

THE PERFORMANCE ANALYSIS OF MATERIAL HANDLING SYSTEMS FOR A LAYOUT WITH DIFFERENT SPEEDS

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ABSTRACT

Flexible manufacturing systems (FMS) are a group of machines most preferably CNC which is coordinated by a common control centre which has the ability to deal with the variety of products. It is a manufacturing system which possesses the flexibility of adopting its machines and factory environments according to the product to be produced. In this paper performance of AGV, CART for U Layout with different speeds were studied and suggested different material handling devices for different processes for different layouts.

KEYWORDS: Flexible Manufacturing System, Automated Guided Vehicle & CART's

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INTRODUCTION

Emergence of flexible manufacturing system (FMS) is an important development in this direction using the novel concept of flexible automation. Lean manufacturing, with a focus on the continuous improvement of time, quality, cost, and flexibility has been one of the most successful philosophies and methodologies recently and still huge potential of future deployment remains. FMS is one of the practical implementations of Lean philosophy. By dynamical responding to system status, FMS is able to significantly reduce the percentage of idle capacity, improves the productivity, and quickly adjust ongoing production based on continuous changing market condition. To achieve the flexibilities included in FMS, machine, process, routing, production, volume, layout, production flexibilities and operation as depicted in the Figure 1, below.

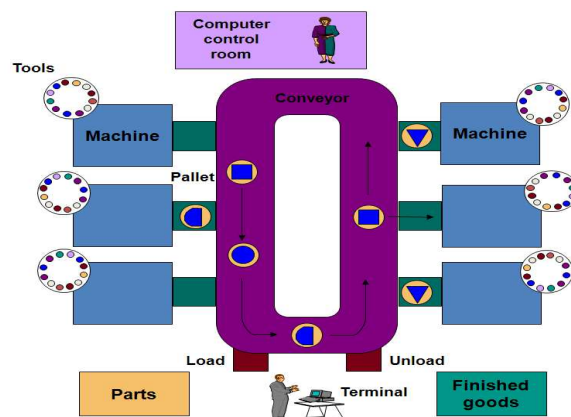


Figure 1: Typical View of FMS

In this paper an attempt is made to find an effective utilization of the material handling devices in the different production layout at different speeds. Manufacturing trades operate in a progressively competitive environment. The profit margin of manufacturing industry, a vital component of the economies of nations, has been significantly reduced by globalization.

Therefore, productivity of manufacturing system and its ability to respond to the dynamically changing market demands, has become a key focus for both researchers and practitioners. Conventional job shops are designed to manufacture small batches of a variety of products. This flexibility is usually off-set by low utilization of the production facilities, long lead times and high in process inventories. Enhancing the productivity of job shop without sacrificing its flexibility had been a long awaited dream of manufacturing system managers.

CASE STUDY

In this paper study is being carried out on the utilization of resources like processors, material handling devices like AGVs and CARTs can be best visualized by the use of simulation software. In order to conduct the study within the working environment, some of the conditions to be taken into consideration for producing parts are tabulated below.

G1-Turning, G2-Welding, G3-Drilling, G4-Milling, G5-Grinding and processing times are in seconds.

Table 1

Part #	Attributes	Process 1	Process 2	Process 3	Process 4	Process 5
Part 1	Sequence	G3	G4	G1	G5	-
	Processing time	35	30	15	30	-
Part 2	Sequence	G2	G3	G4	G5	-
	Processing time	35	27	31	32	-
Part 3	Sequence	G2	G3	G4	G1	G5
	Processing time	35	27	31	15	32
Part 4	Sequence	G3	G2	G4	G1	G5
	Processing time	27	29	19	15	24
Part 5	Sequence	G3	G1	G4	G5	-
	Processing time	23	17	19	24	-

EXPERIMENTAL DESIGN

The input Factors considered for this analysis are AGV, CART for U layout.

AGV Factors

Table 2

#	Layout	No. of AGVs	Speed (m/s)	#	Layout	No. of AGVs	Speed (m/s)
1	U Layout	1	4	1	U Layout	3	4
2	U Layout	1	4	2	U Layout	3	4
3	U Layout	1	4	3	U Layout	3	4
4	U Layout	1	4	4	U Layout	3	4
5	U Layout	1	4	5	U Layout	3	4

Table 3

#	Layout	No. of AGVs	Speed (m/s)	#	Layout	No. of AGVs	Speed (m/s)
1	U Layout	1	8	1	U Layout	3	8
2	U Layout	1	8	2	U Layout	3	8
3	U Layout	1	8	3	U Layout	3	8
4	U Layout	1	8	4	U Layout	3	8
5	U Layout	1	8	5	U Layout	3	8

The above conditions were the AGV Factors for U layout and with 2 different AGVs and with varying two different speeds 4m/s, and 8m/s

CART Factors

Table 4

#	Layout	No. of Carts	Speed (m/s)	#	Layout	No. of Carts	Speed (m/s)
1	U Layout	1	4	1	U Layout	3	4
2	U Layout	1	4	2	U Layout	3	4
3	U Layout	1	4	3	U Layout	3	4
4	U Layout	1	4	4	U Layout	3	4
5	U Layout	1	4	5	U Layout	3	4

Table 5

#	Layout	No. of AGVs	Speed (m/s)	#	Layout	No. of AGVs	Speed (m/s)
1	U Layout	1	8	1	U Layout	3	8
2	U Layout	1	8	2	U Layout	3	8
3	U Layout	1	8	3	U Layout	3	8
4	U Layout	1	8	4	U Layout	3	8
5	U Layout	1	8	5	U Layout	3	8

The above conditions were the CART factors in U layout and with 2 different AGVs and with varying two different speeds 4m/s, and 8m/s

METHODOLOGY

In the Production Layout, Material Handling Devices are the devices, which play a key role in reducing the manufacturing lead time. It is impossible to identify the best suited layout when Material Handling devices are practically applied in the layout. This can be easily done with the help of simulation with realistic conditions within the boundaries. Simulation is the realistic prior approach to the production process with the condition which is exactly similar to the production layout. In this Paper Simulation type used is Flex Sim 7.5. This Simulation Software is helpful to identify the behaviour of the AGV and CART in the production Layout.

