditional experiences in many business areas and research, because the coding and implementation of complex models of real systems (both in the manufacturing sector and in services) are of more and more favorable to the improvement of technology. In general, real-time systems are made up of closely related subsystems. There are several sources of information, apparently, independent and multiple decision points. Moreover, an accident is very important and not an insignificant factor in life: the real systems are generally hierarchical, distributed and contain a large number of decision-makers, relatively independent, but implicitly coordinated, who operate under conditions of great uncertainty. The complexity of the real problems is that in many cases the simplifying assumptions by the appropriate analytical model may be unrealistic model or sufficiently articulated cannot be solved analytically. When the uncertainties in the system are small enough, existing analytical methods can be appropriately modified to address them: in fact, many algorithms related to stochastic systems are closely related with their counterparts in deterministic systems. However, when uncertainty is high, changing existing algorithms is not enough: new paradigms must be considered to support a random environment, and simulation modeling is a very promising alternative for capturing real stochastic behavior of the studied system.

1.5. Genetic algorithm

Genetic algorithms (GA) are a parallel, direct, stochastic method of global search and optimization that mimics the evolution of mortal beings described by Charles Darwin. GA is part of a group of evolutionary algorithms (EA). Evolutionary algorithms use three basic principles of natural evolution: reproduction, natural selection and species diversity, supported by the differences of each generation with the previous ones.

Genetic algorithms work with a set of individuals, presenting possible solutions for the problem. The selection principle is applied using a criterion that assesses the individual with respect to the desired solution. The most suitable people create the next generation. Effectively optimizes continuous and discrete variables. It does not require any derivative information. Look out for a broad sample of the value surface at the same time. He drives big no. variables at a time. Optimizes variables with extremely complex cost areas. It provides a list of optimal variables, not just a solution. The genetic algorithm has the following steps;

1. Generate the initial population: in most algorithms, the first generation is randomly generated by choosing the chromosomal genes of the alphabet allowed for this gene. Because of the simpler calculation procedure, it is assumed that all populations have the same number (N) of individuals.
2. Calculation of the values of the function, which we want to minimize, maximizes.
3. Check the end of the algorithm: as in most optimization algorithms, you can stop genetic optimization:

a. Function Value: The value of the best person function is within a certain range around a certain value. It is not recommended to use only this criterion because of the stochastic element when searching for the procedure, the optimization may not end within a reasonable time.

4. Number Maximum number of iterations: this is the most commonly used criterion of detention. This ensures that the algorithms will give some results at a certain time, provided that they have reached the extreme or not

a. Generation: if the initial number of iterations (generations) does not improve the value of the fitness function of the best person, the algorithms stop.

5. Selection: among all persons of the current population, those selected will be selected that will continue through the intersection, and the mutation will yield a population of offspring. At this stage, you can use elitism: the best people are transferred directly to the next generation. Elitism ensures that the value of the optimization function cannot be worse (once the end reaches, it will remain).

6. Crossover: people selected by breeding will recombine with each other, and new people will be created. The goal is to get hereditary people who inherit the best combination of characteristics (genes) of their parents.
7. Mutation: By accidentally changing some genes, it is guaranteed that even if none of the individuals does not contain the genetic value necessary to achieve the goal, an extreme can still be achieved.
8. A new generation: elite people, selected from the selection, are united with those who have crossed and mutated, and form a new generation. It works well with digital and experimental data. It is suitable for parallel computing.

1.6. Objectives of research

The main goal of any manufacturing industry is to achieve a high level of productivity and flexibility, which can only be achieved in a computer environment. The purpose of this study is to maximize the use of the machine, maximize system performance and optimize factors that affect system utilization and system performance using Taguchi's philosophy and genetic algorithm,

2. Methodology

In this research methodology was adopted as shown in Figure1, it begins with work planning using the sequencing rules, and therefore based on the programming of a small, flexible simulated production was developed. The process variables that the FMS targets were designed using the Taguchi philosophy were treated as input function for the FMS simulation model to generate the throughput and working hours for each machine per year and then use and throughput of the system has been optimized.

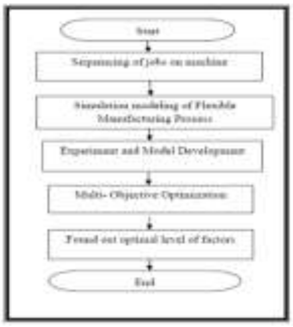

Figure1: Flowchart of analysis of FMS

2.1 Sequencing of jobs on machines

In this Research, four types of parts and five machines were used. Processing time for each operation in different types of parts on different machines is shown in Table 1, in this search the programming rule for the shortest processing time for planning was used.

