

# Optimization of Flow Shop Scheduling by MATLAB

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**Abstract:** In a manufacturing industries , scheduling process in production plays a vital role in different aspects like in reducing the cost of product, productivity to be increased, satisfaction of customer and competition in the market. Proper scheduling provides and leads to proper utilization of parameters like available goods, manpower, machinery and sufficiently reaches the satisfaction of customer and also demand of product. There are different systems of production scheduling process includes flow shop where the jobs are processed through series of machines to reach the final product. To deliver the product in time Multi objective scheduling system is necessary to introduced to process where all machines work and all jobs work in a parallel manner. The SDST (sequence dependent setup time) is critical schedule task used to improve the scheduling process in the flow shop. Here, in this paper an attempt is made to analyse the task of using multi objective minimizing of weighted sum of total weighted squared tardiness, makespan, total weighted squared earliness and number of tardy jobs.

**Keywords:** Scheduling, Flow Shop, Manufacturing System, Genetic Algorithm, Matlab

## I. INTRODUCTION

In a country's development, industries play a key role where the products are manufactured and marketed. The scheduling process is one which effects the product cost, and productivity of the industries. Scheduling is broadly defined as the process of assigning a set of tasks to resources over a period of time or it may be defined as ,the allocation of resources over time to perform a collection of tasks. Production scheduling is generally considered to be the one of the most significant issue in the planning and operation of manufacturing system. Scheduling is a decision making practice that is used on a regular basis in

many manufacturing and services industries. Scheduling in an flexible manufacturing environment which is more complex and difficult than in a conventional manufacturing environment. To achieve high performance in an FMS, a good scheduling system should make a right decision at a right time according to system conditions. The n-job machine problem is known to be NP hard problem, several meta heuristics have been applied.

Performance criteria such as machine utilization, manufacturing lead times, inventory costs, meeting due dates, customer satisfaction, and quality of products are all dependent on how efficiently the jobs are scheduled in the system. Hence, it becomes increasingly important to develop effective scheduling approaches that help in achieving the desired objectives.

## II. LITERATURE SURVEY

**Pugazhenth R. et al., [1]** analysed the flow shop scheduling situation in modern manufacturing. In a permutation flow shop design the machines arranged in series were the jobs are processed in a same order without eliminating any machine. A new heuristic (BAT heuristic) was proposed for the flow shop problems to achieve the minimal makespan by reaching the Lower Bound (LB) through a reverse engineering method. This heuristic has been applied with Genetic Algorithm (GA) for further minimization of makespan. The GA applied BAT heuristic was evaluated by solving Taillard benchmark problem in MATLAB environment. The results were compared with traditional heuristics like CDS and NEH heuristics and found that the GA applied BAT heuristic yielded results better with 11% & 3% more compared to CDS and NEH heuristics.

**Ghorbanali Mohammadi et al .,[2]** discussed the application of Robust Genetic Algorithm to solve a flow-shop scheduling problem. Multi-objective flow shop scheduling with sequence dependent set up time also becomes NP hard with greater complexity toward optimality in a reasonable time. To tackle the complexity of the problem at hand, an approach base on genetic algorithm (GA)has been proposed. However, the performance of most evolutionary algorithms is significantly impressed by the values determined for the miscellaneous parameters which these algorithms possess. Hence, response surface methodology is applied to set the parameters of GA and to estimate the proper values of GA parameters in continually intervals.

**Sultana Parveen et al ., [3]** The contribution of the study conducted a comprehensive survey of the multi-objective literature for both the flow-shop and the job-shop problem.The papers surveyed include exact as well as heuristic techniques for many different multi objective approaches. To comparative evaluation not only includes scheduling specific algorithms but also adaptations of other general methods proposed in then multi-objective optimization literature. finally multi objective studies for more complex scheduling problems with additional characteristics like setup time and parallel machine are scarce and new algorithms for such problems are desirable in practice.

**A.V.S. Sreedhar Kumar et al ., [4]** Optimization procedures have been developed based on the three non-traditional approaches, i.e., GA, D.E. and BFOA algorithms .These are implemented successfully for solving the optimization problems of FMS scheduling. A MATLAB based GUI has also been designed to automate the optimization process by providing the user ease of interface. Results are obtained for 43 jobs- 16 machines. Results obtained by the different approaches are compared and the performances are analyzed for the combined objective function of minimizing total penalty cost and minimizing total machine idleness. BFOA algorithm is found to be superior and gives the minimum combined objective function.

