REDUCE THE TIME OF MULTI JOB OPERATION BY FLOW SHOP AND GANTT CHART

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Abstract - ***In modern manufacturing the trend is the development of Computer Integrated Manufacturing, CIM technologies which is a computerized integration of manufacturing activities (Design, Planning, Scheduling and Control) produces right products at right time to react quickly to the global competitive market demands. The productivity of CIM is highly depending upon the scheduling of Flexible Manufacturing System (FMS). Shorting the make span leads to decreasing machines idle time which results improvement in CIM productivity. Conventional methods of solving scheduling problems based on priority rules still result schedules, sometimes, with significant idle times. To optimize these, this thesis model the problem of a flow shop scheduling with the objective of minimizing the makes pan. The work proposed here deal with the production planning problem of a flexible manufacturing system. This thesis model the problem of a flow shop scheduling with the objective of minimizing the makes pan. The objective is to minimize the make span of batch-processing machines in a flow shop. The processing times and the sizes of the jobs are known and non-identical. The machines can process a batch as long as its capacity is not exceeded. The processing time of a batch is the longest processing time among all the jobs in that batch. Consequently, comparison based on Gupta's heuristics, CDS heuristics are proposed in this work. Gantt chart was generated to verify the effectiveness of the proposed approaches.***

Key Words: *Flexible Manufacturing, flow shop, Gantt chart.*

1. INTRODUCTION

Manufacturing industries have started recognizing the importance of manufacturing strategy in their businesses. Firms are increasingly facing external pressures to improve customer response time, increase product offerings, manage demand variability and be price competitive. In order to meet these challenges, firms often find themselves in situations with critical shortages of some products and excess inventories of other products. Manufacturing scheduling theory is concerned with the right allocation of machines to operations over time.

1.1 Sequencing and Scheduling:

Sequencing is a technique to order the jobs in a particular sequence. There are different types of sequencing which are followed in industries such as first in first out basis, priority basis, job size basis and processing time basis etc. In processing time basis sequencing for different sequence, we will achieve different processing time. As a job is always characterized by its route, processing requirement and priority, scheduling rates the works in order of its priority and then provides for its release to the plant at the proper time and in the correct sequence. Scheduling comes after Routing and the jobs may be scheduled based on various parameters such as lowest processing time, most work remaining etc. Scheduling is categorized into 3 categories. The sequence is adapted which gives minimum processing time. By Scheduling, we assign a particular time for completing a particular job. The main objective of scheduling is to arrive at a position where we will get minimum processing time.

1.2 SINGLE MACHINE SCHEDULE:

Here we arrange the order of jobs in a particular machine. We achieve the best result when the jobs are arranged in the ascending order of their processing time i.e. the job having least processing time is put first in sequence and processed through the machine and the job having maximum processing time is put last in sequence.

1.3 FLOW SHOP SCHEDULING:

A minimal downtime and minimal waiting time are the constraints in these kinds of problems. Flow shop scheduling is a special case of the shop scheduling tasks where there is a strict order of all operations performed on all jobs. In this case, each machine can perform more than one operation for a particular job. It is a typical combinatorial optimization problem, where each job has to go through the processing in each and every machine on the shop floor. Each machine has same sequence of jobs. The jobs have different processing time for different machines. So in this case we arrange the jobs in a particular order and get many combinations and we choose that combination where we get the minimum make span.

1.4 JOB SHOP SCHEDULING

In the job shop process flow, the majority of the items prepared oblige a novel set-up and sequencing of methodology steps. In a job shop problem there are a limited number of jobs are obliged to be handled by a limited number of machines. Each one job comprises of an arrangement of operations which are decided beforehand. For a particular job operations are processed according to their technological sequence and a strict precedence constraint is followed i.e. none of the operations will be able to start processing before the preceding operation is over. The operations on a particular machine are performed without interruption for a period of time. It is also a typical combinatorial optimization problem, but the difference is that, here all the jobs may or may not get processed in all the machines in the shop floor i.e. a job may be processed in only one or two machines or a different job may have to go through the processing in all the machine in order to get completed. Each machine has different sequence of jobs. So it is a complex web structure and here also we choose that combination of arrangements that will be giving the least make span.

