EVALUATION OF AGV CAPACITY IN A FLEXIBLE MANUFACTURING SYSTEM

A Research Project

Class: MIS 64018 - 001 – Systems Simulation – MSBA
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Spring - 2020

ABSTRACT

Studying the performance of manufacturing systems is one of the major concerns of the manufacturers, this allows companies to adapt to any type of change to the environment and to ensure the smooth operation of the production system. Therefore, we conduct a study of a flexible manufacturing system which has a set of Automated Guided Vehicles system (AGVs) in order to define the levels of the most influential factors on the behavior of our system.

Purpose: Evaluate the AGV capacity and investigate the uncertainties and the benefits of flexibilities in a Flexible Manufacturing System through different scenarios.

Methodology: A simulation tool ARENA / Process analyzer has allowed us to analyze the behavior of the system and visualize results that show the impact of different parameters on the system performance through variation in the co-efficient of variance for Inter Arrival Time (IAT) and variation in the number of (AGV) in the system.

Keywords— IAT; flexible manufacturing system; AGVs; performance measurement

INTRODUCTION

Automated guided vehicles (AGVs) have now become commonplace in the manufacturing world. Manufacturers of electronic goods and large automobile manufacturers are some well-known examples of industries that use AGVs in their manufacturing operations. The usage of AGVs in the US has increased significantly in the last few years because of increasing labor costs associated with human-operated material-handling systems (Heragu,S 2008). It is the case, however, that AGV systems themselves tend to be very expensive. Even a single vehicle can cost several thousand dollars. On the other hand, even one AGV can significantly reduce the material-handling time and thereby increase throughput and reduce inventory.

Hence modeling the economics of buying an additional vehicle is an important problem from the standpoint of making a system lean. Optimization of the AGV's capacity can be performed analytically only under some simplifying assumptions about the system. We present a simulation-optimization approach to determine the optimal capacity of an AGV in a closed loop path, where the AGV is used as a device for pick-up from stations and machines and drop-off at station Zones. We consider a flexible manufacturing system that uses (AGVs) for part handling.

LITERATURE REVIEW

The use of flexible production facility allows the manufacturing system to adapt to evolution in the environment through these resources, in order to manage well the workflow of production and improve the overall system performance. (G,.Belson 1995) stated that: “A flexible workshop of production must be able to dynamically manage a large number of tasks, entities and resources and coordinate all the components of the workshop, while managing random occurrings in a quasi-permanent during production”

A system with multiple AGVs is often divided into separate compartments (Bozer and Srinivasan 1992 and Bozer and Park 1992) in which one vehicle serves a dedicated set of workstations. In this paper, we focus on the analysis of a closed loop with one vehicle. The literature presents some models for measuring the performance of *such* a single-loop path; (Thonemann, U.W 1996), which uses a queuing approximation from (Gendreau, M 1984) and (Kahraman, A.F 2008), which uses a Markov chain approximation. However, both of these papers make numerous assumptions about the system in the process of developing a tractable mathematical model. Some of the assumptions are: the inter-arrival time of jobs at the machines is exponentially distributed (Thonemann, U.W 1996), and the time of travel from one machine to another is deterministic (Kahraman, A.F 2008).

According to (Castagna 2004) , the movement of AGV may be mono-directional (or unidirectional). Indeed, the management of AGVs requires management rules called "dispatching rules" that allow you to choose the vehicle available, which are operating to transport jobs from one location to another. The control of these elements transfer requires a control system that can control the areas to be visited prior to the entry of the vehicle. A flexible manufacturing facility consists of multi- tasking machines and transfer means for routings varied with a less time-consuming tool change. An AGVs is considered as a means of handling the most appropriate to a flexible production (N. Gaouar 2004).

In this paper, we attempt to study the capacity-optimization problem while relaxing such restrictive assumptions. To this end, we develop a simulation model of the system and use it for optimization of the AGV’s capacity.

Building and analyzing the Models

This model investigates the impact of uncertainties and the benefits of flexibilities in a Flexible Manufacturing System which consists of 3 workstations, AGV (Automated guided vehicles) and various loading and unloading stations. The following assumptions are made in this experimental set up.

