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Flexible manufacturing technology – A review of facility design and the scheduling

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ABSTRACT

This paper presents developments on facility layout design and the scheduling in Flexible Manufacturing System. We address conventional ways of design and issues related to layout design. We discuss development and approach in facility design for layout design, P/D points and flow path design. Also, various approaches to scheduling in FMS are discussed in the paper. Various literature is reviewed and formulated in a simplified manner.

Keywords: *Facility Design; Flexible Manufacturing System; Scheduling*

1. INTRODUCTION

A flexible manufacturing system provides the flexibility that allows the system to adapt according to the changes which may be predicted or unpredicted. Flexibility in facility layout and scheduling allows us to have various designs of product and also change in product. The design of facility layout for the uncertainty in product design and manufacturing is one of the critical issue in designing the FMS [1]. Optimal design of physical layout play important role in early stage of system design. Thus, there is need to dynamic layout which adapt to changes without compromising the performance of the system. For solving dynamic layout problem various algorithm are used [2].

In FMS, AGVs play an important role in material handling operations and it enhances overall performance of FMS. To achieve this there should be integrity in the workstation scheduling and the AGVs schedule [3].Present paper focuses on the various approaches tooptimize the flexible system.

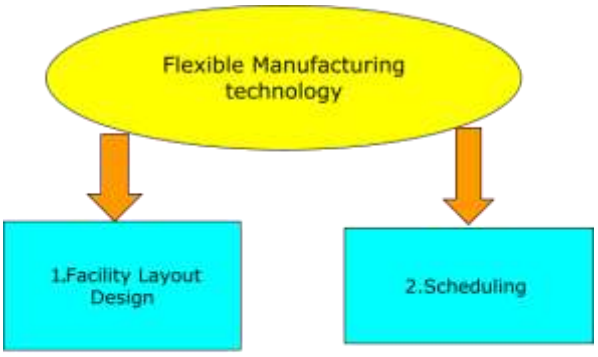

Fig.1.Overview of Content

Scheduling is a principal tool of manufacturing and engineering; it has a major impact on the productivity of a structure [4]. In manufacturing, the need of scheduling is to decrease the production time and expenses, by directing a production team when to make, with which manpower, and on which machine. But it's for academics. For a business purpose, the first mandatory point is to

complete before or on the customer's due date. Most major sectors ask for scheduling for smooth and continuous production, level the production, keep advance in stock, keep cycle time, and to assign jobs to machines or lines as the next priority [5].

Facility design consists of layout design ,pick up and delivery points location selection and theflow path of AGVs.

Nomenclature

LPP	Linear programming problem
QAP	Quadratic assignment programming
P/D	Pickup and delivery
EDD	Earliest due date
SPT	Shortest processing time
FMS	Flexible manufacturing system

2. FACILITY DESIGN

Design of facility include designing the layout, Pick up and delivery points P\D and flow path design.

2.1 Layout Design

The flexibility in FMS depends upon the effective use of total available workspace. Design of layout should effectively balance the workload and have integrity with material handling systems [6].

Thus, layout plays a vital role in smooth working of the whole manufacturing system [6]. Layout Design

2.1.1 Unidirectional layout: In this vehicle flow in one direction. It may have to move long distance and it has lesscomplexity and economical [7]. It further includes S type, W type layouts.

2.1.2 Bidirectional layout: In this vehicle move in two directions. Advantage is distance traveled is reduced and effective utilization of space of facility [7]. It is more complex than unidirectional layout.

2.1.3 Single Loop layout: In this vehicle move in one loop without following any branch route [7]

Tandem layout: It is an application of "divide-and-conquer "principle to AGV system. It is based on division of all stations into non overlapping and single vehicle closed loop. All stations within the same loop are served by only one dedicated vehicle [8]. Ease of control and less complexity are advantages of Tandem layout.

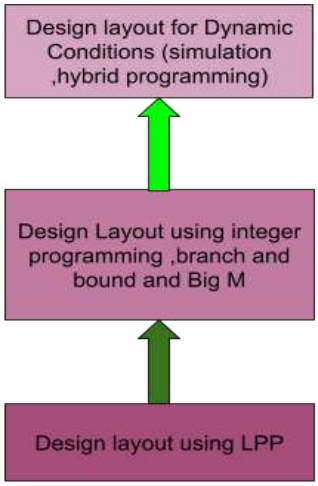

Fig.2 General development stages of facility design

2.1.4 Dynamic layout: For optimal performance of system uncertainty in the manufacturing process should be taken under consideration. In dynamic layout system adapt to changes. For this QAP model is used [8].

