Critical Review On Scheduling of Flexible Manufacturing System

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CERTIFICATE

This is to certify that DIVYA PRAKASH SINGH, (Roll no. 2K14/PIE/08), student of M.Tech, Production Engineering, Delhi Technological University, has submitted the dissertation titled **"Critical Review On Flexible Manufacturing System"** under our guidance towards the partial fulfilment of the requirements for the award of the degree of Master of Technology under our guidance and supervision.

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DECLARATION

I, **Divya Prakash Singh**, hereby certify that the work which is being presented in the Major Project-I entitled **"Critical Review On Flexible Manufacturing System"**, is submitted, in the partial fulfillment of the requirements for degree of Master of Technology at Delhi Technological University is an authentic record of my own work carried under the supervision of **Mr. A.K.MADAN**. I have not submitted the matter embodied in this seminar for the award of any other degree or diploma also it has not been directly copied from any source without giving its proper reference.

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Abstract

Flexible manufacturing systems (FMS) are famous by the use of data processor control in position of the hard automation mainly found in transfer lines. The high investment need for a FMS and the potential of FMS as a strategic competing apparatus make it attractive to engross in research in this extent. This notes ready a reconsider of literature concerning the operations aspect of FMS. Articles intensive many methodological perspectives are exactly reviewed. The review is done from manifold viewpoints. Future study directions are suggested.

Key Words: Flexible manufacturing system, production planning, scheduling, production control.

INTRODUCTION

The emergence of global markets, greater product proliferation, and rapidly evolving technology have emphasized the increasing need for lean manufacturing practices. To this end, supple manufacturing systems (FMSs), with their computer- controlled and versatile machining and assembly capabilities, promise an competent solution to the simultaneous requirements of efficient small batch production in medium to large product varieties. However, because of the close interaction among its various components, the efficient implementation of an FMS propitious a complex curdle of issues to be resolute from both long-and short name perspectives. For greater tractability of these issues, many researchers (see, for example, Stecke55), Jones and McLean23) have proposed hierarchical frameworks that address long-term design decisions, mean-term diagram decisions, and short-conditions scheduling decisions sequentially. FMS project problems include the selection of part types to be processed within the FMS, the selection of machine drive and the material handling system, and the design of buffers. FMS planning decisions primarily address resource disposition issues such as part type selection for simultaneous making, shape grouping and loading that involves the assignment of operations and puppet to individual machines, and pallet and fixture allocation, FMS scheduling problems include determining the part input result, the part advance sequence at each bicycle, and monitoring the actual system performance and taking the necessary corrective actions.

The recent advant of manufacturing and computer technologies has accelerated the realization of information processing system integrated manufacturing where manufacturing processes are fully automated with computer-assisted decision-making capability. Flexible manufacturing systems (FMS) are distinguished by the use of computer control in place of the hard automation usually found in transfer lines. This enables FMS's to reconfigure very rapidly to produce multiple part types. Use of fixtures and tool magazines practically eliminates setup time. These feature permit economic production of a spreading diversity of parts in low volumes. FMS's are increasingly being adopted in the manufacturing sector on calculating of the additional benefit of shoot turn around, high quality, low inventory suffering, and moderate labour costs.The high investment need for a FMS and the potential of FMS as a strategic competitory tool force it attractive to engage in investigate in this measure. The examine problems stir by the industrial maintenance of FMS could be broadly categorized into two topic areas: propose problems and operation problems. At the design stage, one is interested in show the system so that the require performance goals are succeed.

The operation problems are aimed at facture decisions related to the planning, scheduling, and control of a given FMS Flexible manufacturing systems (FMSs), the type of manufacturing systems that can produce a variety of items efficiently, have become increasingly important in the effort to improve the productivity of batch manufacturing. An FMS consists of a number of computer-controlled shape or workstations, an automated material handling system which transports workpieces between any pair of shape, and a number of supervisory computers networked together for on-line control. By integrating the versatile numerical control (NC) machines with the real-time decision-construction capability of the supervisory computers , an FMS is able to conquer the flow-time and the set-up time significantly and, thus, accomplish much needed effectiveness in manufacturing a variety of items simultaneously.

The production environment in an FMS is a highly dynamic one. The machines are versatile and qualified of performing a multifariousness of operations with different set-ups. The work pieces can be transported among machines by mobile robots, automated guided vehicles, or conveyors.

Due to the flexibility of the system, a addicted operation usually can be performed by a many of machines; the decision on assigning a job to a dress rely to a great extent on the situation at the participation moment, that is, the decision is acme-retainer. In addition, sometimes there may be needs for cancelling or reassigning coach or other resources because of unlooked-for breakdowns. Thus, the scheduling decision is a complex one which needs to be adaptive to surrounding changes .This thesis takes a knowledge-based coming to the FMS list question drastically dissimilar with the conventional timeline methods. It models the scheduling prosecute by acme-space transitions; the job passing is obtained through selecting a sequence of scheduling operators guided by heuristics. Keeping footprint of the manufacturing environment by a symbolic world model in the knowledge-based scheduler, this advanced is adaptable to such environmental turn as new thrust arrivals and machine breakdowns, thus suitable for dynamic scheduling/rescheduling. The traditional list approaches usually employ one of the three division of techniques: network analysis, combinable methods, and dispatching heuristic procedures. However, fret analysis is on the whole based on a predetermined network and, thus, is deficient for dynamic scheduling where the priority network is constantly alter. Combinatorial method, also restricted to static scheduling, suffers from the complexity problem (i.e., combinatorial destruction) which is difficult to overcome for large problems. The heuristic scheduling procedures usage relatively frank knowledge representation and are restricted to definite intelligence—they use unmitigated heuristic which cannot adapt to environmental alter .In contrast, the approach presented in this paper can dynamically cause schedules represented by incompletely logical networks; it can incorporate heuristic knowledge to expedite the scheduling anapophysis; lastly, it is equipped with a structured representation scheme based on the same inference organization used as an information advance model for human problem resolve