1.4.1 Significance of Work:

Establishing the timing of the use of equipment, facilities and human activities in an organization can:

1. Determine the order in which jobs at a work center will be processed.
2. Results in an ordered list of jobs
3. Sequencing is most beneficial when we have constrained capacity (fixed machine set; cannot buy more) and heavily loaded work centers
4. Lightly loaded work centers = no big deal (excess capacity)
5. Heavily loaded

a) Want to make the best use of available capacity.
b) Want to minimize unused time at each machine as much as possible.

Parameters of the Work:

1. Average job flow time

a) Length of time (from arrival to completion) a job is in the system, on average
b) Lateness
c) Average length of time the job will be late (that is, exceed the due date by)
d) Makespan
e) Total time to complete all jobs
f) Average number of jobs in the system
g) Measure relating to work in process inventory
h) Equals total flow time divided by make span.

The majority of the studies in machine scheduling literature assume that the machines are continuously available. However, in real life applications, there exist scheduled unavailability periods on the machines due to various reasons such as maintenance activities, pre-scheduled jobs and pre-known material shortages. Among these reasons, preventive maintenance is the most prevailing one due to its increased recognition and importance in today's competitive world for long-term survival. Avoiding from corrective maintenance is an important issue as it is more costly and has more drastic consequences than preventive maintenance. Increased life and reduced breakdowns imply better overall machine condition that reduces the frequency of rework and scrap and improves the quality of the production and products. Besides increasing the production quantity and improving the production quality, preventive maintenance aims to maintain safe machine conditions for operators and prevent environmental damages. Scheduling of the time reduce of the pre-set policy and scheduling of the jobs on the machines having pre-planned maintenance activities are operational level decisions. These two decisions can be made sequentially or simultaneously depending on the flexibility of the maintenance start times and durations. This research is concerned with the operational level decision problem of scheduling jobs on the machines that are subject to time span reduction activities with known start times and durations. The computational experiments involve testing the effects of the reduction in time span of machining and bounding procedures and the problem parameters on the performances of machines.

Classical machine scheduling problems assume that machines are continuously available over the scheduling horizon. This assumption might be justified in some cases but it is not satisfied in many practical situations. The operation of a machine can be interrupted for a certain period of time due to accidental breakdown, preventive maintenance, periodic repair or other reasons, which render the machine nonproductive for a certain period of time. Two jobs with processing times of 1 and 2 units of time are to be scheduled on 2 parallel machines M1 and M2. Machine M1 is unavailable from instant 1 to instant n. Machine M2 is available during the whole scheduling. Another motivation to study machine scheduling with availability constraints is the presence of special tasks. A special task is a task that should be processed within a specific time interval. There are many of other examples where the investigation of machine scheduling with availability constraint is of great importance. The implications of the above–mentioned challenges in the business environment are that manufacturing firms are now forced to focus on cost-leadership issues, optimize the use of available resources, and reduce their operational costs.

PREVIOUS LITERATURES

Felix T.S. Chan et.al [1] developed optimization models for solving distributed FMS scheduling problems subject to maintenance: [Genetic algorithms approach]. The authors have made an attempt to optimize the following things during the cycle in the work: a) Allocation of jobs to suitable factories & b) Determination of the corresponding production scheduling in each factory. Their objective is to maximize the system efficiency by finding an optimal planning for a better collaboration among various processes. They proposed a genetic algorithm with dominant genes (GADG) approach to deal with distributed flexible manufacturing system (FMS) scheduling problems subject to machine maintenance constraint.

KedadSidhoum et.al [2] developed optimization models for lower bounds for the earliness–tardiness scheduling problem on parallel machines with distinct due dates considering the parallel machine scheduling problem in which the jobs have distinct due dates with earliness and tardiness. They considered the earliness tardiness problem in a parallel machine environment. Their objective is related with the parallel machine scheduling problem in which the jobs have distinct due dates with earliness and tardiness costs. The main objective of their model is to optimize tardiness.