1) Each Workstation is continuously available for processing, ie, machine breakdowns are not considered. Machines are never unable to perform a required operation for lack of operator, tool or raw material. Each machine can process one part at a time.
2) Pre-emption is not allowed
3) AVGs are continuously in operation without any breakdown. They carry single load and follow shortest distance.
4) Setup times are small or negligible, due dates are not specified, batch type arrival is not considered.
5) The performance measures studied in this set up are resource utilization (machine utilization) as well as AGV utilization), time-in system (throughput) time and output.

In this study the demand variability and the machine time uncertainty are modeled and to respond to these uncertainties volume flexibility and machine flexibility are considered. We conducted 2 experiments that focus on the variation in the number of AGV, the inter-arrival time of parts, processing time and the interaction of these factors on system performance.

The following are the hypothesis tested.

1) As demand uncertainty increases, machine utilization decreases.
2) Increase in the number of AGVs, increases the system performance initially and the decreases it.

SYSTEM LAYOUT

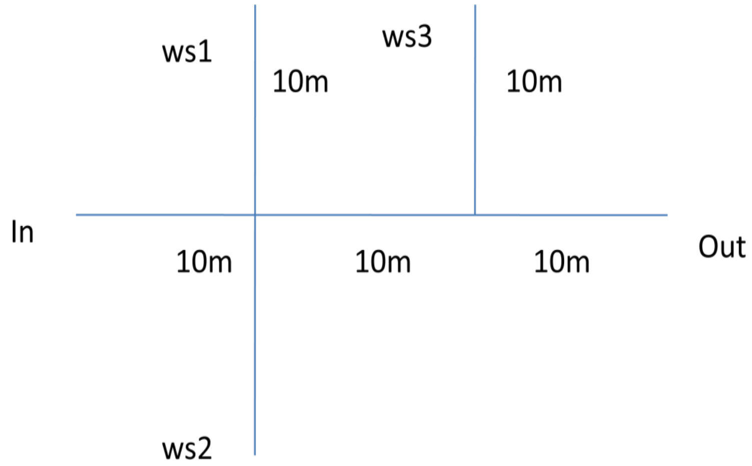

Fig1 :- system layout

DATA GIVEN

Incremental Time: Norm (15, 0.001) min

To study the effect of demand uncertainty, IAT is varied with a co- efficient of variance of 0.13, 0.26, 0.4, and 0.53 respectively.

Processing Time: Norm (15, 0.001) min

To check which machine has minimum impact, the processing time of machine are made to vary with a co-efficient of variance of 0.13, 0.26, 0.4, and 0.53 respectively.

No of AGVs:

To analyze the system performance with respect to number of AGVs, the number is increased from 1,2,3,4 and 5 respectively.

IAT: Norm (15, 8) min, PT: Norm (15, 8) min, Load/Unload times are 1

Other parameters given are:

AGV velocity	20 meter/minute
Distance between each segment	10 meters
Replication Length	100000
Number of replications	1
Warm up time	500 minutes

ADVANCED TRANSFER/DISTANCE-

Transporter1.Distance

No.	Beginning station	Ending station	Distance
1	Arrive Dock	Station1	20
2	Station1	Station2	20
3	Station2	Station3	30
4	Staion3	Exit shop	20
5	Arrive Dock	Station2	20
6	Arrive Dock	Station3	30
7	Arrive Dock	Exit shop	30
8	Station1	Station3	30
9	Station1	Exit shop	30
10	Station2	Exit shop	30

Table1: Distance between stations.

1. *First Experiment: Effect of demand uncertainty Vs FMS performance*

MODEL DESCRIPTION

There are 3 machines and one AGV.IAT Normal (15,0.001)with covariance 0.13,0.26,0.4,0.53 and processing time is kept as Normal(15,0.001) and corresponding machine utilization, output and throughput time for the three machines and AGV, are to be found out.