Table 1: Processing time of each operation on each machine (min.)

Part/Machine	Operation	M/C 1	M/C 2	M/C 3	M/C 4	M/C 5
P_1 (n_1=3)	O_{11}	2	5	4	1	2
	O_{12}	5	4	5	7	5
	O_{13}	4	5	5	4	5
P_2(n_2=3)	O_{21}	2	5	4	7	8
	O_{22}	5	6	9	8	5
	O_{23}	4	5	4	5	5
P_3(n_3=4)	O_{31}	9	8	6	7	9
	O_{32}	6	1	2	5	4
	O_{33}	2	5	4	2	4
	O_{34}	4	5	2	1	5
P_4(n_4=2)	O_{41}	1	5	2	4	12
	O_{42}	5	1	2	1	2

According to the shorter processing time rule, the work with the shortest processing time is processed first, and here each operation can be processed on each machine with a different processing time. The operation in the part will be processed in this machine, the machine that requires less processing time for the operation.

Table 2: Sequencing of operation of jobs on machines

M/C_k	Sequence of operation
M/C_1	O_{21}-O_{41}-O_{23}
M/C_2	O_{12}-O_{42}-O_{32}
M/C_3	O_{31}
M/C_4	O_{11}- O_{13}-O_{33}-O_{34}

For example, the operation O_{11} will be processed in the machine 4, because the machine takes 4 less work done than the other machine. In the same way, for all operations of different tasks, may be a part of the machine.

2.2 Modeling of flexible manufacturing system

In this Research, five machines and four different types were used. As in there are five machines, and in this model, the simulation was assigned 1 hour for 3820 hours which is calculated using the Welch method. With this method, we get the average work average in the process graph and in 3820 hours, this graph is almost fluid. Then it's the warm-up period.

The AGV was used to transfer parts from one station to another station and, It Shows the logical data module that was used in the simulation model. To create an FMS template and run the simulation using Arena, the user will perform the following steps:

1. Construction of the basic model. The sand provides a diagram view of the model window, which is a flowchart environment for building a model. The user selects and moves the forms of the flowchart module to the model window and associates them to determine the flow of the model process.
2. Add data to the parameters of the model. The user adds real data to the model (for example, processing time, resource requests, etc.). This is done by double clicking on the module icons and adding data.
3. Simulate the model. The user starts the simulation and analyzes the results.
4. Analysis of the simulation results provided by Arena automated reports. The user can develop statistics.
5. Modify and improve the model according to the needs of the user.

In this Research, we use 5 work stations and 5 machines that produce 4 types of parts with different operations. The processing time is distributed exponentially, as shown in Table 1. In this search, the processing time is considered exponentially distributed. The arrival of the application is also considered exponentially distributed. This means that the part request will be distributed exponentially here in this search, the arrival request time is 10, 15 and 20 minutes, which means that each request comes in 10, 15, 20 minutes and that the parts are processed according to this sequence.

2.3 Experimentation and modeling

A small production system, modeled on this thesis, is taken from [2]. It consists of five work stations and five machines, and there are four parts manufactured by these machines. Each work station consists of a machine. Here we use four factors that affect the purpose of FMS: these factors and their levels:

1. Distance preference (X_1): distance preference means the distance between two stations. This can be the smallest distance between two stations or the greatest distance between two stations or the distance in a cyclic order, as shown in the figure. Therefore, the distance preference level is the smallest distance (S), the longest distance (L), the longest cyclic distance (C).
2. Arrival time (request) (min.) (X_2): this is the part request time. Here in the simulation, three levels of demand time 10 minutes and 15 minutes were calculated and 20 minutes Smallest Distance.
3. No. of carts(X_3) = The No. of carts used in simulation; there are simulation three levels of no. Carts it was assumed 2, 3 and
4. Speed of carts (feet/min.) (X_4)=this is the speed of carts or AGVs, which also affects the FMS purpose. In this thesis there are three levels of speeds were assumed 60, 65 and 70.

Above each factor in three levels, so that the degree of freedom of each factor is equal to 2, and three demand of interaction time for the arrival of the other three factors (remote preference, the number of carts), the velocity of the carts), so that each interaction has 4 degrees of freedom, therefore, the total degree of freedom factors is 20. The degree of freedom model must be equal to or greater than the total degrees of the factors of freedom. Therefore, in this Research, for "precise" results, "L_{27}" and the process variables, developed using Taguchi's philosophy, were chosen, and considered as the input functions for the FMS simulation model for production capacity and hours. of work for each machine per year, as indicated respectively in Table 3 and Table 4, and the use of the system, the system must be made according to the following formula:

$$\text{System Utilization} = \frac{\sum_{i=1}^{n} W_i}{n * 365 * 24}$$

Where i = No. of machine, n = Total no. of machine

There are total no. of machine is five. System utilization for each treatment has been calculated by using above formula.