The constraints that have been taken into consideration are:

Layout for present study-U Layout and Material handling devices considered are, Automated Guided Vehicle (AGV) &CART

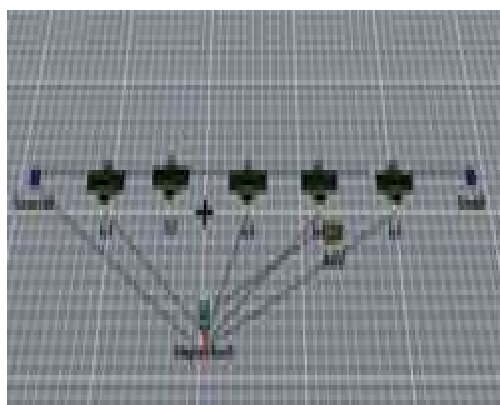


Figure 2: U Layout with 1 AGV

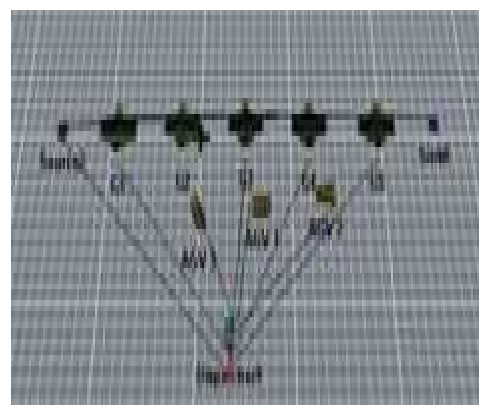


Figure 3: U Layout with 3 AGVs

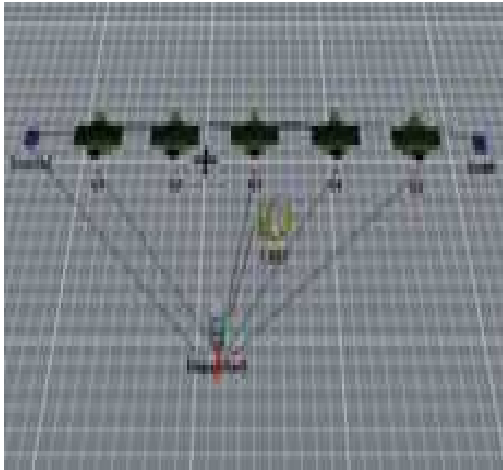


Figure 4: U Layout with 1 CART

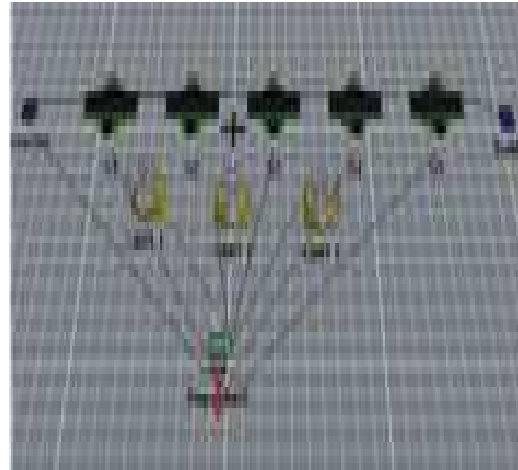


Figure 5: U Layout with 3 CARTs

Total production time observed is 10000 Seconds. In each material handling device, 2 different speeds are selected naming 4m/s and 8m/s with respect to U layout and with respect to each material handling devices (AGV and CART) as shown in the figures 2, 3, 4 and 5.

LITERATURE SURVEY

A Flexible Manufacturing System is an integrated, computer controlled complex of automated material handling devices and numerically controlled machine tools that can simultaneously process medium sized volumes of a variety of part types [1,8]. Job Shop Scheduling can be easily exercised with the help of simulation based techniques in which setup times and sequence dependant [2]. The performance of a simulation engine is a very important issue in developing optimized simulation based scheduling system, it is necessary to simulate multiple alternatives until given criteria are satisfied [3]. The Simulation results indicate that for infinite buffer capacity, the alternative routing planned policy, combined with the shortest total processing time dispatching rule, gives the best results for all performance measures [4]. The Threshold value for each manufacturing system is unique and has a methodology for determining its unique values. The threshold concept and the performance of threshold based alternate routing will minimize mean flow time [5,11]. Operational measures help manufacturing managers to understand the kind and extent of flexibility embedded in their production process and allow them to make informal judgements on new equipments [7]. Flexible Manufacturing System is characterized by versatile work stations with minimum changeover times and a versatile material handling system [9]. Operational control of a Flexible Manufacturing system with flexible alternative machines and flexible alternative operation sequences. Several policies are presented which can select in real time the next operation for a part and the machine to perform that operation, given that flexible process plans are available [10]. Integrated Methodology Planner’s rule based process selection system and flexible manufacturing system’s control simulation model performance real time data exchange in terms of the system status and part routings [13].