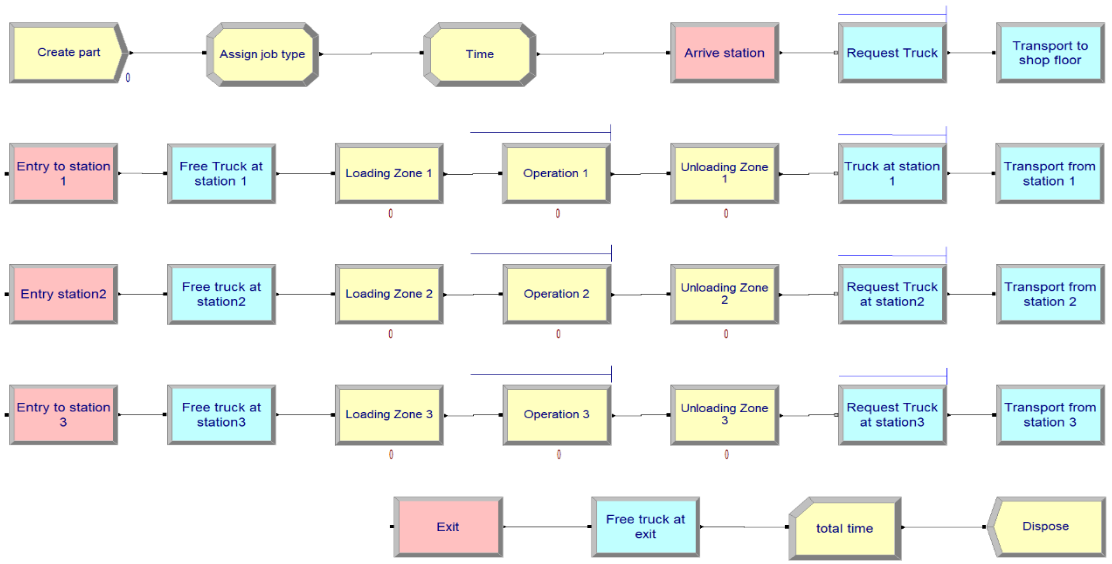

Fig2: Simulation model of demand uncertainty Vs FMS.

Model Verification and coding:

To attempt model verification, we used some of common verification methods. First, we eliminated all model errors. Second, we set max entities arrival to 1 to make sure the model logic is correct. Third, we checked model under extreme conditions by increasing interarrival times, explained in first hypothesis. Lastly, we changed part type distribution and some of the model data to constant.

RESULT AND DISCUSSION:

According to the given data the replication length is set as 1,00,000 minute and for a warmup period of 500 minute for 5 different IAT(Normal(15,001),Normal (15,2),Normal(15,4),Normal(15,6),Normal(15,8)) . The utilizations, output in numbers and throughput time for the three machines and AGV are obtained as given in the table below.

	Scenario Properties			Responses					
S	Name	Program File	Reps	Workstation 1.Utilization	Workstation 2.Utilization	Workstation 3.Utilization	AGV Utilization	System.NumberOut	Throughput Time
1	Scenario 1	1 : Model 1.p	1	1.000	1.000	1.000	0.400	6634.000	51.136
2	Scenario 2	1 : Model 2.p	1	0.999	0.999	0.999	0.486	6624.000	103.757
3	Scenario 3	1 : Model 3.p	1	0.999	0.999	0.999	0.503	6624.000	424.527
4	Scenario 4	1 : Model 4.p	1	0.996	0.996	0.995	0.516	6603.000	202.902
5	Scenario 5	1 : Model 5.p	1	0.987	0.987	0.987	0.506	6551.000	165.684

Table 2 :- Performance variation with respect to inter arrival time variation

From the above results it is found that machine utilization should not have significant variation for same IATs. When IAT are changing from Normal(15,.001) to Normal (15,8) the machine utilization decreases, output decreases and throughput time increases till Scenario 3 and then decreases