Table 1. Development in layout design

Author	Development	Approach
Maxwell and Muckstadt [9]	Unidirectional layout	-
Gaskins and tanchoco [10]	Minimize travel distance	LPP
Gaskins and tanchoco [10]	Design of virtual flow path forAGV	Mixed integer Programming
Sinrich and Tanchoco[11]algorithm	single close loop layout	Optimal single loop
Sinrich and Tanchoco[12]	Mathematical model for single	Heuristic model
loop AGV		
P.Banerjee ,Tanchoco [13]	single loop optimization	Heuristic model
z-Farahani[14]	Design method for loop and simultaneous	Genetic algorithmlocating PD
Nikolaos and Moneley [15]	Reducing overall time	Simulation based optimizationconsidering

		Uncertainty
Erik and Enrique [16]	Layout Design with high uncertainty	Simulation based optimization
Vivek and Arindam [17]	Minimize travel distance and backtracking	Clonal selection algorithm
Hichem and Haddou[18]	Best transition between different process plans	Dynamic algorithmproduct family

2.2 Pickup and delivery points

Pickup and delivery points are the location from where the material handling is start and end respectively. Withing the Facility this point should be set in such a way that reduce the travel as well as the time [18]. For more real situation P/D points are consider to be lie on boundaries[18]. Various algorithms are used to obtain proper locations as follow

Table 2. Development of P/D location approaches

Author	Objectives	Approach
Montreyiu and ratkiff [19]	Maximize flow efficiency	LPP
William G and Pius [20]	Minimize travel distance	LPP
J Kim and M Klien [21]	Minimize travel distance	QAP
R A Arapoglu and B A Norman [22]	Minimize handling cost	Integer programming and genetic programming
Mojtaba and Reza [23]	Minimize distance	Heuristic algorithm
Gerado and Jean [24]	Real time collection anddelivery	Dynamic algorithm

2.3 Flow path design

In FMS material handling is done mostly with AGVs.From pickup point to delivery point AGV is loaded with goods and travel empty to pick up points. Thus proper design of flow path will reduce non beneficial distance and thus the time. In various industries according to applications demand there is constrain on travel distance or time or cost of travelling .

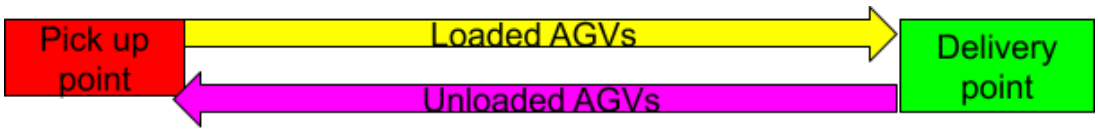

Fig.3. Flow path Design

To obtain the best route i.e. minimum travel various models are proposed [24].Table 3. Development of flow path algorithm

Author	Objective	Development
Gaskins Tanchoco[24]	Minimization of travel distance	LPP
Kap hwan [25]	Minimization of cost	Branch and Bound algorithm
J.Rubaszewski [26]	Minimization of travel distance	Genetic algorithm
Irina Ioachim,gelinas[27]	Minimize the travel distance	Dynamic algorithm
Zheng Wnag,Guangfu Li[28]	Bi level planning	Hybrid Algorithm

3. SCHEDULING

"The term Scheduling generally reflects its meaning i.e., to arranging of particulars or to be done of that objective at a particular time. It is the process of categorizing, to govern and to optimize work and objectives in a production or manufacturing system. This enables the allocation of plants and machines, arrange manpower and production processes and purchasing of raw materials for the production process. [29] The objective of scheduling is to instruct for the sequence on different machines for the manufacturing process that involves different conditions.

3.1 Overview

Scheduling in the production process is becoming a must if that production management wants to take their production to a good level. [30] Many flexible manufacturing systems require onlinescheduling because the requirements of timing for a particular operation are known only a few times before the execution of a new decision.[31] In refinery industries that are of large-scale production scheduling is needed. As we know that scheduling enables us in arranging, to control and to optimize objectives in a production system. Production systems use backward and forward scheduling processes to allocate machineries, utilize manpower, to arrange manufacturing processes and to avail raw materials.