Over the years several heuristic processes such as dispatching rules, locol search and a few metaheuristics for example tabu search, GA have been developed to FJSP. These can be classified into two broad categories: the hierarchical approach and integrated approach. The hierarchical approach reduces difficulty by solving the problem by decomposing into a sequence of sub-problems. Brandimarte [5] Paulli [3], rooms and Barnes [4] followed the same approach among others. They all used different dispatching rules to solve the assignment problem and also solved the resulting schedule using different heuristics.

Drstvensek et.al [6] developed a model of data flow in lower CIM levels considering ,models of production automation based on the idea of five levels CIM hierarchy where the technological database (TDB) represents a backbone of the system . Their main objective is to provide a common environment where the evaluation of a given general order and later composition of work orders, and designation of production resources could be done automatically under the operator's supervision. The authors have approximated these costs with the reason that with many products produced in each period, the percentage of unaccounted setups is usually small. Thus, in all three papers, the costs are underestimated and the capacity is not sufficient to allow for setups in some periods. This will sometimes result in infeasible schedules.

Ezedeen Kodeekha,(Department of Production, Informatics, Management and Control Faculty of Mechanical Engineering Budapest University of Technology and Economics) [7] developed "A new method of FMS scheduling using optimization and scheduling". Conventional methods of solving scheduling problems such as heuristic methods based on priority rules still result schedules, sometimes, with significant idle times. To optimize these, the author proposes a new high quality scheduling method. He uses multi-objective optimization and simulation method. The method is called "Break and Build Method", BBM.

Clarence H Martin [8] developed a hybrid genetic algorithm/mathematical programming approach to the multi-family flow shop scheduling problem with lot streaming. He developed a new aspect of the problem related with sublots, the size of sublots and the interleaving of sublots from different jobs in the processing sequence. His approach allows for quicker movement of items through the manufacturing facility that is a key element of synchronous manufacturing. Of course, lot streaming raises new issues such as determining the number of sublots and their sizes.

Chia and Lee [9] developed the total completion time problem in a permutation flow shop with a learning effect. The concept of learning process plays a key role in production environments. Their objective is to minimize the sum of completion times or flow time .They used the dominance rule and several lower bounds to speed up the search for the optimal solution. Mathematical programming applications for production-planning decisions have been used in process industries like oil, steel, petroleum, food etc. Eilon (1969) proposed a mixed integer program (MIP) for production scheduling in multi-product, single stage environment with capacity constraints in a chemical industry. He developed heuristic algorithms based on batch scheduling approach to schedule 5 products, subject to normal demand distribution with known parameters. In a two-stage production environment, Prabhakar (1974) studied lot sizing and sequence dependent setup time sequencing in the chemical industry using an MIP to obtain production schedules only for a single planning period.

Koulamas and Kyparisis [10] developed single-machine scheduling with waiting-time-dependent due dates in which due dates are linear functions of the job waiting-times. They construct an optimal sequence and assign the optimal due dates analytically in a single-machine setting when due dates are linear functions of the job waiting-times and their objective is to minimize the maximum job lateness. They also compare their solution with the approach that considers lot sizing and sequencing as independent decisions. They argue that decomposing the problem into sub-problems can result in infeasible production schedules.

Das, et.al [11] developed, Optimization of operation and changeover time for production planning and scheduling in a flexible manufacturing system and deals with the production planning problem of a flexible manufacturing system. They specifically addresses issues of machine loading, tool allocation, and part type grouping with the objective of developing an operation sequencing technique capable of optimizing operation time, non-productive tool change times, and orientation change times when processing a group's design features. They present procedures to partition the overall production planning and scheduling problem into manageable and interlinked sub-problems. An important input in hierarchical modeling philosophy is the number of levels recognized in the product structure.

Chen and Lee [12] developed a model for Logistics scheduling with batching [LSB] and transportation. Their objective is to minimize the sum of weighted job delivery time and total transportation cost. Since their problem involves not only the traditional performance measurement, such as weighted completion time, but also transportation arrangement and cost, key factors in logistics management. At the third level, detailed schedules are prepared for each product family using standard inventory control methods, allocating the product type capacity among the product families and at the fourth level, individual run quantities are calculated for each product in each family, again using standard inventory control methods.