From the above results the graphs are drawn for

1. IAT Vs Output
2. IAT Vs Machine utilization
3. IAT Vs AGV utilization.
4. IAT Vs Throughput Time

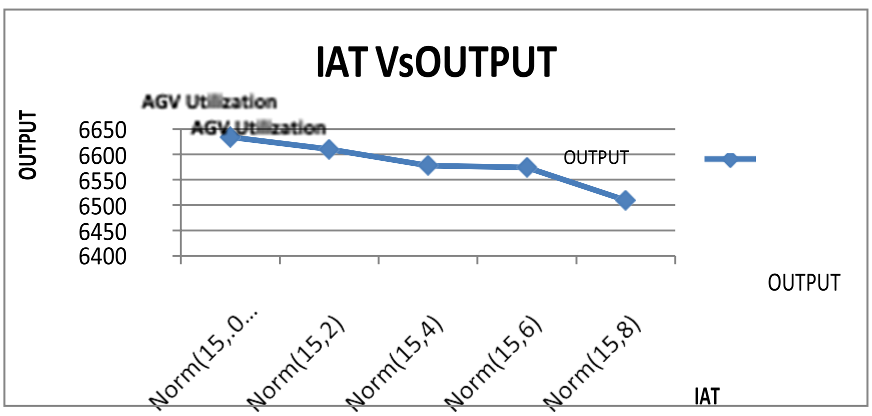

Fig 3:- Inter arrival time vs output.

From the above graph it is understood that according to the changes in Inter arrival time the output decreases.

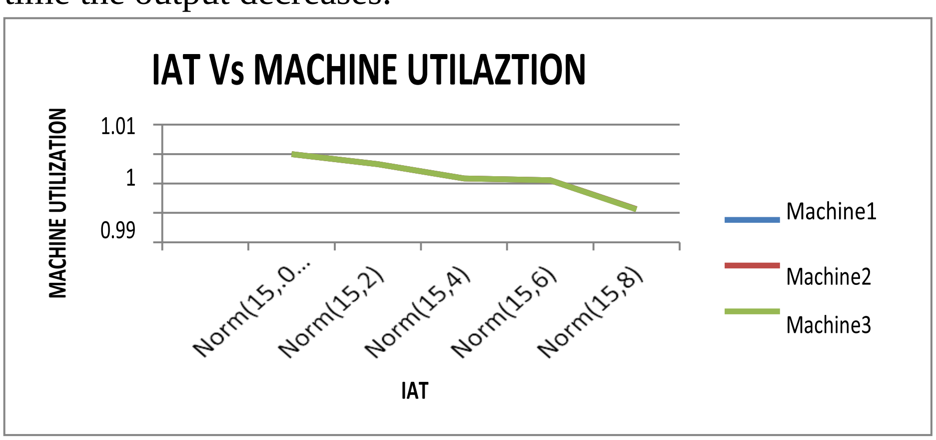

Fig 4 :- Inter arrival time vs machine utilization

From the above graph it is understood that according to the changes in Inter arrival time the machine utilization decreases

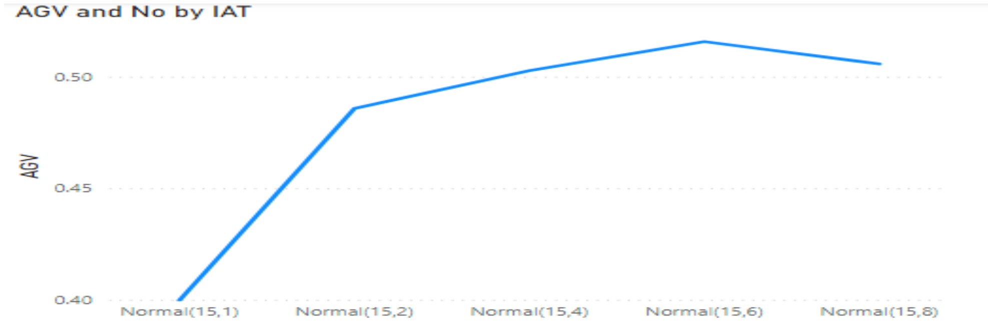

Fig 5:- inter arrival time vs AGV utilization

From the above graph the AGV utilization is increases with increase of IAT and slightly decrease with Norm(15,8).

