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Non-traditional optimization techniques of scheduling in FMS: A Review

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Abstract

Globalization and unstable market with high demand consumers, lead to highly competitive manufacturing industry with competitive prices. Many companies are opting to Flexible Manufacturing System (FMS) in order to meet the demands of the market. The market is very volatile and rapidly changing day to day. Even though the concept of FMS is decades old, there is still a scope of improvement in that area. Scheduling problem in FMS is one of the most researched topic. In order to achieve the full efficiency of FMS, it is necessary to generate an optimal schedule. Optimization of the scheduling is the most sought out topic for research. In this paper we tried to analyze the advancements made in scheduling of FMS for the past two decades. This work mainly focused on scheduling problem of FMS and classified the articles according to the non-traditional approaches used to solve the optimization of scheduling problem in FMS and presented the general ideas of FMS. Different objectives and constraints used in problems have also been studied and analyzed and presented in this paper.

Keywords: Flexible Manufacturing System (FMS), Scheduling, Non-traditional approaches, Heuristic algorithms

1. Introduction

The manufacturing industries are not only forced to adapt to fast evolving demands of consumers but also they have to meet these demands with high quality products at low cost. Recent days the product cost has taken a back seat and the terms like flexibility quality, quick and efficient delivery, customer satisfaction are the dominating factors in today's market. Out of the recent trend changes FMS is gaining popularity just because of its flexibility as the name indicates. FMS concept mainly focuses on customization, thereby reducing the inventory, makes pan time, quickly adapting to new products, meet the delivery time quickly etc.

FMS offers huge benefits and helps the company to achieve great success. A flexible manufacturing system is designed to react and adapt to changes within the production process, including any unexpected issues or problems. Since the 1970s, Flexible manufacturing systems have helped companies to create products quickly and more efficiently.

Flexible manufacturing systems today still work to improve the production process and offer two types of flexibility. Machine flexibility refers to how much a system can change in order to create new product types. It also describes how a system can change the order of operations on a specific part.

The second category is routing flexibility. This is the ability of a system to use many machines to perform the same operations on one part. It also refers to how much a system can adapt changes in volume, capacity, or capability.

2. Scheduling

Scheduling may be defined as the allocation of resources over time to perform tasks. [1].The influence of good scheduling strategies in FMS in today's competitive markets cannot be overstressed. The need to respond to market demands quickly and to run plants efficiently gives rise to complex scheduling problems in all but the simplest production environments.

A general scheduling problem may be stated thus:

njobs {J,,Jz, ... ,Jn} have to be processed. Machines {M\, Mz, ..., Mm} are available. A subset of these machines is required to complete the processing of each job. The flow pattern or order of machines for any job may or may not be fixed for some or all jobs. The processing of job J_j on machine M, is called an operation, denoted by O'j' For each operation O'j' there is an

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associated processing time tij' In addition, there may be a ready time (or release date) r_j associated with each job, at which time $J_j$is available for processing, and/or a due date d., by which time J, should be completed. A schedule in this context is an assignment of jobs over time onto machines. The scheduling problem is to find a schedule which optimizes some performance measure.
The stated scheduling problem may be generalized further by replacing machines by processing stages which may contain several machines.

2.1 Assumptions

Since the real time scheduling problem is very complex and its near to impossible to arrive an optimal solution with these constraints, it is necessary to have some assumptions in the problem. A variety of assumptions are made depending upon the problem or environment that is being studied. The following assumptions are used frequently in scheduling theory literature:

- The set of the jobs and the set of the machines are known and fixed.
- All jobs and all machines are available at the same time and are independent.
- All jobs and machines remain available during an unlimited period.
- The processing time for each job on all machines is fixed, has a known probability distribution function, and sequence independent.
- Setup times are included in processing times.
- A basic batch size is fixed for all jobs.
- All jobs and all machines are equally weighted.
- No preemption is allowed.
- A definite due date is assigned to each job.
- Each job is processed by all the machines assigned to it.
- Each machine processes all the jobs assigned to it.
- The process plan for each job is known and fixed.