Poulos and Zografos [13] developed a model for solving the multi-criteria time-dependent routing and scheduling problem in a multimodal fixed scheduled network. Their objective is to present the formulation and algorithmic solution for the multi-criteria itinerary planning problem that takes into account the aforementioned features. In addition, they proved that the Basic Unit of Concurrency (BUC) is a set of the executed control flows based on the behavioral properties of the net.

Hamania et.al, [14] developed a model for Reactive mode handling of flexible man ufacturing systems. They deal with a new modeling approach for mode handling of flexible manufacturing systems (FMS). Based on a review of the modeling methods and the specification formalisms in the existing approaches, they show that the mutual benefit of functional modeling and synchronous languages is very convenient for mode handling problem. The three phase models developed by Bowers and Jarvis implements inventory planning, short-term production planning and daily sequencing tasks.

Hsu, et.al. [15] developed a model for cyclic scheduling for F.M.S. Modelling and evolutionary solving approach. They concern the domain of flexible manufacturing systems (FMS) and focuses on the scheduling problems encountered in these systems. They have chosen the cyclic behavior to study this problem with the objective to reduce its complexity. This cyclic scheduling problem, whose complexity is NP-hard in the general case, aims to minimize the work in process (WIP) to satisfy economic constraints. They study the problem of FMS control by a predictive approach to compute a cyclic and deterministic schedule. The two stages are the parts production and assembly operations and the third stage is the distribution system. This work lacks the consistency between aggregation and disaggregation procedures, i.e., the link between the production and a distribution module is relatively weak.

Sadykov [16] developed a branch-and-check algorithm for minimizing the weighted number of late jobs on a single machine with release dates. He consider the scheduling problem of minimizing the weighted number of late jobs on a single machine .He proposed a branch-and-check algorithm , where a relaxed integer programming formulation is solved by branch-and-bound and infeasible solutions are cut off using infeasibility cuts.

Wu and Zhou [17] developed a model for Stochastic scheduling to minimize expected maximum lateness. They concerned with the problems in scheduling a set of jobs associated with random due dates on a single machine so as to minimize the expected maximum lateness in stochastic environment. This is a difficult problem and few efforts have been reported on their solution.

Wang et.al [19] developed FBS-enhanced agent-based dynamic scheduling in FMS. The main objective is to show the feasibility of the approach and to evaluate the approach via computational experiments. They propose a multiagent approach integrated with a filtered-beam-search (FBS)-based heuristic algorithm to study the dynamic scheduling problem in a FMS shop floor consisting of multiple manufacturing cells.

Goncalves, et.al [20] developed a genetic algorithm for the resource constrained multi-project scheduling problem. They presents a genetic algorithm for the resource constrained multi-project scheduling problem. The chromosome representation of the problem is based on random keys. They constructed schedules using a heuristic that builds parameterized active schedules based on priorities, delay times, and release dates defined by the genetic algorithm with the objective to optimize the resource constrained multi-project scheduling problem.
DA Koonce [21] used data mining to find the programming model for problems job shop scheduling. This work aimed at applying the method of data mining to explore the model. Genetic algorithm is used to generate a better solution and Data mining is used to find the relationship between the sequences of the operations and predict the next job in the sequence. The result of data mining can be used to summarize new rule that gives the result as a result of the genetic algorithm. They develop models for planning at product type level, product family level and planning at end product level. However, the disaggregation procedures suggested in this work do not guarantee feasibility. The study of earliness and tardiness penalties in scheduling models is a relatively recent area of research. Most of the existing literature on scheduling focuses on problems that have objective functions such as minimizing makespan (completion time of schedule) and tardiness.

Chandrasekharan [21] introduced three new dispatching rules for dynamic flow shop problem and the Job shop problem. He compared the performance of these rules, to 13 sequencing rules. The problem is modified by random route. Problems are changed Job shop flow programming problem scheduling problem. The study concluded that the performance of dispatching rules is influenced by the flow of work.