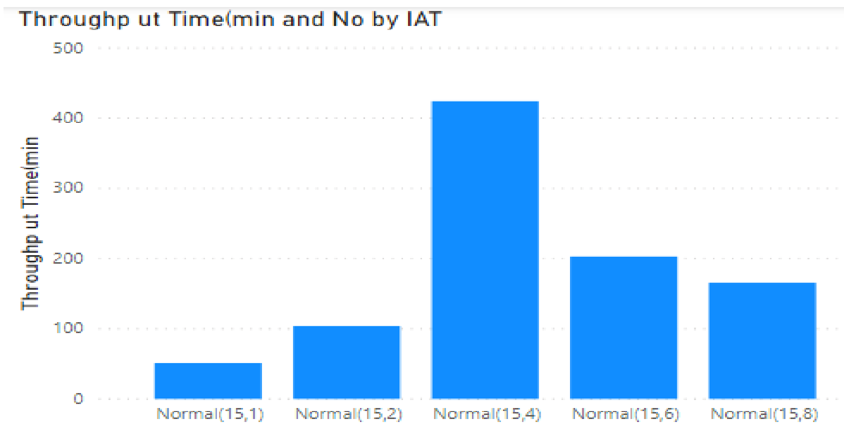

Fig 6:- Inter arrival time vs Throughput Time

From the above graph it is observed that the throughput time increases with increase of IAT untill Norm(15,4) and then deceases again.

Conclusion:

From the above results it is found that machine utilization should not have significant variation for same IATs. When IAT are changing from Normal(15,.001) to Normal (15,8) the machine utilization decreases, output decreases and throughput time fluctuated and has a highest value with Norm(15,4). So, we can say the Hypothesis is accepted.

2. ***First** Experiment: Effect of number of AGV's on FMS* **performance**

Hypothesis tested: increase in the number of AGVs increases the system performance initially and then decreases it.

DATA GIVEN:

Inter arrival time: Norm (15, 8) minute Processing Time: Norm (15, 8) minute No loading \unloading time: 0 , 1
Part type: 1

No of AGVs: 1, 2, 3,4,5,6

MODEL DESCRIPTION

Model created in AREA based on the above procedure. Here in this model the number of transporters is initially set as one. The number of AGV varied to2, 3, 4, 5 and 6. To get variation in model performance the processing time is set as Norm (15, 8).

RESULT AND DISCUSSION

In the experiment the number of AGV is varied as 1, 2, 3, 4, 5 and 6. The utilization of the three machines M1, M2, M3, AGV utilization, output, throughput time are noted from the output sheets after running the simulation model.

	Scenario Properties				Responses					
	S	Name	Program File	Reps	Workstation 1.Utilization	Workstation 2.Utilization	Workstation 3.Utilization	AGV Utilization	System.NumberOut	Throughput Time
1		Scenario 1	1 : AGV 1.p	1	0.989	0.986	0.985	0.552	6483.000	731.004
2		Scenario 2	1 : AGV 2.p	1	0.995	0.986	0.994	0.259	6512.000	815.064
3		Scenario 3	1 : AGV 3.p	1	0.999	0.989	0.988	0.164	6483.000	1069.254
4		Scenario 4	1 : AGV 4.p	1	0.999	0.989	0.979	0.122	6472.000	875.279
5		Scenario 5	1 : AGV 5.p	1	0.994	0.993	0.988	0.098	6480.000	811.254
6		Scenario 6	1 : AGV 6.p	1	1.000	0.980	0.989	0.081	6471.000	907.895

Table 3: Performance variation with respect to no. of AGV‘s

From the above observation, the number of AGV are increased from one to six. Utilization of M1 machine is increasing with number of AGV s and then become steady at 3 AGV‘s. The utilization of machine M2 and M3 also increases initially and then decreases. With increase in number of AGV‘s, the utilization is decreasing. Maximum output is corresponding to two AGV‘s, only slight variation in output for

other cases. Throughput time increase with increase in number of AGV's, but record a sudden decrease when number of AGV is five.
It can be concluded that the test hypothesis can be accepted, i.e. Increase in number of AGV's initially increases system performance and then decreases it.

GRAPH:

The following graphs are drawn based on the data obtained from experiment.

1. Number of AGV v/s Machine utilization
2. Number of AGV v/s AGV utilization
3. Number of AGV v/s Output
4. Number of AGV v/s Throughput time.