2.2 Categories of Scheduling

Generally the technological constraints are formed upon the flow pattern of the jobs to machines. So according to this the scheduling can be roughly classified as the following.

2.2.1 Job shop

Each job has its own individual flow pattern or specific route through the machines which must be adhered to.

2.2.2 Flow shop

Each job has an identical flow pattern.

2.2.3 Open shop

There is no specified flow pattern for any jobs.

2.2.4 Permutation flow shop

A flow shop in which the order of processing of jobs on all machines is constrained to be the same.

2.2.5 Single machine shop: only one machine is available

In cases (1), (2) and (3) the schedule may produce a different order of jobs on machines in the shop. When processing stages are considered rather than machines the following definitions are useful.

2.2.6 Parallel machines

k identical machines in a single processing stage. Each job needs one and only one of these machines.

2.2.7 Job shop with duplicate machines

A job shop in which there are *k*, identical machines in each stage (i = 1,... ,*m)* and any job requiring that stage needs to be processed on one and only one of these machines [2].

3. Scheduling Problems in FMS

The different non-traditional optimization approaches to solve the scheduling problems have been discussed by several investigators as given below.
For solving a problem using optimization techniques, first an objective function has to be set, the physical system of the problem has to be modeled, the solution is then obtained by setting some boundary conditions and constraints, the results are then analyzed and the approaches are validated.
The optimization of scheduling are usually done by different approaches spanning from mathematical approaches and branch and bound techniques to bottleneck based heuristics, artificial intelligence and by local search methods. The optimization of scheduling problems that have been done so far by local search methods, are reviewed and compared.
The Focus is given for nontraditional optimization techniques. Since the optimization by nontraditional techniques are done for a long time and numerous papers have been published, so we have reviewed the papers for the past decade starting from year 2010. JZhang [3] optimized the scheduling process for single objective function of optimizing./minimizing make span by using particle swarm optimization (PSO) and also suggested that same technique can be used for combinatorial objectives of FMS. Udhayakumar P.,Kumanan, S.[30] have generated an active schedules and optimal sequence of job and tool that can meet minimum make-span schedule for the flexible manufacturing system and also proposed non-traditional optimization technique such as ant colony optimization (ACO) algorithm to derive near- optimal solutions which adopt the Extended Giffler and Thompson algorithm for active feasible schedule generation. In this paper, the proposed algorithm is used for solving number of problems taken from the literature. The results available for the various

existing algorithms are compared with results obtained by the ACO algorithm. The analysis reveals that ACO algorithm provides better solution with reasonable computational time. They have suggested for the future, that work availability and handling times of loading/unloading stations, robots, and AGVS can also be included. Tsung-Lieh Lin et al [18] proposed a new hybrid swarm intelligence algorithm (MPSO) that consists of particle swarm optimization, simulated annealing technique and multi-type individual enhancement scheme is presented to solve the job-shop scheduling problem. The experimental results show that the new proposed job-shop scheduling algorithm is more robust and efficient than the existing algorithms. They found that hybridization of techniques gave them a better result. Jun-qing Li et al [16] have taken three minimization objectives the maximum completion time (makespan), the total workload of machines and the workload of the critical machine have been considered simultaneously. They have proposed a tabu search (TS) algorithm with an effective neighborhood structure combining two adaptive rules. They named their technique as hybrid tabu search algorithm (HTSA). They found that the converging results are better due to the hybridization and the results are obtained soon. The statistical analysis of their performance comparisons showed that the proposed HTSA is superior to four existing algorithms including the AL + CGA algorithm the PSO + SA algorithm, the PSO + TS algorithm and the Xing's algorithm in terms of both solution quality and efficiency. Gnanavel Babu et al [10] addressed the problem of simultaneous scheduling of machines and two identical automated guided vehicles (AGVs) in a flexible manufacturing system (FMS). For solving this problem, a new meta-heuristic differential evolution (DE) algorithm had been proposed. The algorithm was tested by using problems generated by various researchers and the makespan obtained by the algorithm is compared with that obtained by other researchers and analyzed. They suggested that DE gives better results and suggested the same can be applied for multi objective optimizations. Subsystems like AS/RS can also be added to the FMS problem and solved. Ghasem Moslehi, Mehdi Mahnam [22] present a new approach based on a hybridization of the particle swarm and local search algorithm to solve the multi-objective flexible job-shop scheduling problem. The efficiency of the new approach was compared against the results reported from other algorithms (weighting summation of objectives and Pareto) to evaluate the proposed algorithm. The results indicate that the proposed algorithm is an effective and competitive approach compared to the multi-objective flexible job-shop problem. They have used multi objectives for their problem.