Cheng et.al [22] developed a model for Single-machine scheduling of multioperation jobs without missing operations to minimize the total completion time. They consider the problem of scheduling multi-operation jobs on a single machine to minimize the total completion time. Each job consists of several operations that belong to different families. In a schedule each family of job operations may be processed as batches with each batch incurring a set-up time. Their objective is to minimize the total completion time.

Teunter et.al [23] developed a model for Multi-product economic lot scheduling problem with separate production lines for manufacturing and remanufacturing. They study the economic lot scheduling problem with two production sources, manufacturing and remanufacturing, for which operations are performed on separate, dedicated lines. Their objective is to develop an exact algorithm for finding the optimal common- cycle-time policy. Their algorithm combines a search for the optimal cycle time with a mixed integer programming (MIP) formulation of the problem given a fixed cycle time.

Tang and Gong [24] developed a hybrid two-stage transportation and batch scheduling problem They study the coordinated scheduling problem of hybrid batch production on a single batching machine and two-stage transportation connecting the production, where there is a crane available in the first-stage transportation that transports jobs from the warehouse to the machine and there is a vehicle available in the second-stage transportation to deliver jobs from the machine to the customer. Their objective is to minimize the sum of the make span and the total setup cost.

Tseng and Liao [25] developed a discrete particle swarm optimization for lot streaming flow shop scheduling problem. They consider an n-job, m-machine lot streaming problem in a flow shop with equal-size sublots where their objective is to minimize the total weighted earliness and tardiness.

Chang et.al [26] developed a hybrid genetic algorithm with dominance properties for single machine scheduling with dependent penalties. They developed a hybrid genetic algorithm to solve the single machine scheduling problem with the objective to minimize the weighted sum of earliness and tardiness costs.

Cheng and Lin [27] developed Johnson's rule, composite jobs and the relocation problem. They consider two-machine flow shop scheduling with the objective to minimize make span. Johnson's rule for solving this problem has been widely cited in their work. They introduce the concept of composite job, which is an artificially constructed job with processing times such that it will incur the same amount of idle time on the second machine as that incurred by a chain of jobs in a given processing sequence.

Seong-Jong Joo et.al [28] developed a model for Scheduling preventive maintenance for modular designed components: A dynamic approach. Their objective is to develop a dynamic approach for scheduling preventive maintenance at a depot with the limited availability of spare modules and other constraints. They proposed a backward allocation algorithm and applied it to scheduling the preventive maintenance of an engine module installed in T-59 advanced jet trainers in the Republic of Korea Air Force.

He and Hui [29] developed a rule-based genetic algorithm for the scheduling of single-stage multi-product batch plants with parallel units. They present a genetic algorithm-based on heuristic rules for large-size SMSP. In their work, the size of the problems was enlarged, and the problems are first solved by MILP methods and then a random search (RS) based on heuristic rules has been proposed.

Chen and Askin [30] developed a model for Project selection, scheduling and resource allocation with time dependent returns. They formulate and analyze the joint problem of project selection and task scheduling. They study the situation where a manager has many alternative projects to pursue such as developing new product platforms or technologies, incremental product upgrades, or continuing education of human resources. Project return is assumed to be a known function of project completion time. Resources are limited and renewable. Their objective is to maximize present worth of profit.

Janiak et.al [31] developed a scheduling problem with job values given as a power function of their completion times. They deals with a problem of scheduling jobs on identical parallel machines, where job values are given as a power function of the job completion times. Minimization of the total loss of job values is the main objective of their work.

Grzegorz Waligo´ra [32] developed a model named Tabu search for discrete continuous scheduling problems with heuristic continuous resource allocation. His objective is to minimize the make span .He considered problems of scheduling non-preempt able, independent jobs on parallel identical machines under an additional continuous renewable resource.