RESULTS

Table 6

Part #	Attributes	Process 1	Process 2	Process 3	Process 4	Process 5
Part 1	Sequence	G3	G4	G1	G5	-
	Processing time	35	30	15	30	-

Table 7

U LAYOUT WITH 1 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	52.77%	33.99%	0.00%	0.00%
G1	Processor	23.34%	19.95%	17.78%	38.93%	0.00%	0.00%
G2	Processor						
G3	Processor	44.08%	47.00%	0.00%	8.92%	0.00%	0.00%
G4	Processor	41.02%	40.22%	5.38%	13.38%	0.00%	0.00%
G5	Processor	47.30%	39.64%	0.00%	13.06%	0.00%	0.00%
AGV	Task Executer	17.81%	0.00%	0.00%	0.00%	41.63%	40.56%
U LAYOUT WITH 3 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	67.30%	15.01%	0.00%	0.00%
G1	Processor	61.91%	25.67%	0.00%	12.41%	0.00%	0.00%
G2	Processor						
G3	Processor	29.23%	60.26%	0.00%	10.51%	0.00%	0.00%
G4	Processor	42.20%	51.32%	0.00%	6.48%	0.00%	0.00%
G5	Processor	41.17%	51.08%	0.00%	7.75%	0.00%	0.00%
AGV 1	Task Executer	49.49%	0.00%	0.00%	0.00%	23.74%	26.77%
AGV 2	Task Executer	66.24%	0.00%	0.00%	0.00%	15.66%	18.10%
AGV 3	Task Executer	75.66%	0.00%	0.00%	0.00%	11.65%	12.69%
U LAYOUT WITH 1 AGV SPEED 8							
State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	53.55%	32.14%	0.00%	0.00%
G1	Processor	21.86%	21.17%	19.88%	37.09%	0.00%	0.00%
G2	Processor						
G3	Processor	41.72%	49.78%	0.00%	8.50%	0.00%	0.00%
G4	Processor	43.79%	42.61%	0.58%	13.02%	0.00%	0.00%
G5	Processor	44.67%	42.03%	0.00%	13.30%	0.00%	0.00%
AGV	Task Executer	21.61%	0.00%	0.00%	0.00%	39.51%	38.88%
U LAYOUT WITH 3 AGV SPEED 8							
State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	68.38%	13.11%	0.00%	0.00%
G1	Processor	61.06%	27.03%	0.00%	11.91%	0.00%	0.00%
G2	Processor						
G3	Processor	26.38%	63.71%	0.00%	9.91%	0.00%	0.00%
G4	Processor	35.82%	54.39%	0.00%	9.79%	0.00%	0.00%
G5	Processor	36.68%	54.03%	0.00%	9.29%	0.00%	0.00%
AGV 1	Task Executer	45.41%	0.00%	0.00%	0.00%	25.99%	28.60%
AGV 2	Task Executer	72.24%	0.00%	0.00%	0.00%	15.02%	12.74%
AGV 3	Task Executer	74.03%	0.00%	0.00%	0.00%	12.98%	12.99%

Table 8

U LAYOUT WITH 1 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	53.01%	31.12%	0.00%	0.00%	0.00%	0.00%
G1	Processor	16.92%	22.81%	24.03%	36.24%	0.00%	0.00%	0.00%	0.00%
G2	Processor								
G3	Processor	39.78%	53.37%	0.00%	6.85%	0.00%	0.00%	0.00%	0.00%
G4	Processor	48.72%	45.70%	0.00%	5.58%	0.00%	0.00%	0.00%	0.00%
G5	Processor	42.31%	45.12%	0.00%	12.57%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	31.88%	0.00%	0.00%	0.00%	4.63%	2.26%	30.47%	30.76%
U LAYOUT WITH 3 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	66.62%	13.13%	0.00%	0.00%	0.00%	0.00%
G1	Processor	58.96%	29.58%	0.00%	11.46%	0.00%	0.00%	0.00%	0.00%
G2	Processor								
G3	Processor	24.88%	69.66%	0.00%	5.45%	0.00%	0.00%	0.00%	0.00%
G4	Processor	34.37%	59.49%	0.00%	6.14%	0.00%	0.00%	0.00%	0.00%
G5	Processor	34.77%	59.12%	0.00%	6.11%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	48.05%	0.00%	0.00%	0.00%	3.22%	1.90%	21.35%	25.49%
CART 2	Transporter	85.29%	0.00%	0.00%	0.00%	2.06%	0.62%	5.44%	6.59%
CART 3	Transporter	80.21%	0.00%	0.00%	0.00%	1.23%	0.42%	8.98%	9.16%
U LAYOUT WITH 1 CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded	TRAVEL Empty	Travel Loaded
Source2	Source	0.00%	0.00%	64.61%	15.52%	0.00%	0.00%	0.00%	0.00%
G1	Processor	55.64%	29.34%	0.00%	15.02%	0.00%	0.00%	0.00%	0.00%
G2	Processor								
G3	Processor	22.38%	68.76%	0.00%	8.86%	0.00%	0.00%	0.00%	0.00%
G4	Processor	37.73%	58.81%	0.00%	3.46%	0.00%	0.00%	0.00%	0.00%
G5	Processor	37.59%	58.37%	0.00%	4.04%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	49.42%	0.00%	0.00%	0.00%	3.61%	2.91%	18.39%	25.67%
U LAYOUT WITH 3 CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	67.60%	10.57%	0.00%	0.00%	0.00%	0.00%
G1	Processor	61.46%	32.28%	0.00%	6.26%	0.00%	0.00%	0.00%	0.00%
G2	Processor								
G3	Processor	18.44%	75.66%	0.00%	5.90%	0.00%	0.00%	0.00%	0.00%
G4	Processor	31.95%	64.60%	0.00%	3.45%	0.00%	0.00%	0.00%	0.00%
G5	Processor	31.23%	64.25%	0.00%	4.52%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	60.58%	0.00%	0.00%	0.00%	2.61%	2.07%	15.70%	19.04%
CART 2	Transporter	81.24%	0.00%	0.00%	0.00%	1.30%	1.02%	9.23%	7.21%
CART 3	Transporter	84.72%	0.00%	0.00%	0.00%	1.51%	0.51%	6.60%	6.66%