Deepak Kumar, H.Ramakrishna and R. Jagadeesh [14] attempted to schedule simultaneously the machine and vehicle in an FMS and attempted to solve the combined problem for the minimization of three objectives, namely, makespan, mean flow time and mean tardiness. They have used PSO Particle Swarm optimization and coded the programming by C language. They have used Bilge and Ulsoy data set for comparison. Chin-Chia Wu et al [31] addressed a single-machine total completion time problem with learning effect and release times based on the sum of processing times. A simulated-annealing algorithm was also proposed to obtain a near optimal solution. They proposed for Future research may consider other criterion such as the tardiness or lateness or studying the problem in the multi-machine setting. M. Bank, S.M.T. Fatemi Ghomi, F. Jolai, J. Behnamian [36] considered a permutation flow shop scheduling problem with deteriorating jobs. A particle swarm optimization algorithm with and without a proposed local search was developed to determine a job sequence which minimizes the total tardiness criterion. Furthermore, a simulated annealing algorithm was pro- posed to solve the problem. They found that PSO gives more promising results than the simulated Annealing (SA). Future scope is for multi objective and trying other new metaheuristics techniques. Narendhar. S and Amudha. T [24] proposed a new hybrid technique of Bacterial Foraging Optimization with Ant Colony Optimization named Hybrid Bacterial Foraging Optimization for solving Job Shop Scheduling Problem. They solved for single objective of minimising makespan for Admas, Balas and Zawaxk (ABZ), Lawrence (LA) Benchmark problems and found that proposed HBFO algorithm gave the best makespan for ABZ, LA instances when compared with BFO algorithm and also observed that the proposed HBFO was effective than BFO algorithm in solving JSSP. They suggested that the proposed HBFO algorithm can also be used for higher instances of size and this HBFO algorithm will surely be able to achieve the best makespan for more number of iterations.

Nidhish Mathew Nidhiry, R. Saravanan [25] presented a Genetic Algorithm based scheduling of Flexible manufacturing system. This work is considering multiple objectives, i.e., minimizing the idle time of the machine and minimizing the total penalty cost for not meeting the deadline concurrently. Software has been written in .net language. Results are obtained for the 43 jobs and 16 machines FMS system. They suggested that with less computational effort it is possible to obtain the solution for such a large number of jobs (43) and machines (16).Future work will include availability and handling times of loading/unloading stations, robots and AGVs. Virginia Yannibelli and Analía Amandi [32] have considered two conflicting, priority optimization objectives for project managers. One of those objectives was to minimize the project makespan. The other objective was to assign the most effective set of human resources to each project activity. They composed an algorithm by a multi-objective simulated annealing algorithm with a multi- objective evolutionary algorithm. The performance of the multi-objective hybrid algorithm was evaluated on nine different instance sets, and is compared with that of the only multi-objective algorithm previously proposed in the literature for solving the addressed problem. The performance comparison showed that the multi-objective hybrid algorithm significantly outperforms the previous multi-objective algorithm. They said that in future works, the integration of other local exploitation/exploration processes (e.g., multi-objective tabu search and multi-objective hill climbing) within the multi-objective evolutionary algorithm would be investigated.