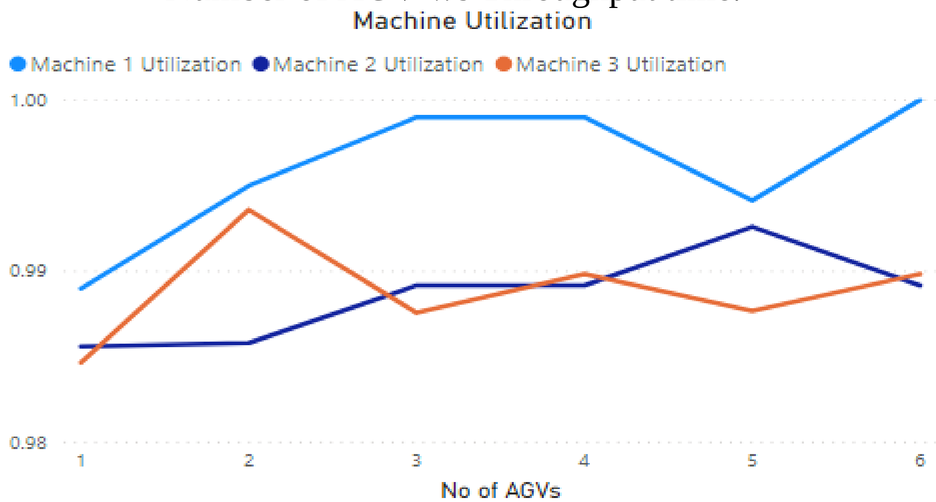

Figure 7: No. of AGV v/s Machines Utilization

From above graph, machine utilization initially increases and shows decreasing trend with increase in number of AGV's. Machine M1, M2, M3 achieve the maximum utilization corresponding to 3, 4, 6no. of AGV's.

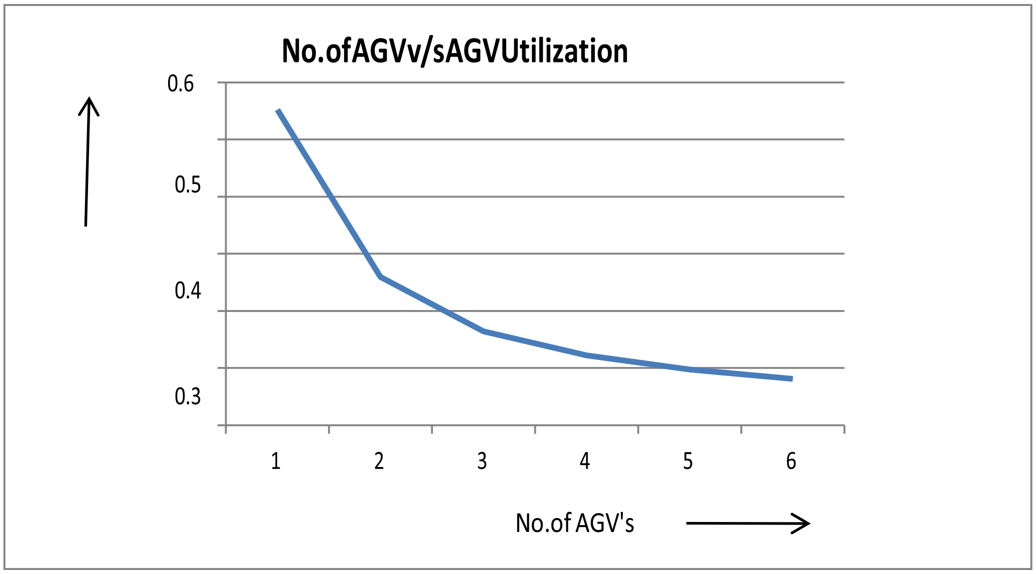

Figure 8: No. of AGV v/s AGV Utilization

AGV utilization shows a downward trend with increase in number of AGV‘s as per the graph above.