Table 9

Part #	Attributes	Process 1	Process 2	Process 3	Process 4	Process 5
Part 2	Sequence	G2	G3	G4	G5	-
	Processing time	35	27	31	32	-

Table 10

U TYPE LAYOUT 1 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	63.17%	20.16%	0.00%	0.00%
G1	Processor						
G2	Processor	31.23%	56.01%	0.00%	12.76%	0.00%	0.00%
G3	Processor	23.69%	42.95%	14.22%	19.14%	0.00%	0.00%
G4	Processor	27.36%	49.06%	0.18%	23.40%	0.00%	0.00%
G5	Processor	32.93%	50.29%	0.00%	16.77%	0.00%	0.00%
AGV	Task Executer	0.83%	0.00%	0.00%	0.00%	52.52%	46.65%
U TYPE LAYOUT 3 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	70.02%	10.62%	0.00%	0.00%
G1	Processor						
G2	Processor	22.64%	67.56%	0.00%	9.80%	0.00%	0.00%
G3	Processor	41.52%	51.88%	0.00%	6.60%	0.00%	0.00%
G4	Processor	30.45%	59.36%	0.00%	10.19%	0.00%	0.00%
G5	Processor	27.60%	61.14%	0.00%	11.26%	0.00%	0.00%
AGV 1	Task Executer	41.11%	0.00%	0.00%	0.00%	27.79%	31.09%
AGV 2	Task Executer	58.83%	0.00%	0.00%	0.00%	20.65%	20.52%
AGV 3	Task Executer	100%	0.00%	0.00%	0.00%	0.00%	0.00%
U LAYOUT WITH 1 AGV SPEED 8							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	62.62%	19.53%	0.00%	0.00%
G1	Processor						
G2	Processor	30.41%	60.91%	0.00%	8.68%	0.00%	0.00%
G3	Processor	25.42%	46.74%	8.92%	18.93%	0.00%	0.00%
G4	Processor	27.25%	53.33%	0.08%	19.34%	0.00%	0.00%
G5	Processor	32.11%	54.79%	0.00%	13.10%	0.00%	0.00%
AGV	Task Executer	2.75%	0.00%	0.00%	0.00%	51.55%	45.71%
U LAYOUT WITH 3 AGV SPEED 8							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	69.78%	9.93%	0.00%	0.00%
G1	Processor						
G2	Processor	21.26%	69.54%	0.00%	9.20%	0.00%	0.00%
G3	Processor	40.26%	53.52%	0.00%	6.22%	0.00%	0.00%
G4	Processor	29.31%	61.11%	0.00%	9.58%	0.00%	0.00%
G5	Processor	26.56%	62.83%	0.00%	10.61%	0.00%	0.00%
AGV 1	Task Executer	44.81%	0.00%	0.00%	0.00%	26.16%	29.03%

AGV 2	Task Executer	61.39%	0.00%	0.00%	0.00%	19.36%	19.25%
AGV 3	Task Executer	100%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 11

U LAYOUT WITH 1 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	63.48%	15.88%	0.00%	0.00%	0.00%	0.00%
G1	Processor								
G2	Processor	24.16%	70.53%	0.00%	5.30%	0.00%	0.00%	0.00%	0.00%
G3	Processor	37.95%	54.30%	0.00%	7.76%	0.00%	0.00%	0.00%	0.00%
G4	Processor	21.61%	62.02%	0.01%	16.36%	0.00%	0.00%	0.00%	0.00%
G5	Processor	27.56%	63.74%	0.00%	8.70%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	26.72%	0.00%	0.00%	0.00%	5.14%	2.99%	33.04%	32.12%
U LAYOUT WITH 3 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	69.16%	8.78%	0.00%	0.00%	0.00%	0.00%
G1	Processor								
G2	Processor	17.84%	76.19%	0.00%	5.97%	0.00%	0.00%	0.00%	0.00%
G3	Processor	37.16%	58.64%	0.00%	4.21%	0.00%	0.00%	0.00%	0.00%
G4	Processor	26.40%	66.99%	0.00%	6.61%	0.00%	0.00%	0.00%	0.00%
G5	Processor	22.95%	68.90%	0.00%	8.15%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	57.63%	0.00%	0.00%	0.00%	2.01%	2.14%	16.50%	21.72%
CART 2	Transporter	70.47%	0.00%	0.00%	0.00%	2.99%	1.08%	12.14%	13.32%
CART 3	Transporter	99.52%	0.00%	0.00%	0.00%	0.01%	0.02%	0.22%	0.22%
U LAYOUT WITH 1CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	65.67%	11.79%	0.00%	0.00%	0.00%	0.00%
G1	Processor								
G2	Processor	17.79%	78.10%	0.00%	4.11%	0.00%	0.00%	0.00%	0.00%
G3	Processor	34.74%	59.97%	0.00%	5.30%	0.00%	0.00%	0.00%	0.00%
G4	Processor	25.74%	68.63%	0.00%	5.62%	0.00%	0.00%	0.00%	0.00%
G5	Processor	24.96%	70.59%	0.00%	4.45%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	45.99%	0.00%	0.00%	0.00%	4.27%	3.30%	23.69%	22.75%
U LAYOUT WITH 3 CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Tavel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	69.38%	7.01%	0.00%	0.00%	0.00%	0.00%
G1	Processor								
G2	Processor	13.34%	82.25%	0.00%	4.41%	0.00%	0.00%	0.00%	0.00%
G3	Processor	32.20%	63.25%	0.00%	4.55%	0.00%	0.00%	0.00%	0.00%
G4	Processor	22.48%	72.29%	0.00%	5.23%	0.00%	0.00%	0.00%	0.00%
G5	Processor	19.78%	74.36%	0.00%	5.86%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	62.95%	0.00%	0.00%	0.00%	2.28%	2.60%	15.51%	16.67%
CART 2	Transporter	82.41%	0.00%	0.00%	0.00%	2.10%	0.88%	7.14%	7.47%
CART 3	Transporter	100%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 12