A.V.S. Sreedhar Kumar et al [13] have demonstrated the effectiveness of evolutionary approaches like Genetic Algorithm and Differential Evolution in scheduling of FMS systems. To demonstrate the code they have considered a two sets of 43 job 10 machines and 43 job 16 machines FMS system. The results of the proposed approach were compared with conventional scheduling rules. The proposed method was coded using Matlab version 7.1.The schedule obtained by the D.E algorithm gives the optimum COF value, i.e., minimum total penalty cost and minimum machine idleness. They suggest that Differential algorithm gives a superior results than traditional approaches. S.A. Torabi et al [28] have worked on parallel machine scheduling.They considered inherent uncertainty in processing times and due dates. Their paper presented an effective multi-objective particle swarm optimization (MOPSO) algorithm to find a good approximation of Pareto frontier where total weighted flow time, total weighted tardiness, and total machine load variation to be minimized simultaneously. They employed generalized dominance concept in a fuzzy environment to find locally Pareto-optimal frontier. They have evaluated the performance of the proposed MOPSO is compared against a conventional multi- objective particle swarm optimization (CMOPSO) algorithm over a number of randomly generated test problems. The procedures were implemented using the Matlab software. They found that 1) The proposed MOPSO can achieve a greater number of Pareto- optimal solutions, (2) It provides various non-dominated solutions with more average value for the diversity metric, and these data reveal that the non-dominated solutions obtained by the proposed MOPSO are more uniformly distributed when compared to the CMOPSO.
Hossein Shirgahi and Ali Ahmadi Katouli [26] found a near-pare to scheduling planning for distributed flexible manufacturing system maximizing the system efficiency. They solved the problem for distributed flexible manufacturing system and proposed a new multi objective gravity search algorithm to tackle this problem and their experimental results demonstrated that their approach was very effective for handling such complex systems. They had the objectives of minimizing the make span, reducing of the job transportation in a machine of a factory and maximizing the load- balance and developed the algorithm in MATLAB Language and run on a pc with 2.00 GHz and 1GB of RAM memory. They felt that there have not been a lot of attempts for scheduling DFMSs by meta-heuristics approach and it was an open filed for these near optimal method and concluded that there are lot of further options to explore this research area with different parameter settings. Shashi kant Burnwal & Sankha Deb [7] developed for scheduling optimization of a flexible manufacturing system by minimizing the penalty cost due to delay in manufacturing and maximizing the machine utilization time. They have proposed a cuckoo search method for optimization. They have used combinatorial optimization and used Matlab for programming and used the data set from Jerald et al [35] for 43x16 job sets and compared their results with existing algorithms including LPT, SPT, GA, and PSO. A.V.S.Sreedhar Kumar et al [4] developed a MATLAB based GUI designed to provide an automated tool for optimization of scheduling using conventional and evolutionary approaches. The primary objective of the tool was to automate and facilitate scheduling using the best possible approach for a particular job scenario involving multiple machines and jobs. The tool box was implemented using MATLAB version 7.1.The tool enables the user easy access in terms of loading the machine timings and job sequence details. They have used Bacterial Foraging Optimization Algorithm (BFOA) for scheduling in FMS systems. They have a taken a combined objective function of minimizing the machine ideal time and minimizing the total penalty cost. Different optimal schedules were obtained for the FMS using the above approaches, and the performances were compared and analyzed. They concluded that among the four approaches used in their work, the schedule obtained by the BFOA algorithm gives the optimum COF value. They evaluated the effectiveness of combined objective function in which the penalty value is moderated by the inclusion of reward. Jinn-Tsong Tsai et al [29] proposed a hybrid sliding level Taguchi-based particle swarm optimization (HSLTPSO) algorithm for solving multi-objective flow shop scheduling problems (FSPs). The proposed HSLTPSO integrates particle swarm optimization, sliding level Taguchi-based crossover, and elitist preservation strategy. They considered the problem of finding the job schedule for the objectives of minimizing both makespan and maximum tardiness. The authors had applied the weighted sum approach. The authors evaluated the performance of the proposed HSLTPSO approach by comparing its optimization results with those obtained for the same cases found in the literature. They have used Matlab to test for 6 problems. In this study, the weighted sum approach is used as the fitness function to find the Pareto set solutions. They found that their approach is superior to the other approaches. Yan Zheng, Yujie Xiao & Yoonho Seo To [33] studied the simultaneous scheduling problem of machines and AGVs in a flexible manufacturing system (FMS) .A mixed integer linear programming (MILP) model was developed with the objective of makespan minimization. Since the problem is NP hard they have proposed Tabu search, a heuristic approach to solve the problem with less computational time and proposed algorithms were written in C language, and the MILP model was solved using CPLEX 9.0. by considering two problem sets like Problem set-1 includes a set of 23 randomly generated problems, and problem set-2 includes a benchmark set of 82 test problems generated by Bilge and Ulusoy (1995) [36].The results found by them were always better or at least equal to those of the literature. A.V. S. Sreedhar Kumar et al. [27] investigated the scheduling problem associated with FMS by application of metaheuristics approach improvement in planning for production for FMS scheduling. This research considers flexible manufacturing system 6 machine producing system with consideration of 3 distinct parts with 3 machines at different setup considers each setup and consideration of 3 alternative routes. Scheduling for optimization involves Bacterial Foraging optimization algorithm (BFOA, Genetic algorithm (GA) and Differential Evolution (DE) for optimal scenario in to consideration. Through analysis this research

