Pandey and Singh, J Material Sci Eng 2016, 5:4
DOI: 10.4172/2169-0022.1000263

Journal of Material Science & Engineering

Review Article　　Open Access

Utilization of AGVs and Machines in FMS Environment

Pandey R* **and Singh A**

Department of Mechanical Engineering, SLIET, Longowal, India

Abstract

Automatic guided vehicle systems are now well known and recognized in automated material handling systems, FMS and also in container handling applications. It improves response time for material movement. It is an efficient, dependable and versatile material handling solution. AGVs consist of one or more computer-controlled wheel based load carriers that run on the plant floor without the need for a driver. These are designed to perform their operations without direct human guidance and are used in a wide variety of industrial applications.

This paper presents a review on design and control of automated guided vehicle systems. The paper present a methodology to unify various lines of research related to AGVs and to suggest directions for future work for most key related issue i.e., including vehicle scheduling. Various types of scheduling problems are solved in different job shop environments, vehicle routing, guide-path design, vehicle dispatching. The prior objective of this paper is to extend previous research by examining the effects of scheduling rules and routing flexibility on the performance of a constrained and utilization of AGVs and machines.

Keywords: FMS; AGVs; Scheduling; ARENA simulation software

Introduction

Automated guided vehicle systems (AGVs) have received increased attention by the designers and engineers of automated manufacturing systems [1-3]. Fifty years ago AGVs was invented, Barrett Electronics Corporation invented the world's first AGV for industrial applications in 1954. The term AGV (Automatic Guided Vehicle) was actually introduced in the 1980's. And that time it is called unmanned vehicles that carry work pieces among the workstations following guide paths and are usually controlled either by on-board computers or by a central computer [4-6]. Automated Guided Vehicles can be used in a wide variety of applications to transport many different types of material including pallets, rolls, racks, carts, and containers. AGVs excel in applications with the following characteristics:

- Repetitive movement of materials over a distance
- Regular delivery of stable loads
- Medium throughput/volume
- When on-time delivery is critical and late deliveries are causing inefficiency
- Operations with at least two shifts
- Processes where tracking material is important

AGVs navigate in manufacturing areas with sensors. There are two main sensors AGVs use for navigation, a wired and a wireless sensor. The communication between an AGV and its controller is generally established through dedicated wiring embedded in the floor, although some recent AGVSs utilize wireless communication [7-9]. AGVSs are widely used in FMS as they provide flexibility in routing parts among elements present in the system, and also used to transport an object from one point to another point. These systems are highly complex and expensive due to the dynamic environment in which FMS functions [8].

A variety of analytical methods have been proposed by researchers for the scheduling and dispatching of AGVs. Simulation is used to compare the performance of tandem AGV system with that of conventional AGV track systems. Numbers of simulation studies have been conducted to evaluate the effect of different parameters such as the number of AGVs, the number of pallets, buffer sizes, dispatching rules, bi-directional flows etc. [9-12]. Since FMS involve high capital costs, significant attention has been paid to improving system efficiency via production scheduling.

Scheduling is concerned about the allocation of limited resources to tasks over time and is also a decision making process that links the various operations, time, cost and overall objectives of the company. Scheduling of the material handling system in FMS has an equal importance as of machines and is to be considered together for the actual evaluation of cycle times [13-15]. Recent developments in scheduling theory have focused extending the models to include more practical constraints. Automated guided vehicles (AGVs) are widely used in FMS due to their flexibility and compatibility. Most of the researchers have addressed the machine and vehicle scheduling as two independent problems. However, only a few researchers have emphasized the importance of simultaneous scheduling of jobs and automated guided vehicles (AGVs). Scheduling is difficult for the variety of reasons: 1) Desirability 2) Stochasticity 3) Tractability 4) Decidability [16,17].