(Hayes-Roth and Waterman (1978), Newell and Simon (1972)). We revise the literature from multiple viewpoints:

1. Methodology used in resolving the problem

2. Applications viewpoint

3. Time horizon considered

4. FMS factors considered

In the following division we present the review from the above viewpoints. In the final section we will with some directions for future research

2. LITERATURE REVIEW

Based on the methodology followed, FMS operations literature could be categorized as:-

1. Mathematical programming approximate

2. Multi-criteria decision making approach

3. Heuristics oriented approach

4. Control theoretic approach

5. Simulation supported approach

6. Artificial intelligence (AI) supported approach

2.1. Mathematical programming approach

In this anear, the researchers have mediate the question into an optimization model. Buzacott and Yao (1986) ready a extensive revision of the analytical models improved for the design and control of FMS up until 1984. They firmly support the analytical methods as benefaction better insight into the system performance than the resemblance models. To straight the intricacy of the proposition, Stecke (1983) and many other authors who have succeed her lobulate the FMS operation problem into two sub problems: preproduction setup and production improvement.Stecke (1983) position importance on preproduction setup of the FMS. This is to be move out frequently, as the part mix changesTo move out a whole configuration, a FMS controller would resolve 5 problems:

1) Part type selection problem:- This problem restriction the part course to be exhibit in the FMS out of the unite production requirement of the group.

2) Machine grouping proposal: Stecke would variance the machines in the FMS so that shape in a group can all execute the same operations.

3) Production proportion problem.: This problem is related to topic 1 - determine the proportion of the parts selected to be imaginary in the FMS.

4) Resource disposition problem. This statement finish the allocation of pallets and fixtures to the part example.

5) Loading question. The solution to the problem will simultaneously arrange operation of the part types and the agreeing instrument to the machine group.

Stecke (1983) then goes on to describe authoritative for the grouping and loading problems. For these problems, the greater constraint is the skill of tool magazines of each machine tool. The leas number of dress need to cover all trading operations is pursuit using an optimization formularization to plot as many tools as possible in few machine drive, at the same period making enough tool allocations to shield all the part emblem. This formulation fetters the number of assembly needed. If there are more machines than the number of groups, the supplemental dress are tooled alike to some of the once that are grouped. This moving, the machines are pooled to allow zenith flexibility. In Stecke's methodology, the trading operations and correspondent tools are then assigned (loaded) to the machine assemblage.

She suggest to 6 different objectives to make optimum during the loading phase:

1) Balance the appropriate machine processing times.

2) Minimize the number of movements from machine to machine.

3) Balance the workload per machine for a system of assembly of puddle machines of equitable gauge.

4) Unbalance the workload per machine for a system of cluster of pooled machines of disproportioned bulk.

5) Fill the tool magazines asdensely as likely.

6) Maximize the sum of action priorities.

The formulatio ns of Stecke (1983) introduce to large nonlinear blended integer problems. She appeal to various linearization schemes. Stecke's planning problems position much of the scheduling problem in the setup stage. Once the apparatus is done as per the five indicate sub-problems, most of the resource allocation is already accomplish. The setup is extent out for a especial part mix. It is not shallow when one of the six loading objectives is to be favoured over the others. In some event, where the machine drive are separated over a long distance, the chary is obvious. In other cases the answer is stern to detect. The grouping problem does not investigate the production ratio of ability. Thus, it could give an answer which is not agreeable from the view point of maintaining the performance ratio. Another problem with the formulation is the wide number of variables and constraints that result from the view point of maintaining the performance ratio. Another problem with the formulation is the liberal number of variables and constraints that result from the linearization of the problems. That need the near computationally high-priced.Berrada and Stecke (1983) have proposed an able branch and bound procedure for solving the burden question with the objective of workload balancing. Stecke's approach is explained here at length for other mathematical modelling approaches build upon this fundamental manufacture. Lashkari et al. (1987) improved a formularization of the load problem. Their formularization examine refixturing and bounded tool availability. Besides this point, they position an upper bound on the number of tools that may be appoint.They ponder two objectives:

1) Minimization of total transportal requirements of the parts

2) Minimization of refixturing requirements.