concluded that proper decision in industry performs excellent setup and scheduling by meta-heuristics approach and modeled using Promodel software for different runs. This research does not provide application variation of FMS sector.Gaurav Kumar et al [15] developed a simulation modelling and optimization of FMS with objectives for evaluating the effect of factors such as demand arrival time, no. of AGVs, velocity of AGVs, and distance preference between two work stations used in system. They had their Jobs scheduled according to dispatching rule of shortest processing time (SPT) rule. Taguchi concept and Genetic algorithm have been used for optimization of the flexible manufacturing system with scheduling. They designed a suitable fitness function for optimum values of factors affecting FMS objectives and maximization of system utilization with maximization of throughput of system.

Nidhish Mathew Nidhiry et al [26] considered in their work, a FMS that has 32 CNC Machine tools for processing 40 varieties of products. They thought that minimizing machine idle time and minimizing total penalty cost are contradictory objectives hence concluded that the problem has a multi objective nature. So in their work, they have developed a multi-objective optimization procedure based on Non-dominated Sorting Genetic Algorithm-II (NSGA-II) and software had been developed using .net programming for setting the optimum product sequence. A Comparison between the proposed NSGA II and other algorithms namely SPT, PSO, CS (found in literature) and NSGA II after 40 generations were done.NSGA-II-based algorithm is found to be better than 70 or as good as the best results obtained by the aforementioned methods. After 3000 generation the best solution was obtained. Karthikeyan.S. et al [11] proposed a hybrid discrete firefly algorithm for solving multi-objective flexible job shop scheduling problems. Three minimization objectives - the maximum completion time, the workload of the critical machine and the total workload of all machines are considered simultaneously. Their proposed algorithm discrete firefly algorithm (DFA) was combined with local search (LS) method to enhance the searching accuracy and information sharing among fireflies. The experimental results on the well-known benchmark instances and comparison with other recently published algorithms showed that the proposed algorithm was feasible and an effective approach for the multi-objective flexible job shop scheduling problems. They implemented the algorithm in C++ on an Intel Core 2 Duo 2.0 GHz PC with 4 GB RAM memory. The dimensions of the instances ranged from 4 jobs × 5 machines to 15 jobs × 10 machines. The best and average results of experiments from 20 different runs were collected for performance comparison and they found their proposed performance. Ahmed T. Saadeq Al-Obaidi, Samer Alaa Hussein [5] proposed two improvements for the cuckoo search algorithm for solving Flexible Job-Shop Scheduling problem (FJSP); the first one depends on Best Neighbors Generation (CS-BNG) and the second one is based on Iterative Levy Flight (CS-ILF). From the experiments, they found (0.2) of the iterated Levy flight is a suitable ratio for obtaining feasible solutions and increasing this ratio has a time consuming for finding better solutions. Their Experimental results showed that the two improvements have higher quality solutions and speed up the convergence rate in most instances in comparison with the basic cuckoo search algorithm. The algorithms have been applied on Hurink et al. [11] instances with three different instance sets “edata”, “rdata”, and “vdata” which the set of assignable machines with a particular probability distribution has been expanded Xinyu Li, Liang Gao [18] studied an effective hybrid algorithm (HA) by hybridizing the genetic algorithm (GA) and tabu search (TS) and proposed for the FJSP with the objective to minimize the makespan. For solving their problem they used effective encoding method, genetic operators and neighborhood structure. Six famous benchmark instances (including 201 open problems) of FJSP had been used to evaluate the performance of the proposed HA. They also compared the computational time of the proposed method with other algorithms. Mousavi et al. (2017) [24] developed a mathematical model by integration of genetic algorithm (GA), particle swarm optimization (PSO), and hybrid GA-PSO for optimal AGVs task scheduling for reducing makespan and number of AGVs for consideration of battery charge. Numerical analysis of results demonstrated that makespan is decreased by application of three algorithm through scheduling before and after optimization approach for AGVs. Results illustrated that GA-PSO provides optimum results and performance output for other two algorithm. AGVs mean value for operation improves efficiency in terms of 69.4%, 74%, and 79.8% for multi-objective function such as PSO, GA and hybrid GA-PSO, respectively. Validation and evaluation of model is