Doo Yong Lee et al. [18] worked on the approach that simulation using heuristic dispatch rules, path are supposed to be straight to the machine. In this paper, two types of AGV's are modeled by Petri nets. The two models cover both the cases i) AGV is exclusively assigned to a job until the job is completed and ii) where the AGV is shared by multiple jobs. The models combine the part processing facility such as machines and robots, and the material handling system, AGVs, into one coherent formulation. In both the models, a pair of paths in the opposite directions between any pair of machines is assumed to exist. This scenario requires more paths, simpler navigation devices and less delay in transportation than the scenario employing a single bidirectional path.In this paper, a simple traffic control is assumed for the junction of the paths. The proper scheduling of subsystems is

***Corresponding author:** Pandey R, Department of Mechanical Engineering, SLIET, Longowal, India, Tel: 911672280057; E-mail: rachna.pandey18@gmail.com

Received March 21, 2016; **Accepted** June 01, 2016; **Published** June 11, 2016

Citation: Pandey R, Singh A (2016) Utilization of AGVs and Machines in FMS Environment. J Material Sci Eng 5: 263. doi:10.4172/2169-0022.1000263

necessity to achieve higher efficiency. In this context one problem has been taken linked with the scheduling together of all the subsystems such as AS/RS, machines with jobs and that problem is being dealt. Authors have worked to the definitive approach that although scheduling solves the manufacturing problems in FMS. But together scheduling of machine and vehicle makes the problem complicated and more over scheduling of alone machine makes it more complex. So in this paper two heuristics are developed and tried to solve the problem of this kind. Several pilot runs were carried out to select the DE parameters and also different DE strategies available in the literature are studied for their suitability to the problem, and finally two strategies were proposed. BSP Reddy et al. [14] addressed multi-objective scheduling problems in a flexible manufacturing environment using genetic algorithms. In this paper the authors made an attempt to consider simultaneously the machine and vehicle scheduling aspects in an FMS and addressed the combined problem for the minimization of make span, mean flow time and mean tardiness objectives. Author approached to the problem through this paper about the new genetic adaptive approach for the simultaneous scheduling of AGV's and parts; an adaptive genetic approach has been found effective as comparison told. MS Akturk et al. [15] addressed the problem of incorporating the AGVs module to the decision making hierarchy is analysed by stating the reasons and of this difficulty. To overcome this difficulty, a hybrid model for AGV module is proposed [17]. To solve the AGV scheduling problem a micro-opportunistic heuristic method is developed. Author through this paper aimed at explaining about the new dispatching algorithm with the use of bidding concept. Various dispatching functions together with these biding functions are suggested and tested [8]. A comparison of the dispatching functions showed that the function of a product form with a denominator is more effective than others. A grid search method is used for finding the most appropriate values of parameters that are used in the dispatching function. Author worked on the approach that the problem of dispatching containers to AGVs and selecting ASCs and perform a simulation study and use several performance criteria such as the unloading times of the ship, the number of AGVs required and the utilization of these vehicles to examine dispatching rules. Paper concluded the choice for a certain AGV dispatching rule hardly impacts the total cycle times, for all different experiments [18]. While, the amount of vehicles required differs per dispatching rule Results obtained to compare the dispatching rules with the following performance measures: Total cycle time required to unload all containers off the ship and store them in the stack. Minimum number of AGVs is required to achieve a minimal total cycle time. Average utilization of the AGVs generates 100 replications of each experiment to obtain a high level of accuracy in the results [9].

Assumptions

a. AGV speed is same for both loaded and unloaded.

b. The free AGV stays at the destination station until requested by another station.

c. The FMS works for 24 hours a day in 3 shifts at 8 hours each.

Arena Model

Modelling system

The given system is modelled using ARENA Simulation software. Figures 1 and 2 depicts the Arena model for the job, consisting of four main segments:

- Job Arrivals
- Job Transportation
- Job Processing
- Job Departure

Simulating the model

The ARENA model was simulated for a period of one year. Parameters like *Replication Length* and *Hours Per Day* etc. are mentioned in *Run Setup* as shown in Figure 3. While running in simulation, we can see the movement of entities (jobs) through different facilities, waiting for processing, transfer between machines etc. After completing the simulation, report is generated automatically. From the report, we can find Job flow times (by type), Job delays at operations locations, Machine utilizations etc.

Results

The following result has been derived from the report generated through simulation.

Job delays at operation locations (Before AGV)

The resulting output is displayed in Figure 4. The Figure 4 depicts much variation in waiting time of all machines i.e., M1, M2, M3, M4. The waiting time of machine M3 is more than expectation. Due to this there will be much job delays at operation locations which will consequently affect production output.

Job delays at operation locations (After AGV)

The Figure 5 depicts the job delays of all machines M1, M2, M3, and M4. It is shown that when AGV was introduced in the system waiting time of each machine was greatly improved. Due to reduction of waiting time the job manufacturing process time was reduced. And thus are aim was achieved.