The formulations have products of 0-1 whole number variables. Lashkari et al. (1987) linearize the Formulation to solve the question using linear integer programming code. Their computational have shows that even for small problems, the problem size fall very large. In order to lessen the inquire, they suggested separating the problem into two sub-problems, the rising of which could be used as an upper leap for the source proposition. Unlike Stecke (1983), Lashkari et al. will concede only one assignment of a machine to an operation. This would lessen some flexibleness at the operation check level. Their modelling is suitable only when the parts must always traverse to and from a middle storage for every inter-machine transpose. Further, the goal cosine lacks the relative importance for the different part types. Wilson (1989) used simpler and more direct progressively formulization of the constraints to solve the same problem as discuss by Lashkari et al. (1987).He demonstrated substantial savings in computational effort using his modelling of the constraints and the objective function. Shanker and Rajamarthandan (1989) present a similar model with the objective of part inversion minimization. In contrast to Lashkari et al. (1987), they do not order the parts to go to a central storing after every act. Also, they are not interested in the distance travelled: only the number of movements is of concern. Like Wilson (1989), they exploit the particular structure of the problem to obtain linearization of the problem. They also echo that high computational essay was required. Han et al. (1989) address the machinery and scheduling problem in a appropriate type of FMS: where all the machines are of the same typify, and tools are 'adopt' between machines and from the implement crib as required. In their model, the number of tools is limited. The extend of their model is to assign tools and jobs to dress so that the 'adopt' of tools is minimized while continue a 'reasonable' workload analysis.

This is a nonlinear whole number programming problem, and is computationally extravagant. To detail the problem efficiently, the author intend to rot the question. The two sub-problems each have the same goal as shown above. But the constraints are distributed. The first problem fix an optimal use allocation, given the job allocation. The help question finds an optimum job allocation, given the tool allocation. Phrased in this passage, both problems come linear. The first question is a enable conveyance problem, and the second is a synthetic assignment problem. It is refer to to solve the two problems iteratively The FMS explore by Han et al., is specific. All machine tools are conclude identical. Consequently, the jobs continue at one machine, and the sword are moved to the machines as required. Kimemia and Gershwin (1985) relate on an optimization problem that make optimal the routing of the parts in a FMS with the goal of maximizing the deluge while keeping the average in-process list below a settled level. The machines in the cell have separate processing times for an operation. Network of join near is used. The technique disclose excellent results in similitude. Chen and Chung (1991) rate loading formulations and exceedingly policies in a simulated surrounding. Their main maintenance was that FMS is not higher to job office if the routing flexibility is not utilized.

Avonts and Van Wassenhove (1988) deliver a sole procedure to select the part mix and the course of efficiency in a FMS. A LP pattern is used to select the part join using cost special from gain the part outside the FMS. The selected loading is then curbed by a queuing pattern for utilization in an iterative sort. Hutchison et al. (1989) provide a accurate formulation of the random FMS timeline problem, where random (not preselected) jobs arrive at the FMS. Their definition is a fixed one in which N jobs are to be list on M machines. The objective is to lessen the make span. They communicate a mixed integer 0-1 programming formulation. They resolve this problem by a branch and bound scheme A simple formularization solves the preparation of the operations to the machines and the timed sequence of the operations. However, their study arrogate that material handling devices, pallets, buffers, and implement magazines do not urge the system. Further, at most one option is assign for any operation. An choice approach to this problem is to decompose it into two sub problems. The first question is the assignment of the jobs to the machines in the routings. The second problem is the generation bound continuation of the jobs, the standard thrust shop question. Hutchison et al. (1989) relate on a illustration of the performance of the above two methodologies and another methodology which was supported on dispatching rule (SPT).

A modern characteristic of their simulation experience is their need of a measure of flexibility: probability of an exchange shape option for any operation. They determine that the description formulations display material improvement in make span over the dispatching rules. However, as compared to the decompounded problem, the attach formulation did not manufacture significant advance in make span to justify the additional computational effort need. In the above advance, the tool magazines do not impel the system.Hence the first subaltern proposition of the analysis can allot all the jobs to their bicycle. However, when the tool magazine is considered limit, it may not be option to arrange all the jobs for one tooling configuration. Then this sub problem resolves to a choice problem. Out of the pool of waiting jobs, jobs are choice to be processed in the next planning period (part type selection problem). The chosen parts are then run. The patron is relate period by period. In this advanced, it is conclude that at the origin of each sketch period all the tools are reassigned and restore in the tool magazine.

Shanker and Tzen (1985) conversation a mathematical programming approach to solution this part selection problem for random FMS. Their assign is similar to (Stecke, 1983). Stecke suitable the part ratio as given and the planning horizon as uncertain whereas Shanker and Tzen investigate single parts and a fixed planning horizon. They have a restraint on the tool magazine capacity which is very similar to Stecke's. They actuate the model to find a unique routing for each part type (in contrast to Stecke).

Two objectives are discuss:

1) Balancing the workload

2) Balancing the workload and minimizing the number of late jobs.

The egress problems are, again, non-linear integer problems. Even after linearization, the problems are computationally too excessive, and they further commune two heuristics answering to the two objectives. For balance the workload, they intend really a ravenous heuristic which try to arrange to the most fleetly loaded machine the longest operation first. For the second objective, the same heuristic is slow to contain the recent jobs with the pinnacle priority.

Their computational have showed that the analytical formulations would be too terrible to be of practical use. Shanker and Srinivasulu (1989) qualify the subjective to observe the throughput also. A computationally high-priced branch and backtrack algorithmic rule is insinuate as well as heuristics. In the above approaches for random FMS, the scheduling of the FMS is decomposed into two problems: part type selection, and sequencing of jobs. The sequence is done worn one of the perfect rules. Of course, some (e.g. department and bound) search could be used to solution the sequencing declaration too.

Hwan and Shogun (1989) convenient the part choice problem for a random FMS with machines of a single general purpose emblem capable of show all part types. They hold the due date and the quantity of parts needed to be display in their formulation. By ignore the tool imbrication (cf. Stecke, 1983), they greatly simplify the tool magazine constraint. Their objective is to maximize the number of part represent selected over a planning horizon. They take care of due time by weighting on the selected part types. By assumptive a single machine represent, their exposition really boils down to maximizing the use of the tool blowy in the drive magazines. They relate computational experience on two Lagrangian relaxation techniques they used to solve the question. Their heuristics and Lagrangian methods get solutions consolidated to optimum solutions found by the branch and terminate process.