Valls et.al [33] developed skilled workforce scheduling in Service Centre's. Their main objective with SWPSP is to quickly obtain a feasible plan of action satisfying maximum established dates and timetable worker constraints. Secondary their objectives deal with the urgency levels imposed by the criticality task levels, to obtain well-balanced worker workloads and an efficient assignment of specialists to tasks.

Tiwari et.al [34] developed a model for scheduling projects with heterogeneous resources to meet time and quality objectives. Their approach guides decision-making concerning which workers to cross-train in order to extract the greatest benefits from worker-flexibility. They demonstrates how the output of the model can be used to identify bottlenecks (or critical resource skills), and also demonstrates how cross-training the appropriately skilled groups or individuals can increase throughput.

P.Y. Fung [35] developed a model for Lower bounds on online deadline scheduling with preemption penalties. He generalizes and improve results of online preemptive deadline scheduling with preemption penalties. He consider both the preemption-restart and the preemption resume models, and give new or improved lower bounds on the competitive ratio of deterministic online algorithms. In many cases his proposed bounds are optimal when the job deadlines are tight.

Tang and Zhao [36] developed a model for scheduling a single semi continuous batching machine. They address a new problem, called semi continuous batch scheduling, which arises in the heating-operation of tube billets in the steel industry. Each heating furnace can be regarded as a semi continuous batching machine, which can handle up to C jobs simultaneously.

Jansen [37] scheduling problem solved store work under the assumption that the jobs have a controllable processing time. This means we can reduce the processing time of work by paying a cost. Jansen presented two models and these are the continuous pattern and the reduction model. The test may be clear that the two can solve in polynomial time approximation scheme is fixed when the number of machines and the number of operations. Problem of job-shop scheduling to minimize makespan is considered.

Wu and Zhou [38] developed a model for Stochastic scheduling to minimize expected maximum lateness. They concerned with the problems in scheduling a set of jobs associated with random due dates on a single machine so as to minimize the expected maximum lateness in stochastic environment. This is a difficult problem and few efforts have been reported on their solution.

Yang and Geunes [39] developed a predictive–reactive scheduling model on a single resource with uncertain future jobs. Their objective is to minimize the sum of expected tardiness cost, schedule disruption cost, and wasted idle time cost. They develop lower bound for both the problems. Using lower bound, they propose branch and bound algorithms for the two problems. For larger problems, they propose heuristics for both the problems.

Mosheiov and Sarig [40] developed a model for Due-date assignment on uniform machines. Their objective is to find the job schedule and the due-date that minimize a linear combination of all three (earliness, tardiness and due-date) cost factors.

Ganesen[40] solved a special case of job shop scheduling problem by adding a new constraint, Minimum variance time competition restriction (CTV) to the problem. The lower limit of the CTV is developed for the problem to solve this problem using programming approach backwards. The result obtained from the programming approach backwards is compared with those of obtained from the forward approach.

Chena et.al [42] developed a model for dense open-shop schedules with release times. They study open-shop scheduling problems with job release times. Their objective is to minimize the make span. Dense schedules, easy to construct, are often used as approximate solutions. Performance ratios of the make spans from dense schedules and that of the optimal schedule of the problem are used to evaluate the quality of approximate schedules.

PROBLEM IDENTIFICATION

The problem of flexible Job-shop Scheduling process (FJSP) is a generalization of the traditional JSP, where there are a set of machines available and each operation is allowed to be processed on any one of the available ones. A FJSP is more troublesome than the established JSP, because it adds a level of decision yet beside that sequencing i.e. job routes. Towards job route decides appropriate machine to process a particular operation among the available machines.

Need to assign a job to a machine/resource to process it.
Loading.
Need to decide how many jobs can be assigned to each machine.
Scheduling.
Need to decide on a starting time for each job at each workstation.
Sequencing.
Need to order processing of individual jobs at each workstation.