Resources utilization (Before AGV)

Before introducing AGV only 9.88% utilization of J1 process of machine M1 was reported. On the other hand 45.88% utilization of J3 process of machine M3 was reported which shows great variation as compared to machine M1 (Figure 6).

Resources utilization (After AGV)

After introducing AGV all the process of each machine was almost uniform. Thus AGV proved to be beneficial in improving percentage utilization of resources (Figure 7).

Conclusion

From the simulation model which has been developed in the present work the conclusion are interpreted as below. The given Flexible Manufacturing System was modelled in ARENA Simulation Software and the results were generated. The obtained results were analyzed that waiting time of machine M3 was more as compared to other machine. After introducing AGV in the system the waiting time of each machine was improved. This can be seen by comparing both the outputs i.e., Tables 1 and 2.

In next objective the graph obtained before and after introducing AGV in the system depicts that the percentage utilization was greatly improved by introducing AGV in the system, thus the process of job production was also improved. Also the efficiency of the whole system has improved significantly.

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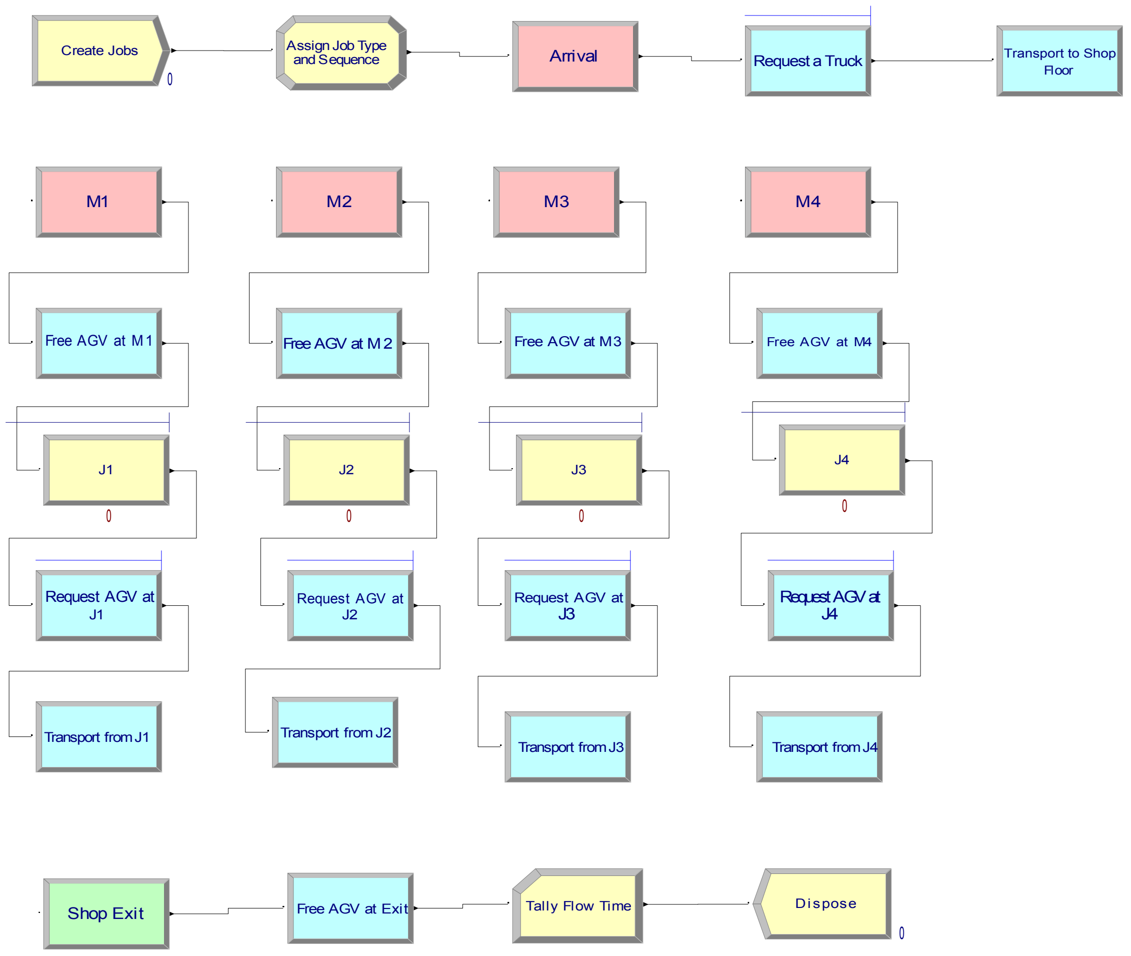

Figure 1: Arena model for the job manufacturing.