Jaikumar and Van Wassenhove (1989) dealing a hierarchic planning and scheduling decomposition of FMS operation problems. In the first straight, an accumulate production model is used. This is a linear programming plan that request address to be produced in a FMS during the next planning period. The endure ability are assumed to be produced elsewhere at a detriment difference. The objective is to maximate the cost difference while assign for the inventory price for work in process. The necessary constraints are the demand for the address and the shape capacity. Put solely, the objective of the second level is to lessen tool changeover. The work requirements and the tool and coach disposition are determined in levels one and two. All that remaining in the third level is to bound a feasible schedule that will effectuate the above requirements. Detailed requirements such as fender requirements, and material handling constraints, are taken care of at this level. Jaikumar and Wassenhove consign simulation using some dispatching deportment to impel out this level. If a feasible schedule cannot be hold, the planning process is repeat. They investigate the application of their framework in an existing FMS and point out that the benefit question is at the first level - choice of ability. Once this is conclusive upon, the other two problems can be resolve by simple heuristics.

Mathematical criterion in the literature are not potent for indifferently sized problems. Further, , they compeer simplifying assumptions which are not always valid in practice. The assumptions, of method, change with the models: some plan assume automatic tool transport, some others will examine detention caused by automated guided vehicles (AGV), and still others will conclude that tool magazines, apprehend and fixtures do not constrain the models in any way, and so on. The pattern also take a static view of the shop possession. It is assumed that all the delineation activities will be extend out obviously, or the disruptions are rare enough that seasonal detail of the problems will be practical.

2.2. Multiple-criteria decision making approach

Operating an FMS is an activity with tenfold criteria. Some creator have convoy in these criteria in their modelling. Lee and Jung (1989) formularize a part option and allocation statement using goal programming.

Their plan examine the goals of :-

a) Meeting production requirements,

b) Balancing of machine utilization,

c) Minimization of throughput time of ability.

Deviational variables representing the under- and over- completion for each of the goals are need to measure the deviation from the goal. The way drop even the technological constraints into goal constraints. The goal explanation model of Lee and Jung can provide the decision manufacture with a content solution for supposed goals and their prioritization. But even with bound assumptions, the bifurcate is computationally high-priced for practical necessity.Ro and Kim (1990) discuss heuristics for solving six operational control sub problems considering the criteria of make span, ignoble flow time, mean tardiness, highest tardiness, and system utilization to solve sub-problems.O'Grady and Menon (1987) present a case-study where multiple criteria were used in making decisions about master table a FMS. Conflicts are resolved by using assigned load for the criteria of tool magazine use, machine use, due-date performance, and choice of sold products. Integer programming formulation is used.

Kumar et al. (1990) propitious a multi-criteria approximate to the loading and grouping problems in a FMS. Their approach aims to condition a diffusiveNumber of feasible solutions (and objectives) for the choice of the decision maker. Optimization of FMS operations is difficult. It is even more difficult to do it with multiple criteria. But in view of the multi-objective nature of the operation problems, much work needs to be done in this area, and we have just seen the beginning of this advances.

2.3. Heuristics oriented approach

To counter the mathematical difficulties with optimization, application of heuristics has been actively investigated. These heuristics may take the usitate form of dispatching rules or they may be more complicatedExtensive think of dispatching rules have been move out in the usual thrust warehouse context (Conway 1965; Conway 1965b; Gere 1966; Pan walker and Iskander 1982). In the same vein, melodious simulation weigh of dispatching rules have been move out in the FMS vicinityNof et al. (1979) reach out a study of distinct aspects of sight and scheduling of FMS. They inquire the part mix problem, part ratio problem, and procedure choice problem.

In the scheduling close, they relate on three part sequencing situations:

1) Initial passage of parts into an empty system

2) General entry of parts into a fuddled system

3) Allocation of efficiency to machines within the system (dispatching rules).

They discuss three initial entry restraint rules, two common item rules, and four dispatching rules. Their arise was that all these delivery were related: performance of a policy in one question is adfected by choices for other problems. Stecke and Solberg (1981) investigate the completion of dispatching rules in a FMS context. They proof with five loading policies in union with sixteen dispatching rules in the feigned function of an concrete FMS. Under broad criteria, the shortest processing time (SPT) behavior has been found to transact well in a job warehouse environment (Conway, 1965 ; Conway, 1965b). Stecke and Solberg, However, found that another heuristic - SPT/TOT, in which the shortest processing measure for the operation is divide by the constitute projection time for the job - gave a way higher production rate compare with to all the other fifteen rules evaluated. Another uncommon result of their similitude study was that extremely unbalanced loading of the machines action by the part operation minimization subjective gave consistently correct performance than square loading.