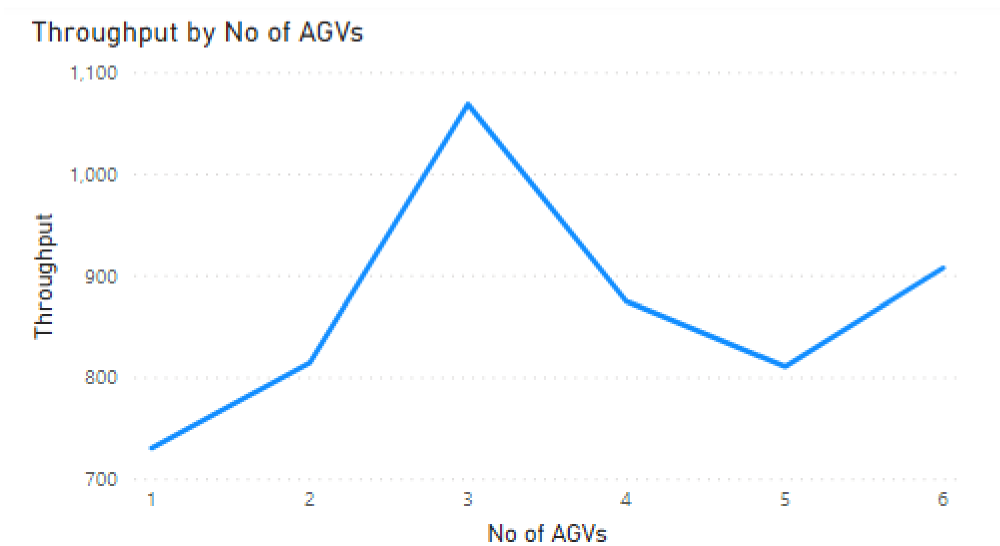

Figure9: No. of AGV v/s Throughput time

Throughput time shows fluctuation with variation in number of AGV‘s, it initially increases , reaches a maximum value and then decreases. It again shows positive trend with further increase in number of AGV‘s. AGV utilization is maximum at 2 then decreases for (3, 4, 5)AGVs and again increases with 6 no. of AGV‘s.

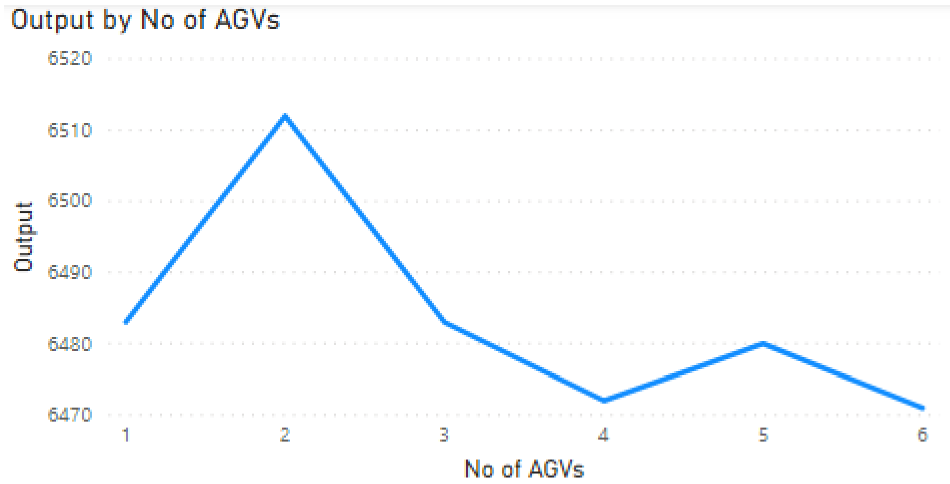

Figure10: No. of AGV vs. Output

The output varies slightly with the increase in number of AGV's. The trend is to increase initially, then to decrease. The maximum output corresponds to 2 AGV's.

Conclusion:

From the simulation it can be seen that the increase in performance of the system is small compared to the decrease in AGV utilization with respect to the variation in no. of AGV's. The AGV utilization continually shows a downward trend. Here the test considers the AGV's without specifying the route or variation in speed. Also the loading/unloading time assumed to be zero. But practical situations may be different from the assumed. As the uncertainties in processing time and inter arrival time increases, the effect of no. of AGV on utilization of resources also increase. To account that effect here both the time are considered as Norm (15, 8) instead of Norm (15, .001) in other experiments.

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