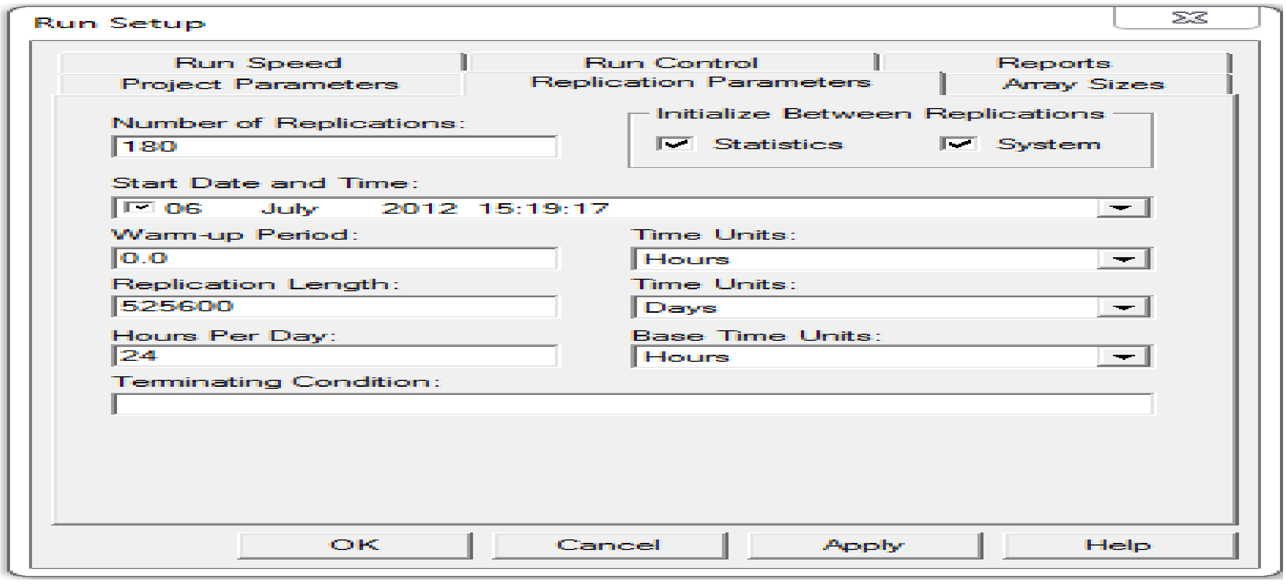

Figure 2: Dialog box of run setup.