Part #	Attributes	Process 1	Process 2	Process 3	Process 4	Process 5
Part 3	Sequence	G2	G3	G4	G1	G5
	Processing time	35	27	31	15	32

Table 13

U LAYOUT WITH 1 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	67.81%	17.62%	0.00%	0.00%
G1	Processor	60.42%	21.63%	0.00%	17.94%	0.00%	0.00%
G2	Processor	27.02%	51.12%	0.00%	21.86%	0.00%	0.00%
G3	Processor	38.49%	39.15%	0.00%	22.36%	0.00%	0.00%
G4	Processor	40.64%	44.74%	0.00%	14.62%	0.00%	0.00%
G5	Processor	40.91%	45.81%	0.00%	13.28%	0.00%	0.00%
AGV	Task Executer	0.74%	0.00%	0.00%	0.00%	49.83%	49.43%
U LAYOUT WITH 3 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	67.30%	14.88%	0.00%	0.00%
G1	Processor	65.52%	25.67%	0.01%	8.80%	0.00%	0.00%
G2	Processor	28.03%	60.69%	0.00%	11.28%	0.00%	0.00%
G3	Processor	41.09%	46.73%	0.00%	12.18%	0.00%	0.00%
G4	Processor	37.26%	53.41%	0.00%	9.34%	0.00%	0.00%
G5	Processor	35.54%	54.73%	0.00%	9.73%	0.00%	0.00%
AGV 1	Task Executer	37.10%	0.00%	0.00%	0.00%	30.48%	32.42%
AGV 2	Task Executer	49.68%	0.00%	0.00%	0.00%	25.38%	24.95%
AGV 3	Task Executer	79.17%	0.00%	0.00%	0.00%	10.31%	10.53%
U LAYOUT WITH 1 AGV SPEED 8							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	OFFSET Travel Empty	OFFSET Travel Loaded
Source2	Source	0.00%	0.00%	65.77%	17.44%	0.00%	0.00%
G1	Processor	60.43%	23.86%	0.00%	15.71%	0.00%	0.00%
G2	Processor	26.83%	56.38%	0.00%	16.79%	0.00%	0.00%
G3	Processor	38.55%	43.26%	0.00%	18.19%	0.00%	0.00%
G4	Processor	40.62%	49.34%	0.00%	10.04%	0.00%	0.00%
G5	Processor	40.83%	50.56%	0.00%	8.60%	0.00%	0.00%
AGV	Task Executer	0.76%	0.00%	0.00%	0.00%	49.79%	49.45%
U LAYOUT WITH 3 AGV SPEED 8							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	68.05%	13.38%	0.00%	0.00%
G1	Processor	63.29%	27.02%	0.00%	9.69%	0.00%	0.00%

G2	Processor	25.79%	63.86%	0.00%	10.35%	0.00%	0.00%
G3	Processor	41.06%	49.16%	0.00%	9.78%	0.00%	0.00%
G4	Processor	34.73%	56.11%	0.00%	9.15%	0.00%	0.00%
G5	Processor	34.10%	57.62%	0.00%	8.28%	0.00%	0.00%
AGV 1	Task Executer	33.76%	0.00%	0.00%	0.00%	32.81%	33.43%
AGV 2	Task Executer	57.99%	0.00%	0.00%	0.00%	20.45%	21.56%
AGV 3	Task Executer	83.70%	0.00%	0.00%	0.00%	7.24%	9.07%