RESULTS OBTAINED

Conventional methods of solving scheduling problems based on priority rules (FIFO, SPT, EDD) determined the corresponding schedule but usually, still having idle times. To reduce these and improving CIM productivity optimization is necessary. Single factory production in traditional manufacturing has been gradually change by multi-factory production due to the trend of globalization. These factories may be geographically distributed in different locations, which allow them to be closer to their customers, to comply with the local laws, to focus on a few product types, to produce and market their products more effectively, and to be responsive to market changes more quickly. Each factory is usually capable of manufacturing a variety of product types. Some may be unique in a particular factory, while some may not. In addition, they may have different production efficiency and many more constraints depending on the machines, labor skills and education levels, labor cost, government policy, tax, nearby suppliers, transportation facilities, etc. This induces different operating costs, production lead time, customer service levels, etc. in different factories. The objective of this work is to maximize the system efficiency by finding an unique planning for a better collaboration among various processes.

5.2 TWO MACHINES WITH JOBS

For two shop problem taking two machine i;e CNC lathe and CNC milling with eight different jobs and their operation timing in minutes are shown in table 5.1.

Table 5.1 Timing of 2 Machine With 8 Jobs

Jobs	1	2	3	4	5	6	7	8
M-1 Time ti1	20	18	28	14	28	16	28	20
M-2 Time ti2	12	24	18	20	24	28	18	14

Solution of above problem by Johnson's Rule
Step 1; Job Set U = {2, 4, 6} V= {1, 3, 5, 7, 8}
Step 2; Sort Jobs in U increasing order of time.

Job i	=	4	6	2
Time ti1	=	14	16	18

Step 3; Sort Jobs in V decreasing order of time.

Job i	=	5	7	3	8	1
Time ti2	=	24	18	18	14	12

Step 4; An optimum solution is {4, 6, 2, 5, 7, 3, 8, 1}

Table 5.2 Optimum Sequence by Johnson's Rule

Jobs	M-1 Time in min	M-2 Time in min
4	14	20
6	16	28
2	18	24
5	28	24
7	28	18
3	28	18
8	20	14
1	20	12

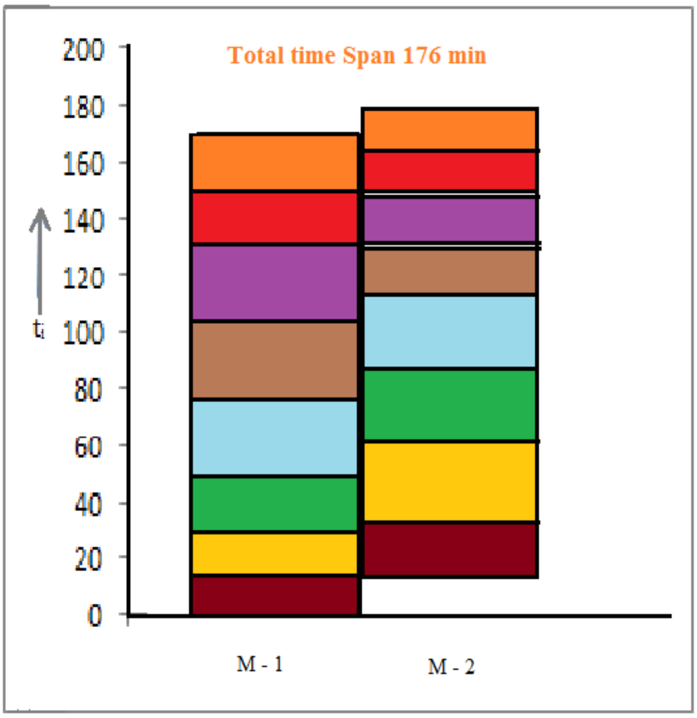

Fig 5.1 Gantt Chart by Johnson's Rule

Solution for same problem by Kusiak's Rule
Step 1; Select minimum timing in both machining
Table 5.3 Performance of Operation

M-1 Time ti1	20	18	28	14	28	16	28	20
M-2 Time ti2	12	24	18	20	24	28	18	14

In this solution first short the timing according to minimize time with each job to their respective machine. After shorting the machine select the sequence to combine of machine 1 and Machine 2, for machine one take sequence from left to right and then for machine two in reverse of machine one as shown in table 5.3.