evaluated through Flexsim software for simulation performance measures. This research fails to provide implementation of proposed algorithm in scheduling of AGVs. Mishra et al. [22] evaluated the FMS manufacturing system for production of multiple products which requires reconfiguration in production line. This research utilizes Particle Swarm Optimization (PSO) with multi-objective scheduling process for manufacturing process for tasks such as transport and storage requires appropriate scheduling mechanism. To resolve scheduling problem related to FMS PSO provides optimal solution for obtaining solution by means of scheduling by genetic algorithm (GA). Application of genetic algorithm provides certain conclusion such as compared with performance of GA and tabu search (TS) provides effective optimal solution for PSO in case of scheduling problem associated with multi-objective scenario. Results presented that for various instances PSO achieve significant performance for solving scheduling and control problems in operation. But this research fails to provide details about consideration of job for scheduling and processing involved in FMS. Mehrabian et al. (2017) [21] presented a mathematical programming model based on two-objective function which integrates AVGs routing in flexible manufacturing system and scheduling of flower shop. Uncertainty is always of higher demand for real-life problems like processing time and due dates. In order to resolve realistic problem several parameters are considered in this research for developed mathematical model. In formulation of fuzzy based

model for programming effective technique is identified through literature. Mathematical model is evaluated using meta-heuristic algorithms of Non-dominated Sorting Genetic Algorithm-II (NSGAII) and multi-objective particle swarm optimization (MOPSO) for evaluation of accuracy value and efficiency of the system assessment. But this research does not provides practical application of proposed model in FMS scheduling for AVGs. Chawla et al. (2018) [8] investigated dynamic job selection for simulation by means of rules involved in dispatching and scheduling is performed with consideration of multi-load scenario of automated guided vehicles (AGVs) FMS of different size vehicles. AGVs incorporates multi-load scenario consideration of rules for dispatching machine initiated nearest vehicle (NV) and materials for pick and drop in FMS. Results revealed that rules for dispatching involves similarity of outperforms of jobs and rules involved in dispatching. This research concluded that FMS throughput depends on AGV speed and fleet. But this research does not considered any mathematical formulation for analysis in FMS. V.K. Chawla et al [9] had integrated Particle Swarm Optimization (PSO) with Memetic Algorithm (MA) and named as Modified Memetic Particle Swarm Optimization Algorithm (MMPSO) and applied to yield initial feasible solutions for scheduling of multi load AGVs for minimum travel and waiting time in the FMS. The proposed MMPSO algorithm exhibited balanced exploration and exploitation for global search method of standard Particle Swarm Optimization (PSO) algorithm and local search method of Memetic Algorithm (MA) which further results into yield of efficient and effective initial feasible solutions for the multi load AGVs scheduling problem. In computational result the proposed method found to be efficient and better in generation of optimum initial solutions in comparison to other methods for the scheduling problems of multi load AGVs. Edilson Reis Rodrigues Kato et al [13] presented the resolution of the FJSP multi- objective, using a hierarchical approach that divides the problem into two sub-problems, being the Particle Swarm Optimization (PSO), responsible for resolving the routing sub-problem, and Random Restart Hill Climbing (RRHC) for the resolution of scheduling sub-problem. The implementation of the proposed hybrid algorithm has new strategies in the population initialization, displacement of particles, stochastic allocation of operations, and management of scenarios partially and totally flexible. Experimental results using technical benchmarks problems were conducted, and proved the effectiveness of the hybridization, and the advantage of PSO+RRHC algorithm compared to others local search algorithms in the resolution of the scheduling problem. The performance analysis of the effect of initial population treatment was accomplished on three scenarios from Kacem dataset, 8x8, 10x10 and 15x10, to verify and validate the stochastic improvement to initial population on the proposed PSO+RRHC algorithm. Their results showed that the incorporation of the stochastic improvement of initial population variant implemented in the algorithm in conjunction with the RRHC algorithm, obtain a PSO+RRHC metaheuristic presented better results in comparison to the other metaheuristics tested independently of the number of iterations and the results found in literature.