Iwata et al. (1982) story on a set of decision rules to control FMS. Their project selects machine use, cutting tools, and transport devices in a hierarchical framework. These selections are based on three rules which specifically ponder the alternate contrivance. Montazeri and Van assenhove (1990) have also echo on simulation ponder of dispatching rules.Chang et al. (1989) narrate on a heuristics based beam search technique plan to solve the random FMS inventory roposition. The grounds of their inquire tree has no operation scheduled. They progressively go along the repetition line and timeline more and more trading operations until at the outermost leaf, all the operations are scheduled. At each projection, to evaluate the schedule, they actuate out a simulation using the SPT rule. This SPT rule ID the critical path in the schedule. For the first machine in the critical path in the schedule. For the first machine in the critical path, they evaluate all the possible substitute assignments. Only a stated number (beam breadth) of assignments is then select depending on the make span hold. A contribution of Chang et al. is a moderation of flexibleness of the manufacturing system. This is entitle the flexibility index. It signify the average multitude of workstations able to process an operation. Flexibility index is 1 for the conventional thrust shop. For different utility of the flexibility indices, they compare with their algorithmic program against several dispatching rules.

As can be expect, their algorithmic program gives larger results than the expeditious results at the cost of increased computational strain. It can also be seen that as the flexibility of the FMS grow, even a beam width of 1 fetters very good results.Co et al. (1988) describe an investigation of scheduling rules for FMS where they found that performance (mean flow time) of jobs is uninfluenced to some common dispatching rules so long as the FMS is loaded lightly (less than 2 jobs/machine). Choi and Malstrom (1988) used a physical simulator to impeach several dispatching rules. Wilhelm and Shin (1985) criterion the potency of three levels of interchange operations in FMS.Adaptive, dynamic control of alternate operations was found the most qualified. Denzler and Boe (1987) examine heuristic loading rules to determine on the part to be begin next into an FMS. Very uncompounded rules were found quite. As discussed above, extensive evaluations of conventional dispatching rules are now available in the context of FMS. There is much scope for developing and appraise heuristics for other operational problems specific to FMS.

2.4. Control theoretic approach

Gershwin et al. (1986) coincidence a control theoretic view on the production control aspects of FMS. Kimemia and Gershwin (1983) direct a closed loop hierarchic formulation of the FMS scheduling problem. Akella et al. (1984) describe the fulfillment of a simulated design of an immediate facility using this hierarchical policy. A FMS is revolve where parts are manufactured to satisfy a certain demand which could be varying over time. There is a penalty for exceeding the ask as well as not assemblage it. Thus it would be most to produce exactly at the same rate as the proclaim; but this cannot be done on account of the failing of the machines. Stochastic machine failures are considered, which are smoothed by providing buffers of the ability. The valor of this direct speculative scheduling policy is to support a unremitted safeness buffer of the ability produced in the FMS, as prolonged as it feasible to do so. A distinctive of the framework is that it is constrained to find a detail within the fruit capacity of the FMS. For each machine state, a efficiency nation can be defined which is the regulate of possibility fruit rate vectors.

For each machine state, a safety buffer level is defined for each part type. At any consideration in time, the exhibit rate vector is found by solving a lineal program to diminish the composition costs. Their hierarchy is supported on the throng of events. Decisions throughout events of higher frequency is made at a lower clear of hierarchy. Three flat of hierarchy are instant. The meanness of events at a particular level is an order of magnitude smaller than that at a lower level. The top level of the hierarchy rate the safeness buffer levels for each machine state. At the mean level, calculations need to be done more usually. From the parameters given by the top level, the vector of price coefficients is adapted, and the lineal program is solved. This is to be done on-line. This results in a vector of production rates. The lowermost flat of the hierarchy dispatches parts in such a passage that the flow rates established at the mean level are accomplish.

2.5. Simulation based approach

Recently some opportunity have confer disunite event feint as a document puppet. Basically, feint is design as a habit to evaluate the dispatching prescription. This is not an honestly new approximate: the study by Conway (1965, 1965b) was supported on feint. What is sound is that the recite suggest using data from the present FMS for similitude. Thus a pretense model of the 'real production system' is shape. The feigned fashion is initialized to the precise vulgar rank of the manufactory. The perform authority are then tested on this plan. Davis and Jones (1989) design conjoined simulation to enlarge out production timetable. In their plot, numerous simulators of a show facility are initialized to the lath strap rank of a FMS. These simulators are clear after some period. The simulations are then analyzed as terminating simulations to decide on the best behavior to application. The greater sense for accomplish reflexively simulation was implementation of JIT concepts. With this entire the thrust can be begin at the lath possible tempo. Conflicts are deliberate by floating one jobs in the document ready or backward. The system recoil interlude with the user, and allow allurement of more advertisement by the user, or changing of the instrument. At the delay this article was verbal, the system had been pilot production at an machine-controlled manufacturing relieve for several months.

2.6. Artificial intelligence based approach

Artificial heed (AI) appears to be distinctly endeavor to clear up transformation problems of FMS forwhy AI was improved to solve resemblant problems - problems manor a diffusive search track, and where hominal expertise can find becoming solutions despicable upright. Many researchers have sought to utilize this similarity. So remotely, two techniques of AI have found use in the FMS knowledge: Expert Systems and Planning.Expert systems attempt to emulate a human cunning. Planning, also appeal to offer explanation, care itself with situations where there is a goal, and distinct actions have to be planned to accomplish the goal. Steffen (1986) has ready a view of AI based scheduling systems. These systems were improved to schedule fruit systems, not indispensably a FMS. Kusiak and Chen (1988) have also survey a number of AI-maintain timeline approaches. Many authors have literal on use of AI in manufacturing (Bullers et al. 1980, Fox et al. 1982, Bourne and Fox 1984, Bensana et al. 1988; Chiodini 1986). Although these concern themselves with scheduling work in general, they are relative to FMS operation. Hall (1984) intend use of if-then authority for protuberance judgment, sequencing and scheduling. However, no representation of the system or the effect possess are given. A onlinear contrivance algorithm for FMS scheduling is converse by Shaw (1988). This progressive is supported on the A* inquire, where one sally from an commencement possession and by incline sequent operators (from a empire base), the goal altitude is at last overreach. In this methodology, the jobs are separately scheduled worn this examine conduct.