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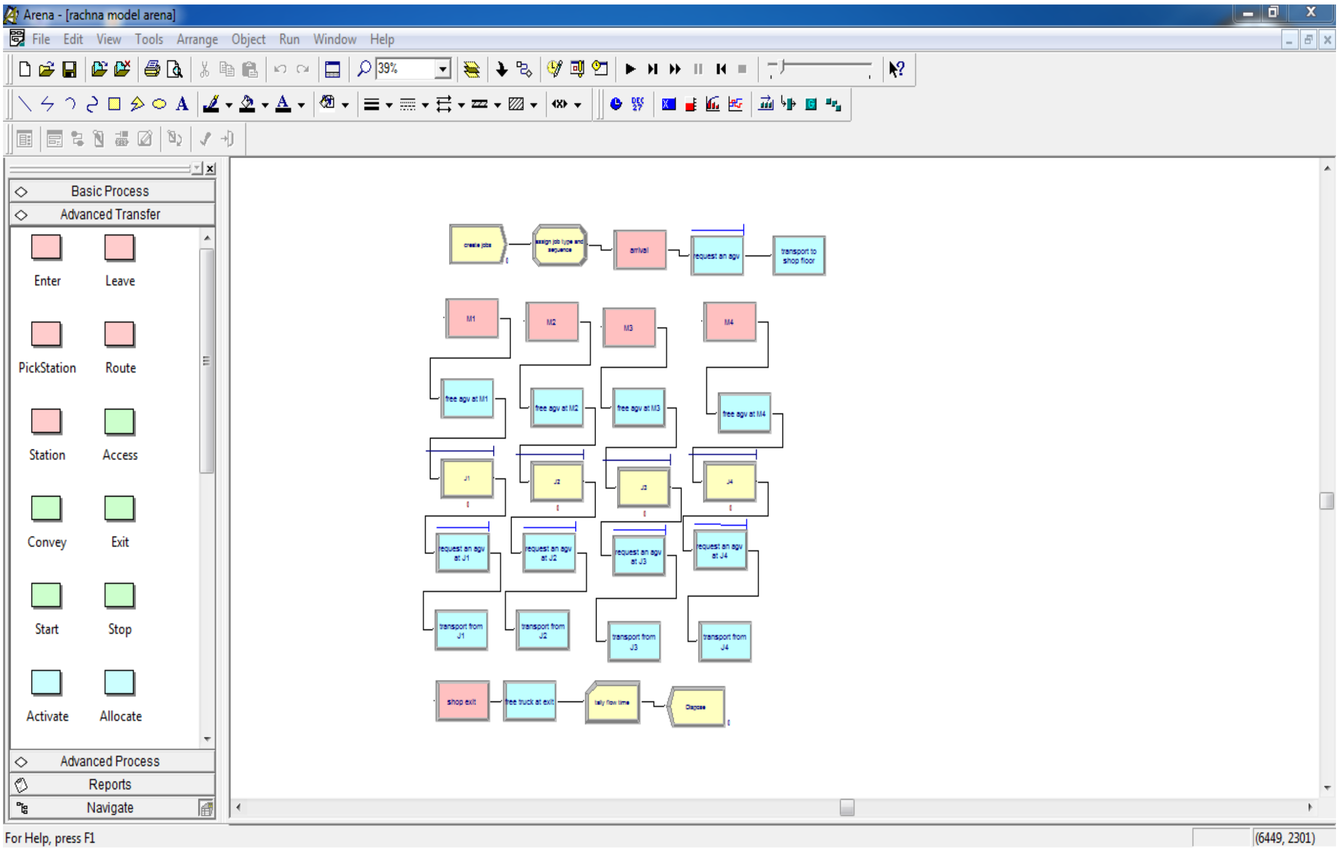

Figure 3: Screen shot of ARENA model.