Table 14

U LAYOUT WITH 1 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Travel Empty	Travel Loaded	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	66.41%	14.28%	0.00%	0.00%	0.00%	0.00%
G1	Processor	64.01%	28.69%	0.00%	7.30%	0.00%	0.00%	0.00%	0.00%
G2	Processor	21.33%	67.60%	0.00%	11.07%	0.00%	0.00%	0.00%	0.00%
G3	Processor	30.68%	51.87%	0.00%	17.45%	0.00%	0.00%	0.00%	0.00%
G4	Processor	34.67%	59.32%	0.00%	6.01%	0.00%	0.00%	0.00%	0.00%
G5	Processor	34.11%	60.87%	0.00%	5.02%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	23.37%	0.00%	0.00%	0.00%	31.96%	35.34%	6.00%	3.33%
U LAYOUT WITH 3 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Travel Empty	Travel Loaded	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	68.46%	9.73%	0.00%	0.00%	0.00%	0.00%
G1	Processor	60.08%	32.11%	0.00%	7.81%	0.00%	0.00%	0.00%	0.00%
G2	Processor	17.64%	75.60%	0.00%	6.76%	0.00%	0.00%	0.00%	0.00%
G3	Processor	33.55%	58.11%	0.00%	8.34%	0.00%	0.00%	0.00%	0.00%
G4	Processor	27.41%	66.39%	0.00%	6.20%	0.00%	0.00%	0.00%	0.00%
G5	Processor	24.83%	68.22%	0.00%	6.95%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	49.68%	0.00%	0.00%	0.00%	22.23%	21.19%	4.87%	2.04%
CART 2	Transporter	73.08%	0.00%	0.00%	0.00%	11.45%	12.17%	1.93%	1.37%
CART 3	Transporter	90.63%	0.00%	0.00%	0.00%	3.35%	3.73%	1.95%	0.33%
U LAYOUT WITH 1 CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Travel Empty	Travel Loaded	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	66.41%	11.22%	0.00%	0.00%	0.00%	0.00%
G1	Processor	60.12%	32.74%	0.00%	7.14%	0.00%	0.00%	0.00%	0.00%
G2	Processor	16.79%	77.22%	0.00%	5.99%	0.00%	0.00%	0.00%	0.00%
G3	Processor	35.28%	59.43%	0.00%	5.29%	0.00%	0.00%	0.00%	0.00%
G4	Processor	27.63%	67.92%	0.00%	4.45%	0.00%	0.00%	0.00%	0.00%
G5	Processor	19.87%	69.77%	0.00%	10.36%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	37.44%	0.00%	0.00%	0.00%	28.24%	25.42%	5.09%	3.81%
U LAYOUT WITH 3 CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Travel Empty	Travel Loaded	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	69.57%	6.84%	0.00%	0.00%	0.00%	0.00%
G1	Processor	59.66%	34.83%	0.00%	5.51%	0.00%	0.00%	0.00%	0.00%
G2	Processor	12.68%	82.12%	0.00%	5.20%	0.00%	0.00%	0.00%	0.00%
G3	Processor	31.23%	63.19%	0.00%	5.59%	0.00%	0.00%	0.00%	0.00%

G4	Processor	23.50%	72.30%	0.00%	4.19%	0.00%	0.00%	0.00%	0.00%
G5	Processor	21.14%	74.14%	0.00%	4.72%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	58.74%	0.00%	0.00%	0.00%	17.82%	17.71%	2.86%	2.87%
CART 2	Transporter	90.80%	0.00%	0.00%	0.00%	4.09%	3.77%	0.74%	0.61%
CART 3	Transporter	88.00%	0.00%	0.00%	0.00%	4.79%	4.91%	1.72%	0.58%

Table 15

Part #	Attributes	Process 1	Process 2	Process 3	Process 4	Process 5
Part 4	Sequence	G3	G2	G4	G1	G5
	Processing time	27	29	19	15	24

Table 16

U LAYOUT WITH 1 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	67.56%	16.54%	0.00%	0.00%
G1	Processor	58.16%	23.01%	0.00%	18.83%	0.00%	0.00%
G2	Processor	38.71%	44.71%	0.00%	16.58%	0.00%	0.00%
G3	Processor	26.91%	41.91%	0.00%	31.18%	0.00%	0.00%
G4	Processor	43.33%	29.29%	0.00%	27.37%	0.00%	0.00%
G5	Processor	42.86%	36.56%	0.00%	20.58%	0.00%	0.00%
AGV	Task Executer	0.63%	0.00%	0.00%	0.00%	48.82%	50.55%

U LAYOUT WITH 3 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	61.62%	16.21%	0.00%	0.00%
G1	Processor	54.80%	32.40%	0.00%	12.79%	0.00%	0.00%
G2	Processor	27.55%	63.08%	0.00%	9.36%	0.00%	0.00%
G3	Processor	31.76%	58.95%	0.00%	9.29%	0.00%	0.00%
G4	Processor	48.83%	41.26%	0.00%	9.92%	0.00%	0.00%
G5	Processor	37.47%	51.71%	0.00%	10.82%	0.00%	0.00%
AGV 1	Task Executer	29.50%	0.00%	0.00%	0.00%	32.94%	37.56%
AGV 2	Task Executer	79.32%	0.00%	0.00%	0.00%	10.15%	10.53%
AGV 3	Task Executer	51.54%	0.00%	0.00%	0.00%	23.14%	25.31%

Table 17

U LAYOUT WITH 1 AGV SPEED 8							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	65.84%	16.49%	0.00%	0.00%
G1	Processor	58.19%	25.24%	0.00%	16.57%	0.00%	0.00%
G2	Processor	38.79%	49.02%	0.00%	12.19%	0.00%	0.00%
G3	Processor	26.90%	45.92%	0.00%	27.18%	0.00%	0.00%
G4	Processor	43.34%	32.11%	0.00%	24.55%	0.00%	0.00%
G5	Processor	42.83%	40.12%	0.00%	17.05%	0.00%	0.00%
AGV	Task Executer	0.66%	0.00%	0.00%	0.00%	48.87%	50.47%