- Forward scheduling organizes the task from the date material becomes available tofind the due date or delivery date.
- Backward scheduling organizes the task from the due date or delivery date to findthe start date and/or any modification in quantity requirement.

The pros of production scheduling contain:

- Process change-over reduction

- Inventory decrement, leveling
- Reducing schedule effort
- Increase in production efficiency
- manpower load leveling
- exact delivery date
- Real time messages

Production scheduling operates greatly surpass older scheduling methods. These provide the manufacturing scheduler with great graphical interfaces which is used to visually identify real-time workloads in many processes of production. For example, an airline may wish to decrease the number of airport entry required for aircrafts, to reduce costs, and scheduling applications allows the planners to check how this can be executed, by analyzing time schedule, aircraft traffic, or the availability of passengers.

3.2 important concept in Scheduling

The main aspect of scheduling is productivity, the limitation of quantity of inputs and quantity ofoutputs. Principal concepts here are:

- Inputs: Inputs are industry, labor, raw materials, a clean environment.
- Outputs: Outputs are the products manufactured in factories.
- Output within the industry: The output within the system is an input to the next area in that manufacturing unit according to the manufacturing procedure. As anexample, the output of cutting is an input to the smoothening room.
- Output for the next manufacturing: As an example, the output of a jute mill is an input to a cloth factory. The output of a steel plant is an input to an utensil industry, a hardware factory and a vehicle factory.
- Output for the buyer: Factory product reaches to the consumer through a serviceprovider such as a retailer or a small company.
- Allocation of resource: Resource allocation means giving inputs to generate output. The aim is to increase output with present inputs or to minimize the quantity of inputs to manufacture required product or output.

3.3 Rules of scheduling that are used mostly[29]

(1) First Come First Serve (FCFS)- The service will be provided according to the sequence of consumers, whoever is ahead in the queue will be entertained firstly.
(2) Earliest Due Date (EDD)-The service will be provided according to the order having earliest delivery date given.
(3) Longest Processing Time (LPT)-The service will be provided according to the order having the longest processing time.
(4) Shortest Processing Time (SPT)-The service will be provided according to the order having the shortest processing time.

Table 4. Various approaches to scheduling

Author	Objectives	Approach
Muhammad A. [29]	Scheduling of FMS	FCFS, SPT,LPT,EDD
Joost Van Pinxten[30]	FMS	Online Scheduling
Le Shi, Yongheng Jiang[31]	Refinery Production	Predictive Control
Sergio N.,Carlos[32]Recipes	Optimal Reactive Scheduling	Flexible Batch
Sanjay J., Karon Barber [33]Approach	Expert Simulation For Online Scheduling	Expert System
Stacy L. Janaki [34]	Production Scheduling ofa Large Scale Industrial Batch Plant	Reactive Scheduling
iftekhar A. Karimi [35]scheduling	Planning and scheduling of Semicontinuous process	Short term
Ka Fai Chan[36]	Scheduling batch production	Stepwise Approach
Seyed Mahdi Homayouni[37]	Joint scheduling of productionAnd transport	Alternative job routing in FMS
V. Poongothai[38]	Minimising total tardiness ofa weighted jobs in a batch	Single Machinescheduling delivery system
Ghita Lebbar [39]	Scheduling problems of FMS	Classification andopportunities
Boris Detienne[40]	Two machine flow shop total	Branch and Boundalgorithm
Ruslan Sadykov[41]	completion time problem	based on network flow formulation
Stephen C. Graves [42]	Production Scheduling	Problem Classification
Fernando Emilio Puntel[43]	Review of Scheduling Algorithms	Meta-analyticApproach
Saraswathi Seemakuthi[44]	Scheduling Algorithms	FCFS algorithm
Reena Sharma [45]	scheduling and process	Optimal Task approach
Mahima Shrivastava [46]	CPU Scheduling	CPU Scheduling Algorithm
Harshita Jha [47]	various Scheduling Algorithms	Robin & Priority scheduling

4. CONCLUSION

In this paper, we have discussed various developments in layout design ,pickup and deliverylocation of AGVs ,flow path design and the scheduling .In this paper we review literature and found the various algorithm and approaches for dynamic adaptive environment

in flexible manufacturing system which is recent competitive market's need. Objectives and Approaches comparison is discussed in well formulated manner. Further research in a dynamic environment with next generation AI is anticipated in this field.

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