Table 3: Experimental design of L27 array for throughput

Distance preference	Demand time	No. of Carts	Velocity of Carts	Throughput
Small	10	2	60	29586
Small	10	3	65	29733
Small	10	4	70	29552
Small	15	2	60	19463
Small	15	3	65	19586
Small	15	4	70	19812
Small	20	2	60	14870
Small	20	3	65	14778
Small	20	4	70	14976
Large	10	2	65	29373
Large	10	3	70	29284
Large	10	4	60	29380
Large	15	2	65	19844
Large	15	3	70	19623
Large	15	4	60	19749
Large	20	2	65	14595
Large	20	3	70	14670
Large	20	4	60	14594
Cyclical	10	2	70	29285
Cyclical	10	3	60	29595
Cyclical	10	4	65	29285
Cyclical	15	2	70	19875
Cyclical	15	3	60	19865
Cyclical	15	4	65	19770
Cyclical	20	2	70	14764
Cyclical	20	3	60	14732

Cyclical	20	4	65	14885

Table 4: Experimental design of L27 array for System utilization

Distance preference	Demand time	No. of Carts	Velocity of Carts	System Utilization
Small	10	2	60	0.1.6313
Small	10	3	65	0.106346
Small	10	4	70	0.105746
Small	15	2	60	0.070139
Small	15	3	65	0.070316
Small	15	4	70	0.070486
Small	20	2	60	0.055483
Small	20	3	65	0.052751
Small	20	4	70	0.053747
Large	10	2	65	0.105842
Large	10	3	70	0.105249
Large	10	4	60	0.105111
Large	15	2	65	0.071236
Large	15	3	70	0.070445
Large	15	4	60	0.071466
Large	20	2	65	0.052381
Large	20	3	70	0.052368
Large	20	4	60	0.052429
Cyclical	10	2	70	0.105198
Cyclical	10	3	60	0.106638
Cyclical	10	4	65	0.105174
Cyclical	15	2	70	0.071295
Cyclical	15	3	60	0.071832
Cyclical	15	4	65	0.070563
Cyclical	20	2	70	0.052861
Cyclical	20	3	60	0.05335
Cyclical	20	4	65	0.054687

2.4 Optimization:

Optimization of the use of the system and the flow was carried out using a genetic algorithm. The regression equation created by the Taguchi philosophy for use and performance of the system was used as a function of fitness for a genetic algorithm, and the genetic algorithm provides the optimal value of factors for maximizing productivity and efficiency. Use of the system.

In addition to the unique target functions considered for this problem, the combined function is also used for multi-purpose optimization of FMS parameters. The function and limits of a variable are specified using the following function. The scales are considered equal for all answers in this task of multi-purpose optimization. Then W_1 and W_2 are equal to 0.5.

$$Z_{Multi} = w_1 * \frac{Z_{system\ utilization}}{system\ utilization_{max}} + w_2 * \frac{Z_{throughput}}{Throughput_{max}}$$

3. Results and Discussions

3.1. Scheduling

In this Research, the shortest Processing time (SPT) was used. In the shortest processing time (SPT), the job with the shortest run time enters the service first (local rule). The SPT rule is simple, fast, usually an excellent rule in terms of minimizing the execution time in the system, minimizing the average number of workstations in the system, generally current inventory (less purchases) and downtime (greater resource load), and, as a general rule, a shorter average duration of work. The planning of a flexible production system according to the SPT rule is given in Table 5. According to this sequence, the step is 12 minutes.

Table 5: Sequencing of Operation on jobs

M/C_k	Sequence of operation
M/C_1	O_{21}-O_{41}-O_{23}
M/C_2	O_{12}-O_{42}-O_{32}
M/C_3	O_{31}
M/C_4	O_{11}- O_{13}-O_{33}-O_{34}

3.2. Experimental design

In this search, the $\mathbf{L_{27}}$ table was used, as discussed in the previous chapter. When a process variable developed using the Taguchi philosophy is considered as an input function for the FMS simulation model, it generates working time for each machine per year, and also provides system performance. Depending on the purpose of the FMS implementation and the use of the system is better. Then the use of a larger size is better in the $\mathbf{L_{27}}$ matrix in the Taguchi philosophy after obtaining the obtained graphs and regression equations.