U LAYOUT WITH 3 AGV SPEED 8							
Flexsim State Report							
Time:	10000						

Object	Class	idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	62.56%	14.42%	0.00%	0.00%
G1	Processor	54.51%	33.77%	0.00%	11.72%	0.00%	0.00%
G2	Processor	25.31%	65.54%	0.00%	9.15%	0.00%	0.00%
G3	Processor	28.98%	61.32%	0.00%	9.70%	0.00%	0.00%
G4	Processor	47.86%	42.78%	0.00%	9.36%	0.00%	0.00%
G5	Processor	36.02%	53.83%	0.00%	10.15%	0.00%	0.00%
AGV 1	TaskExecuter	31.84%	0.00%	0.00%	0.00%	31.52%	36.64%
AGV 2	TaskExecuter	80.31%	0.00%	0.00%	0.00%	10.17%	9.53%
AGV 3	TaskExecuter	55.21%	0.00%	0.00%	0.00%	21.65%	23.15%

Table 18

U LAYOUT WITH 1 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	58.30%	17.28%	0.00%	0.00%	0.00%	0.00%
G1	Processor	22.15%	36.77%	17.57%	23.51%	0.00%	0.00%	0.00%	0.00%
G2	Processor	21.33%	71.53%	0.04%	7.10%	0.00%	0.00%	0.00%	0.00%
G3	Processor	28.03%	66.81%	0.03%	5.13%	0.00%	0.00%	0.00%	0.00%
G4	Processor	21.42%	46.76%	19.17%	12.64%	0.00%	0.00%	0.00%	0.00%
G5	Processor	31.66%	58.57%	0.00%	9.76%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	5.43%	0.00%	0.00%	0.00%	9.49%	4.28%	37.25%	43.56%
U LAYOUT WITH 3 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	61.57%	13.25%	0.00%	0.00%	0.00%	0.00%
G1	Processor	52.36%	38.41%	0.00%	9.23%	0.00%	0.00%	0.00%	0.00%
G2	Processor	20.99%	74.56%	0.00%	4.45%	0.00%	0.00%	0.00%	0.00%
G3	Processor	25.23%	69.67%	0.06%	5.05%	0.00%	0.00%	0.00%	0.00%
G4	Processor	45.83%	48.65%	0.00%	5.52%	0.00%	0.00%	0.00%	0.00%
G5	Processor	32.47%	61.24%	0.00%	6.29%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	46.02%	0.00%	0.00%	0.00%	3.71%	2.54%	20.12%	27.61%
CART 2	Transporter	75.64%	0.00%	0.00%	0.00%	4.21%	1.29%	6.70%	12.16%
CART 3	Transporter	82.56%	0.00%	0.00%	0.00%	1.68%	0.64%	7.14%	7.98%

Table 19

U LAYOUT WITH 1 CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	53.18%	22.65%	0.00%	0.00%	0.00%	0.00%
G1	Processor	23.49%	35.85%	16.16%	24.49%	0.00%	0.00%	0.00%	0.00%
G2	Processor	26.43%	69.64%	0.00%	3.93%	0.00%	0.00%	0.00%	0.00%
G3	Processor	29.68%	64.96%	0.00%	5.36%	0.00%	0.00%	0.00%	0.00%
G4	Processor	39.27%	45.43%	8.46%	6.85%	0.00%	0.00%	0.00%	0.00%
G5	Processor	34.56%	56.99%	0.00%	8.44%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	38.09%	0.00%	0.00%	0.00%	5.72%	4.16%	24.25%	27.78%

U LAYOUT WITH 3 CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	62.01%	10.73%	0.00%	0.00%	0.00%	0.00%
G1	Processor	51.99%	42.04%	0.00%	5.97%	0.00%	0.00%	0.00%	0.00%
G2	Processor	13.29%	81.79%	0.00%	4.91%	0.00%	0.00%	0.00%	0.00%
G3	Processor	19.48%	76.33%	0.01%	4.18%	0.00%	0.00%	0.00%	0.00%
G4	Processor	43.11%	53.46%	0.00%	3.43%	0.00%	0.00%	0.00%	0.00%
G5	Processor	27.97%	67.21%	0.00%	4.82%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	59.33%	0.00%	0.00%	0.00%	3.21%	2.77%	14.46%	20.23%
CART 2	Transporter	77.56%	0.00%	0.00%	0.00%	2.24%	1.42%	9.03%	9.76%
CART 3	Transporter	90.00%	0.00%	0.00%	0.00%	1.09%	0.70%	3.95%	4.26%

Table 20

Part #	Attributes	Process 1	Process 2	Process 3	Process 4	Process 5
Part 5	Sequence	G3	G1	G4	G5	-
	Processing time	23	17	19	24	-

Table 21

U LAYOUT WITH 1 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	62.17%	20.11%	0.00%	0.00%
G1	Processor	29.70%	28.75%	24.30%	17.24%	0.00%	0.00%
G2	Processor						
G3	Processor	32.88%	39.13%	10.17%	17.82%	0.00%	0.00%
G4	Processor	27.28%	31.93%	18.61%	22.18%	0.00%	0.00%
G5	Processor	31.23%	40.13%	0.00%	28.63%	0.00%	0.00%
AGV	Task Executer	0.49%	0.00%	0.00%	0.00%	45.88%	53.63%
U LAYOUT WITH 3 AGV SPEED 4							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	58.26%	19.03%	0.00%	0.00%
G1	Processor	49.26%	38.16%	0.00%	12.58%	0.00%	0.00%
G2	Processor						
G3	Processor	36.74%	51.77%	0.00%	11.48%	0.00%	0.00%
G4	Processor	43.92%	42.43%	0.02%	13.63%	0.00%	0.00%
G5	Processor	31.90%	53.56%	0.00%	14.54%	0.00%	0.00%
AGV 1	Task Executer	24.84%	0.00%	0.00%	0.00%	37.70%	37.46%
AGV 2	Task Executer	66.08%	0.00%	0.00%	0.00%	16.86%	17.06%
AGV 3	Task Executer	66.61%	0.00%	0.00%	0.00%	16.67%	16.72%