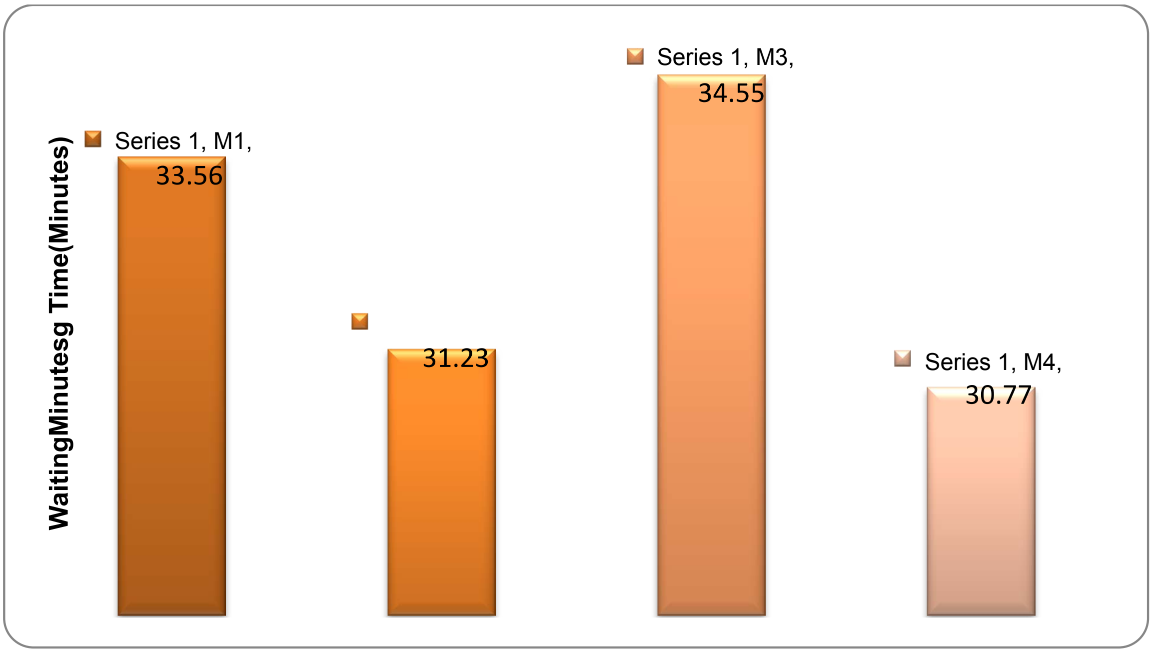

Figure 4: Job delays at operation locations before AGV.

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Figure 5: Job delays at operation locations after AGV.

Figure 6: Resources utilization before AGV.

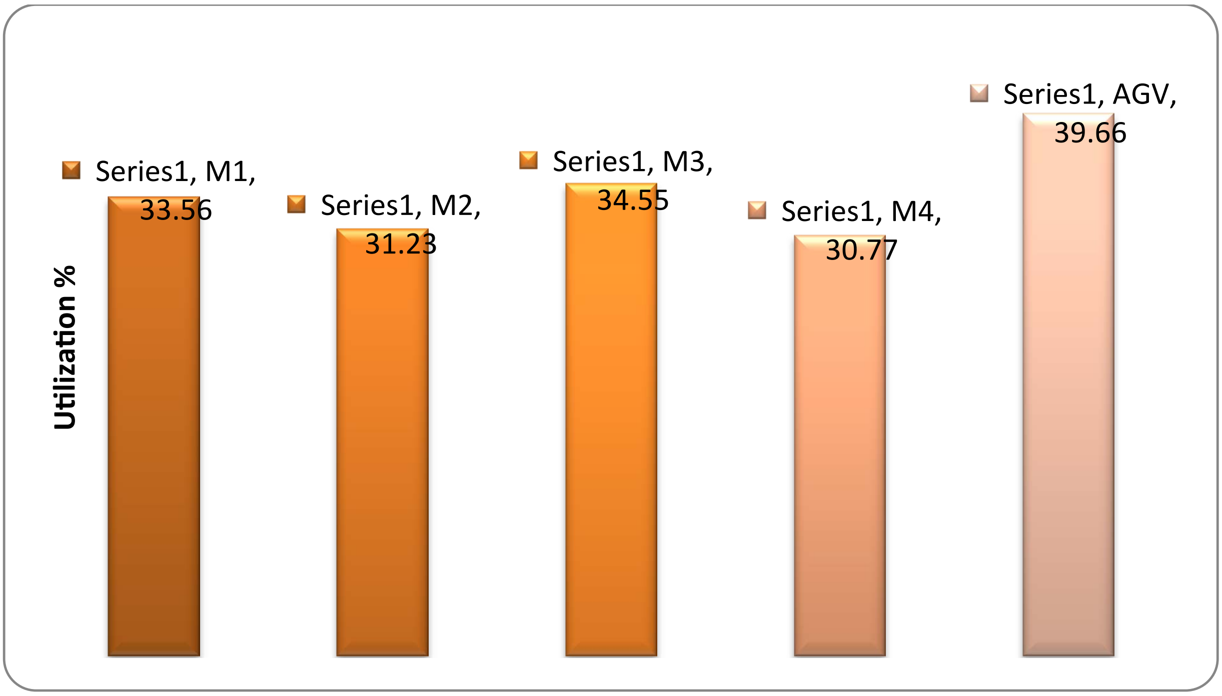

Figure 7: Resources utilization before AGV.

JOB DELAYS AT OPERATION LOCATIONS		
	INITIAL	**FINAL**
M1	0.6555	1.802
M2	14.5105	2.0025
M3	44.7111	4.0012
	3.0533	3.0533

Table 1: Represents job delays at operation locations.

RESOURCES UTILIZATION		
	INITIAL	**FINAL**
J1	9.88	33.56
J2	14.55	31.23
J3	45.88	34.55
J4	30.77	30.77
AGV		39.66

Table 2: Represents resource utilizations.

Future Scope

The present study can be extended in the broad scope in following context the model could be developed for more number of machines and more job types, selection and optimization of number of machines and job types, application of metaheuristic techniques etc. can be explored for simultaneous scheduling of jobs, AGV and machines.

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