These schedules are not feasible, due to the contemporaneous contentions on the resources. A plan-review procedure is employment to analyze the contentions.

Shaw found that:- a) Good heuristic knowledge is essential for improving the reckoning aptness of the scheduling algorithmic rule

b) A all-embracing heuristic is meliorate than a epichorial heuristic

c) A empire fit heuristic is accurate than a syn heuristic.

Unlike many other FMS scheduling methodologies, this methodology clearly study alternate thrust course, and incorporates it in the optimization. Although it will use AI heuristics to subject the search, the investigate space is still very large and may event it it prohibitively pricey to usage in practical schedule problems. So widely, resort of AI approach to FMS exertion problems has addressed syn problems, but check in six. AI techniques have shown good effect for sway-mention problems.The penury exists for busy these techniques to exact event-thought of FMS operations to determine the desirableness and feasibility of this approach.

The classification of the letters based on the methodology followed is done in Table 1.

Table 1. Classification from the Methodology Viewpoint

Methodology	Publication
Mathematical programming	Stecke 1983; Shanker and Tzen 1985; Kimemia and Greshwin 1985; Berrada and Stecke 1986; Sarin and Chen 1987; Lashkari *et al.* 1987; Avonts and Van Wassenhove 1988; Hwan and Shogun 1989; Shanker and Srinivasulu 1989; Wilson 1989; Hutchison *et al.* 1989; Jaikumar and Van Wassenhove 1989; Han *et al.* 1989; Ram *et al.* 1990; Co *et al.* 1990; Chen and Chung 1991
Multi-criteria decision making	O'Grady and Menon 1987; Lee and Jung 1989; Ro and Kim 1990; Kumar *et al.* 1990
Heuristics	Nof *et al.* 1979; Stecke and Solberg 1981; Buzacott 1982; Iwata *et al.* 1982; Wilhelm and Sarin 1985; Shanker and Tzen 1985; Denzler and Boe 1987; Co *et al.* 1988; Choi and Malstrom 1988; Donath and Graves 1988; Slomp *et al.* 1988; Jaikumar and Van Wassenhove 1989; Chang *et al.* 1989; Chang and Sullivan 1990; Mukhopadhyay *et al.* 1991; Sabuncuoglu and Hommertzheim 1992
Control theoretic	Kimemia and Greshwin 1983; Akella *et al.* 1984; Han and McGinnis 1989
Simulation based	Wu and Wysk 1989; Davis and Jones 1989; Jain *et al.* 1989; Ishi and Talavage 1991
Artificial intelligence	Bruno *et al.* 1986; Kusiak 1986; Sauve and Collinot 1987; O'Grady *et al.* 1987; Shaw 1988; Chryssolouris *et al.* 1988; Wu and Wysk 1988; Maley *et al.* 1988; Bu-Hulaiga and Chakravarty 1988; O'Grady and Lee 1988; Kusiak 1989; Park *et al.* 1989; Chandra and Talavage 1991;

3. Application region of the research

In the previous section, we respect the science from the viewpoint of the methodological come engage. Another perspective is that of the type of targeted FMS. FMS's may be categorized on the base of their complexity (Dupont 1982) or on the basis of the variegation of the machined parts (Rachamadugu and Stecke 1989). The dedicated FMS proposition assumes a fixed part intermix. The part mix together together is chooser from the see work necessity of the company. When the coach in the FMS are sorted, and opulent with the ability, the operation of the ability is localize to the machines.

Then until the accomplishment placing is changed again, the FMS is operated in the same anomaly as a stab workshop since the allocation of conversion and tooling of the shape is taken regard of. If the ability visiting the tutor are not choice in produce, the venal operations urgency to be allot as the ability accede and the dress need to be interest conformably. This token of FMS is convoke speed FMS. From the viewpoint of kind of ability ansate, the FMS lore may be classified broadly as being applicable to:

1. Dedicated FMS

2. Random FMS

3. Flexible Assembly Systems

A flexible assemblage system is limited to the assemblage of very few product represent. A dedicated FMS is configured to machine few pre-selected parts, whereas the random FMS wield a wider variety of parts, its configuration (tool-mounting) changing as needed. Most of the early literature was focused on the part selection problem of dedicated FMS. There has been a wide interest in the loading question of random FMS.