Table 22

U LAYOUT WITH 1 AGV SPEED 8							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting for Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	61.22%	20.03%	0.00%	0.00%
G1	Processor	29.80%	31.66%	21.23%	17.32%	0.00%	0.00%
G2	Processor						
G3	Processor	32.69%	43.02%	6.29%	18.00%	0.00%	0.00%
G4	Processor	27.38%	35.17%	15.40%	22.04%	0.00%	0.00%
G5	Processor	31.09%	44.23%	0.00%	24.67%	0.00%	0.00%
AGV	Task Executer	0.52%	0.00%	0.00%	0.00%	46.14%	53.34%

U LAYOUT WITH 3 AGV SPEED 8							
Flexsim State Report							
Time:	10000						
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded
Source2	Source	0.00%	0.00%	59.23%	16.66%	0.00%	0.00%
G1	Processor	47.11%	40.70%	0.00%	12.18%	0.00%	0.00%
G2	Processor						
G3	Processor	33.58%	55.22%	0.00%	11.21%	0.00%	0.00%
G4	Processor	41.43%	45.28%	0.01%	13.28%	0.00%	0.00%
G5	Processor	27.41%	57.13%	0.00%	15.47%	0.00%	0.00%
AGV 1	Task Executer	26.83%	0.00%	0.00%	0.00%	36.70%	36.47%
AGV 2	Task Executer	67.07%	0.00%	0.00%	0.00%	16.44%	16.49%
AGV 3	Task Executer	68.75%	0.00%	0.00%	0.00%	15.59%	15.66%

Table 23

U LAYOUT WITH 1 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	55.00%	20.10%	0.00%	0.00%	0.00%	0.00%
G1	Processor	31.85%	43.37%	9.12%	15.66%	0.00%	0.00%	0.00%	0.00%
G2	Processor								
G3	Processor	33.44%	58.74%	0.00%	7.82%	0.00%	0.00%	0.00%	0.00%
G4	Processor	24.32%	48.28%	5.52%	21.88%	0.00%	0.00%	0.00%	0.00%
G5	Processor	30.55%	60.73%	0.00%	8.72%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	5.74%	0.00%	0.00%	0.00%	6.39%	3.79%	35.44%	48.65%

U LAYOUT WITH 3 CART SPEED 4									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	58.28%	15.21%	0.00%	0.00%	0.00%	0.00%
G1	Processor	45.63%	45.74%	0.00%	8.63%	0.00%	0.00%	0.00%	0.00%
G2	Processor								
G3	Processor	29.98%	61.95%	0.00%	8.07%	0.00%	0.00%	0.00%	0.00%
G4	Processor	39.74%	50.97%	0.00%	9.29%	0.00%	0.00%	0.00%	0.00%
G5	Processor	23.09%	64.13%	0.00%	12.78%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	47.84%	0.00%	0.00%	0.00%	5.29%	2.03%	20.77%	24.07%
CART 2	Transporter	70.66%	0.00%	0.00%	0.00%	1.94%	0.73%	13.19%	13.48%

CART 3	Transporter	73.69%	0.00%	0.00%	0.00%	0.73%	1.23%	12.06%	12.28%
U LAYOUT WITH 1 CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	55.80%	15.76%	0.00%	0.00%	0.00%	0.00%
G1	Processor	24.51%	49.71%	13.61%	12.18%	0.00%	0.00%	0.00%	0.00%
G2	Processor								
G3	Processor	25.89%	67.44%	0.00%	6.67%	0.00%	0.00%	0.00%	0.00%
G4	Processor	19.61%	55.39%	8.49%	16.51%	0.00%	0.00%	0.00%	0.00%
G5	Processor	23.62%	69.76%	0.00%	6.62%	0.00%	0.00%	0.00%	0.00%
CART	Transporter	27.36%	0.00%	0.00%	0.00%	5.59%	4.35%	27.46%	35.23%
U LAYOUT WITH 3 CART SPEED 8									
Flexsim State Report									
Time:	10000								
Object	Class	Idle	Processing	Blocked	Waiting For Transporter	Offset Travel Empty	Offset Travel Loaded	Travel Empty	Travel Loaded
Source2	Source	0.00%	0.00%	59.29%	9.85%	0.00%	0.00%	0.00%	0.00%
G1	Processor	37.04%	53.56%	0.00%	9.40%	0.00%	0.00%	0.00%	0.00%
G2	Processor								
G3	Processor	21.59%	72.71%	0.00%	5.70%	0.00%	0.00%	0.00%	0.00%
G4	Processor	35.78%	59.72%	0.02%	4.48%	0.00%	0.00%	0.00%	0.00%
G5	Processor	18.10%	75.53%	0.00%	6.37%	0.00%	0.00%	0.00%	0.00%
CART 1	Transporter	51.70%	0.00%	0.00%	0.00%	2.95%	3.10%	18.99%	23.26%
CART 2	Transporter	70.79%	0.00%	0.00%	0.00%	3.07%	1.53%	10.37%	14.24%
CART 3	Transporter	98.93%	0.00%	0.00%	0.00%	0.08%	0.07%	0.41%	0.51%

CONCLUSIONS

From the study on the production layout with material handling devices concludes that the effective utilization of the processors and material handling devices is useful. When comes to the criteria of effective use of the AGV and CART is concerned CART is a better choice than AGV in the layout. As the results shows blocking of the processors is more when AGV is used than with the usage of CART. Also helps us to determine the requirement of the AGVs and CARTs for the production layout.

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