A graph of the main performance effects shows that the distance preference should be at the first level, which means that the preferred distance should be lower for this simulated flexible production system to maximize system performance. for this simulated flexible manufacturing system for maximizing throughput of system and throughput of system is maximum at demand time is 10 min and no. of carts used is 4, and the speed of the cart - 60 feet / min.

Interaction diagrams for averages between the application request arrival time (B) and the no. The carts (C) give that as the time of the demand of arrival increases the rate of reductions of the system, there is much less effect of no. carts in the flow according to this investigation.

The interaction diagrams for the arrival request time (B) and the distance preference (A) indicate that the arrival request time increases the performance of the system and when the arrival request time is 20 minutes. The maximum production at level 1 means that when the distance preference is smaller, but the arrival request time is 15 minutes, the maximum production at level three means that the distance preference is cyclical, and when the distance is time of arrival is 10 minutes and the distance preference is smaller, so the system performance is maximum. This means that when the arrival time increases, the system performance decreases.

Interaction diagrams for arrival request time (B) and cart speed (D) result in arrival request time increasing system performance decreasing the effect of cart speed on performance after this research on this problem.

The main effect graph of the use of the system shows that the distance preference must be at the first level means that the distance preference must be lower for this simulated flexible manufacturing system in order to maximize the use of the system of the system. The maximum request time is 10 min and no. of carts is 2 and the speed of the car is 60 feet / min.

The interaction diagrams for the arrival request time (B) and the distance preference (A) indicate that the arrival request time increases the performance of the system and when the arrival request time is 20 minutes. The maximum production at level 1 means that when the distance preference is smaller, but the arrival request time is 15 minutes, the maximum production at level three means that the distance preference is cyclical, and when the distance is time of arrival is 10 minutes and the distance preference is smaller, so the system performance is maximum. This means that when the arrival time increases, the system performance decreases.

Interaction diagrams for the media between the arrival time of the request (B) and the no. carts (C) gives the time of the arrival request increases the performance of the system, the effect of no decrease. carts in the use of the system according to this investigation in this problem.

Interaction diagrams for arrival request time (B) and cart speed (D) result in arrival request time increasing system performance decreasing the effect of cart speed on performance after this research on this problem. As indicated in the response table, averages indicate that the demand time is a more influential factor than other factors. Carriage speed affects system utilization and distance preference has a much lower effect on performance.

3.3. Optimization

In this research, system throughput of system and system utilization both are optimized by genetic algorithm, using genetic algorithm following results obtained as shown in table 4.4 and table 4.5 respectively for maximum throughput = 43321 - 17*distance preferences (X_1) - 1469 *arrival demand + 19* no. of carts (X_3) + 0.1 * velocity of carts (X_4)

The use of the system obtained by the value of the previous factor in the simulation is 0.1071%. In addition to the single objective functions considered for this problem, a combined function is also used to perform the multi-objective optimization for FMS settings. The function and the limits of variables are given using the following function. Weights are considered equal for all responses in this multi-objective optimization problem. Therefore, W_1 and W_2 are 0.5.

Using above function a following combined function obtained which is optimized by using genetic algorithm and gives results as

Z_{Multi} = 0.5 * (1.49155 - 0.0000938 * X(1) distance preferences - 0.049155 * X(2) arrival demand time + 0.0006566 * X(3) No. of carts + 0.0005628*X(4) Velocity of carts)-0.75*(1.4642 - 0.0005717 * X(1) distance preferences -0.49406 * X(2) arrival demand time +19 * X(3) No. of carts +0.0006390 * X(4) Velocity of carts)

Table 6: Factor and their level for maximizing throughput and system utilization through genetic algorithm

Factors	LEVEL	VALUE
Distance preference	Level1	Smallest distance
Demand arrival time	Level1	10 minutes
No. of carts	Level3	4
Velocity of cart	-	62.495
Throughput		30018
System utilization		0.1085%

4. Conclusions

In this Research, we presented simulation modeling and optimization of FMS targets to assess the impact of factors such as requirement arrival time of carts used in the system, speed of carts and distance preference between two stations. These factors affect both system utilization and throughput. System utilization and throughput are more influenced by the time of arrival than other three factors. The distance preference also affects throughput and system utilization. For both system utilization and throughput removal, the preference should be the smallest and as the arrival time of the demand increases, both the system utilization and the throughput of the system decrease. The number of cars and the speed of the cars are less affected.

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