Table 5.4 Solution by Kusiak's Rule

Job	1	4	8	6	2	3	7	5
Time ti	12	14	14	16	18	18	18	24
Machine	M-2	M-1	M-2	M-1	M-1	M-2	M-2	M-2
Sequence	8	1	7	2	3	6	5	4

Machine 1 →

Machine 2 ←

An optimum sequence is {4, 6, 2, 5, 7, 3, 8, 1}

Table 5.5 Sequence by Kusiak's Rule

S No.	Job	Machine 1	Machine 2
1	4	14	20
2	6	16	28
3	2	18	24
4	5	28	24
5	7	28	18
6	3	28	18
7	8	20	14
8	1	20	12

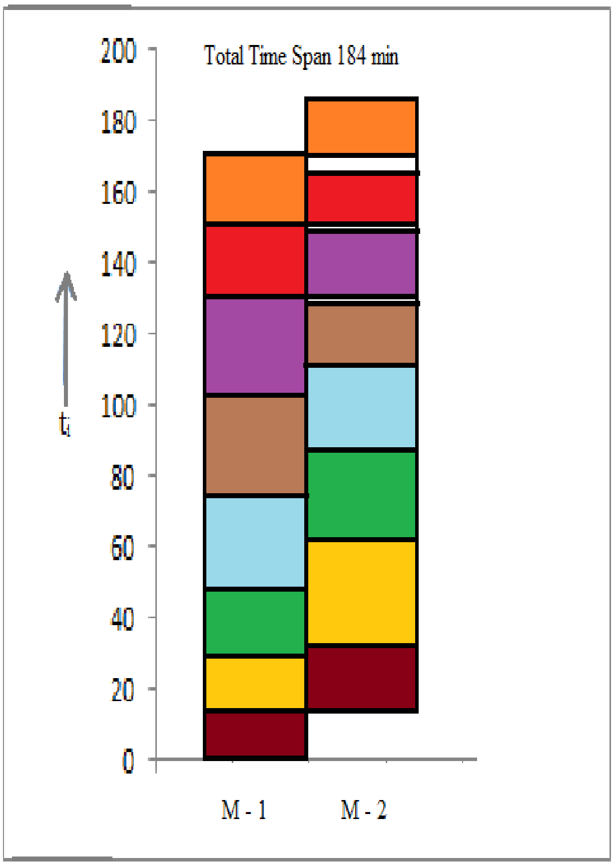

Fig 5.2 Gantt Chart by Kusiak's Rule

3. CONCLUSIONS

By Scheduling, we assign a particular time for completing a particular job. The main objective of scheduling is to arrive at a position where we will get minimum processing time. The problem examined here is the n-job, m-machine problem in a flow shop. These works arrange the jobs in a particular order and get many combinations and choose that combination where we get the minimum make span. This study try to solve the problem of a flow shop scheduling with the objective of minimizing the makes pan. Here the objective is to minimize the make span of batch-processing machines in a flow shop. Comparison based on Gupta's heuristics and CDS heuristics are proposed here and for two machine jobs Jonson's and Kausik's rule have been Compared. Analytic solutions in all the heuristics are investigated. Gantt chart was generated to verify the effectiveness of the proposed approaches. The algorithm is written in a very few lines of code, and requires only specification of the problem and a few parameters in order to solve it. To all over these methods are very close to each other but the optimum method has been selected for this situation is Jonson's for two machine and Gupta's for three machine shop flow.

FUTURE WORK

Further research may be conducted to investigate the applications of other metaheuristics to the lot-streaming flow shop problem. It is also worthwhile to design other versions of RA heuristics to continue pursuing the best performance of RA heuristics. Future research should address problems with different shop environments, including parallel machines flow shop, job shop, and open shop. Problems with other performance measures, such as minimum due dates, maximum lateness, and multi-criteria measures should also be studied. Future research should be directed to generalize the method to multipart, multi machine group cases. As a result of the work proposed here the researcher found that out of the four proposed algorithm RA heuristics yields efficient result because here the processing times are determined from a weighting. Here in this work RA heuristics yields efficient result, this was explained with the help of numerical examples and their performances are examined with the help of Gantt charts.

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