4. Results and Discussions

FMS performance evaluation is considered based on meta-heuristics approach, decision making with consideration of multi-objective terms, multi-objective scheduling and artificial intelligence technique in processing of FMS. Analysis of literature presented that scheduling in FMS is performed via consideration of incoming jobs count, operation, task assignment and scheduling. Under multi-objective scenario optimization approaches such as Tabu search, Ant-colony optimization, Particle Swarm Optimization and simulated annealing is adopted. Among those optimization approaches performance is not desire since it involves minimal change in objective function alters the entire performance of the system. In case of multi-criteria decision making process clear description is not presented for job scheduling. In case of AI and scheduling through multi-objective scenario not recent researches are conducted. The programming has been done mostly in C, C++, JAVA, .Net, Matlab. Matlab is gaining popularity among the researchers as the coding is comparatively easy and has effective results. From all the literature, it is also found that the researchers are showing more interest in hybridization among nontraditional algorithms as the computational time for those are less than classic methods. Also they provide a better optimal value. Especially swarm intelligence techniques have relatively good results. But still the development of fast and efficient algorithms solving multi-objective job shop scheduling problems remains a challenge for the researchers from different areas of applied mathematics. Almost all the papers have compared their proposed methods with benchmark instances got from the literature. Especially of Kacem et al [41-42], Brandimarte et al [43], Bilge Ulsoy et al. [38]. The research in the past ten years in optimization of scheduling have been done mostly using nontraditional optimization techniques. And the techniques that have gained popularity is mostly based on nature inspired techniques. Further research can be done by hybridizing two or more techniques so that we can obtain the advantages of all the techniques. Though more advancement is being done, still the area of multi-objective remains less explored. Also simulation and modeling of FMS should also be explored. From the literature, we also have identified not many studies have focused on the integration of manufacturing scheduling and transportation system, in particular utilizing artificial intelligence technique. This is because AI-based techniques have a design procedure that basically consists of the network training which has drawbacks in terms of speed and data collection. Further deciding how to evaluate the reward for a given action can be quite challenging tasks.

5. Conclusions

The following conclusions were drawn from the investigation

- Mathematical models with less constraints and high

efficiency have to be developed.

- Multi objective FJSSP (flexible job shop scheduling problem) has to be investigated as most of the researchers have used single objective only.
- To solve large scale real life FMS problems, it is also necessary to simulate them with less assumptions.
- As the problem scales large complexity also scales high. Meta heuristics shows good results to solve such cases.
- Hybridizing new Meta heuristic promises a very good pare to optimal solution in a reasonable computational time.
- The research can further be extended to simultaneous scheduling of parts and automated guided vehicles.

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