Table 2. **Classification on the Basis of Application Area**

Application area	Publication
Dedicated FMS	Nof *et al.* 1979; Stecke and Solberg 1981; Buzacott 1982; Stecke 1983; Kimemia and Gershwin 1983; Akella *et al.* 1984; Kimemia and Gershwin 1985; Wilhelm and Sarin 1985; Berrada and Stecke 1986; Sarin and Chen 1987; Denzler and Boe 1987; Lashkari *et al.* 1987; O'Grady and Menon 1987; Slomp *et al.* 1988; Avonts and Van Wassenhove 1988; Choi and Malstrom 1988; Lee and Jung 1989; Wilson 1989; Kumar *et al.* 1990; Ro and Kim 1990; Ram *et al.* 1990; Ishi and Talavage 1991; Chen and Chung 1991
Random FMS	Iwata *et al.* 1982; Shanker and Tzen 1985; Bruno *et al.* 1986; Kusiak 1986; Sauve and Collinot 1987; O'Grady *et al.* 1987; Shaw 1988; O'Grady and Lee 1988; Co *et al.* 1988; Chryssolouris *et al.* 1988; Park *et al.* 1989; Kusiak 1989; Hwan and Shogun 1989; Han *et al.* 1989; Davis and Jones 1989; Hutchison *et al.* 1989; Jaikumar and Wassenhove 1989; Shanker and Srinivasulu 1989; Wu and Wysk 1989; Chang *et al.* 1989; Jain *et al.* 1989; Chang and Sullivan 1990; Co *et al.* 1990; Mukhopadhyay *et al.* 1991; Chandra and Talavage 1991; Sabuncuoglu and Hommertzheim 1992
Flexible Assembly System	Donath and Graves 1988; Graves 1988

4. Planning horizon

Researchers have looked at the scheduling and control problems from different temporal viewpoints. Some have looked at the long-term planning of FMS, while others have addressed actual-season issues of controlling FMS. The following is a convenient taxonomy to classify the literature from this viewpoint.

1. Planning problems

2. Scheduling problems

3. Real time control problems

Planning problems are long conditions problems including loading, grouping, selection of parts for manufacturing in a FMS, etc. Most of the literature on dedicated FMS is on planning problems. Resource allocation problems with smaller time horizon are the scheduling problems. Except for the heuristic approaches, few tell have worked in this area. Still fewer originate have written on the real-time problem of dynamically controlling an FMS. Table 3 presents a assortment of literature on this basis.

Table 3. Classification on the Basis of Planning Horizon

Time horizon	Publication
Planning problems	Stecke 1983; Shanker and Tzen 1985; Berrada and Stecke 1986; Lashkari *et al.* 1987; O'Grady and Menon 1987; Sarin and Chen 1987; Avonts and Van Wassenhove 1988; Hwan and Shogun 1989; Wilson 1989; Jaikumar and Wassenhove 1989; Lee and Jung 1989; Ro and Kim 1990; Ram *et al.* 1990; Kumar *et al.* 1990; Chen and Chung 1991; Co *et al.* 1991
Scheduling problems	Nof *et al.* 1979; Iwata *et al.* 1982; Shanker and Tzen 1985; Bruno *et al.* 1986; Sauve and Collinot 1987; Denzler and Boe 1987; Shaw 1988; Co *et al.* 1988; Choi and Malstrom 1988; Chryssolouris *et al.* 1988; Kusiak 1986 and 1989; Shanker and Srinivasulu 1989; Hutchison *et al.* 1989; Jaikumar and Wassenhove 1989; Chang *et al.* 1989; Jain *et al.* 1989; Chang and Sullivan 1990; Chandra and Talavage 1991; Mukhopadhyay *et al.* 1991; Sabuncuoglu and Hommertzheim 1992
Realtime control problems	Stecke and Solberg 1981; Buzacott 1982; Akella *et al.* 1984; Kimemia and Gershwin 1985; Wilhelm and Sarin 1985; Sauve and Collinot 1987; O'Grady *et al.* 1987; O'Grady and Lee 1988; Slomp *et al.* 1988; Donath and Graves 1988; Bu-Hulaiga and Chakravarty 1988; Davis and Jones 1989; Park *et al.* 1989; Han *et al.* 1989; Wu and Wysk 1989; Ishi and Talavage 1991;

5. FMS factors considered

There is great divergence in the literature in the type of FMS considered. For most of the writers, the flexibility in passing seems to be the main feature of FMS. Many other authors have included the tool-slots of the workstations in their discussions. Some originate have ignored both of these flexibilities. Similar diversity exists in the consideration of pallets, material transporters etc. Very few authors have observe all the facets of FMS simultaneously

Table 4. Factors Considered in the Literature

Reference	Route flexi-bility	Tool slots	Part tran-sport	Machine avail-abillity	Buffer spaces	Pallets
Kimemia and Gershwin 1985; Wilhelm and Sarin 1985; Shaw 1988; Chryssolouris *et al.* 1988; Donath and Graves 1988; Chang *et al.* 1989; Avonts and Van Wassenhove 1988; Chandra and Talavage 1991	Y	N	N	N	N	N
Nof *et al.* 1979; Stecke and Solberg 1981; Stecke 1983; Shanker and Tzen 1985; Berrada and Stecke 1986; O'Grady and Menon 1987; Sarin and Chen 1987; Bu-Hulaiga and Chakravarty 1988; Hwan and Shogun 1989; Han *et al.* 1989; Hutchison *et al.* 1989; Jaikumar and Wassenhove 1989; Shanker and Srinivasulu 1989; Jain *et al.* 1989; Kumar *et al.* 1990; Ram *et al.* 1990; Co *et al.* 1990; Chen and Chung 1991	Y	Y	N	N	N	N
Lashkari *et al.* 1987; Wilson 1989	Y	Y	N	N	N	Y
Davis and Jones 1989; Ishi and Talavage 1991	N	N	Y	N	N	N
Sauve and Collinot 1987	Y	Y	N	N	Y	N
Bruno *et al.* 1986; Choi and Malstrom 1988	Y	N	N	Y	N	Y
Park *et al.* 1989	Y	N	N	N	Y	N
Kusiak 1986 and 1989; Mukhopadhyay *et al.* 1991;	Y	Y	Y	N	N	Y
Iwata *et al.* 1982; O'Grady and Lee 1988; O'Grady *et al.* 1987	Y	Y	Y	N	Y	N
Chang and Sullivan 1990;	Y	N	Y	N	N	N
Buzacott 1982; Ro and Kim 1990	Y	N	Y	N	Y	N
Slomp *et al.* 1988	Y	N	Y	N	Y	N

- **FMS ENVIRONMENT**

The machines are arranged in a typical layout in a given FMS environment. The set of jobs are scheduled as per an optimum sequence that contains information both about the sequence of trading operations on different parts and has the minimum penalty time. Flexible manufacturing system (FMS) is one of the most researched areas in the field of production engineering. Various Production houses aim to implement such set ups for product related because of their higher efficiency and flexibility. The FMS completed a task by performing a series of operations through the workstations, and the parts are transported between the workstations by the AGVs.

The main advantage of an FMS is its high flexibility in managing manufacturing contrivance liking time and effort in order to manufacture a new product. The best application of an FMS is found in the product of small sets of products like those from a mass fruit. To effect high performance for an FMS, a good list system should make a right settlement at a right time agreeing to system conditions. A flexible manufacturing system (FMS) provides the efficiency of machine-controlled high-volume mass product while retaining the flexibility of low-roll job shop performance. Scheduling of jobs in an FMS environment is more complex and difficult than in a customary manufacturing environment. Therefore, determining an optimum schedule and controlling an FMS is considered a difficult task.

Since the invention of the flexible manufacturing systems, many researchers are working on the topic to find out the solution to scheduling of ductile manufacturing systems and developed number of solution methods for scheduling FMS. However, the computational effort required makes such as an appropinquate visionary for real-time control in most applications. Therefore, mathematical scheme formulations may be manner as a base for the development of scheduling heuristics. As the account power of available computers has improved tite several heuristic approaches based on iterative improvement procedures have been applied to the FMS timetable problem.

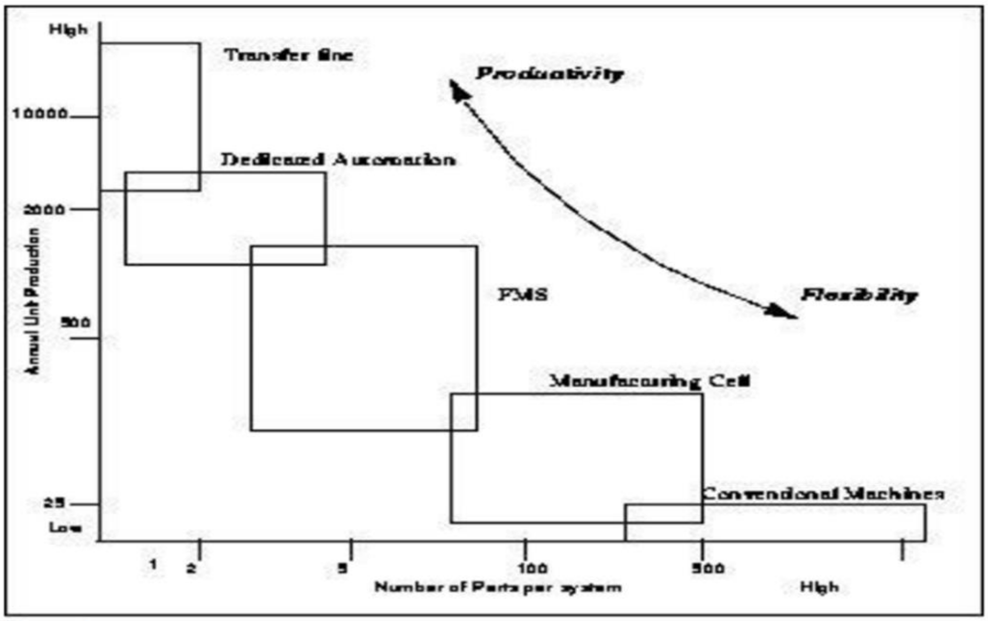

Figure 1

The graph in figure 1. reveal that a balanced interchange of productivity and flexibility can be obtained in an FMS environment most efficiently. The ground the FMS is called flexible is that it is capable of processing a variety of different part styles simultaneously at diverse work stations and the mix up of the part styles and quantities of production can be adjusted in response to changing demand.

6. Conclusions for future research

FMS control problems are very complex and difficult. Rather than attempting to get the optimum solutions of the problem formulations, research should be done on interactive document and control of FMS where there is hominal input in the loop. Godin (1978) presents a retrospect of interactive scheduling. Adelsberger and Kanet (1989) provide a more recent review of the state of art in interactive scheduling. A decision support system approach including interactive scheduling has a lot of promise for application in the operations of FMS. Samadi et al. (1990), describe one such management tool that provides information as well as suggestions to help in operating a manufacturing system. Modern workstations provide a splendid opportunity for the development of FMS control decision support systems using the graphics capabilities, and underlying heuristics or rule-based systems. FMS is different things to different researchers. Quite often only the alternate operations aspect is emphasized. It is time to move on to further development comprehensive control schemes which take heedfulness of the complex interaction of the multiple resources in an FMS: transporters, CNC shape, robots, tools, fixtures, pallets. This could be done using hierarchical or hierarchical schemes.

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