**J. Garen [5]** has presented a multi-objective GA for job-shop scheduling with a new kind of representation that allows the use of simple recombination operators. The new representation has initially been tested in a single-objective on text to evaluate its effectiveness with quite promising results. The algorithm has been applied to two JSP presented by Bagchi . The simulation results clearly show that the proposed approach is able to and a set of solutions close to the Pareto-optimal front and also to a set of diverse solutions.

**Shahram Saeidi et al ., [6]** new mathematical linear programming model for scheduling the jobs in a parallel environment to minimize the total machine cost and the completion time is proposed . NP-Hard nature of the problem and the complexity of the proposed algorithm, a multi-objective meta-heuristics based on NSGA-II and

MOPSO are developed for solving the model. The obtained results show the efficiency of the proposed mathematical model and the developed GA algorithm. Besides, the better performance of NSGA-II in comparison with MOPSO approach for solving the proposed model is identified.

**Thomas Hanne et al .,[7]** originally developed as an discrete-event simulation model, there are various variables to be fixed corresponding to process parameters, task assignment, and scheduling. With respect to the usually important aspects quality, costs, and projects duration, a multi objective optimization model problem was formulated. For solving it, an evolutionary algorithm has been designed.

**Sanjoy K Paul et al ., [8]** flow shop problem concerns the sequencing of a given number of jobs through a series of machines in the exact same order on all machines with the aim to satisfy a set of constraint as much as possible and optimize a set of objectives. Fuzzy sets and logic can be used to tackle uncertainties inherent in actual flow shop scheduling problems. Fuzzy due dates, cost over time and profit rate results the job priority and to determine the machine priority processing time of each machine is considered. MATLAB fuzzy tool box is used to calculate the priorities of jobs and machines at different stages..

**Hymavathi Madivada et al.,[9]** a new meta-heuristic solution approach for Multi-objective Job Shop Scheduling Problems (JSSP) is presented. The proposed algorithm makes use of Mehrabian & Lucas's heuristic 'Invasive Weed Optimization' (IWO) in generating optimal schedules. For performance evaluation of solutions in a Multi-objective scenario, a concept called 'Fuzzy dominance' has been employed. The results obtained from the study shown that the proposed algorithm can be used as a new alternative solution technique for finding good solutions to the complex Multi-objective Job Shop Scheduling problems.

**M.Vairamuthu et al., [10]** Artificial Immune Systems (AIS) are new intelligent problem solving techniques that are being used in scheduling problems. It is defined as computational systems inspired by theoretical immunology, observed immune functions, principles and mechanisms in order to solve problems. In research, a computational method based on clonal selection principle and affinity maturation mechanisms of the immune response is used. Matlab code was generated to use the algorithm for finding the optimal solution.

**Dr. Akeela M. Al-Atroshi et al., [11]** includes the modeling of the objective function and adopting a fuzzy logic to solve the issue of scheduling production orders. The matlab is used for Programmable fuzzy Logic, whereas the C++ is used for programming the genetic algorithm with mechanism for linking C++ and matlab. Finally, the algorithm is tested on instances of 10 working procedures (jobs) and 3 machines. The result

shows that the hybrid fuzzy-genetic algorithm has been successfully applied.

**Martin Ždánký et al.,[12]** tested the possibilities of Matlab in Genetic Algorithm application for sequencing of production in chemical batch plants, specifically in the case of the flow shop topology and found that Matlab realization of GAs allows us to obtain optimum or good sub-optimum solutions in acceptable computation times.

**R. Ramezani et al.,[13]** considered a flow shop scheduling problem with bypass consideration for minimizing the sum of earliness and tardiness costs. There are several constraints which are involved in modelling such as the due date of jobs, the job ready times, the earliness and the tardiness cost of jobs, and adapted genetic algorithm based on bypass consideration to solve the problem. The basic parameters of this meta-heuristic are briefly discussed in paper. Also a computational experiment is conducted to evaluate the performance of the implemented methods. The implemented algorithm can be used to solve large scale flow shop scheduling problem with bypass effectively.

**Michal Kutil et al.,[14]** presents the TORSCHÉ Scheduling Toolbox for Matlab which covers scheduling on mono processor, dedicated processors, parallel processors, open shop, flow shop, job shop scheduling, cyclic scheduling and real-time scheduling. The toolbox includes scheduling algorithms that have been used for various applications as scheduling of Digital Signal Processing algorithms on a hardware architecture with pipelined arithmetic units, scheduling the movements of hoists in a manufacturing environment and scheduling of light controlled intersections in urban traffic. The toolbox already has several real applications. It has been used for the development of a new method for re-configuration of the tasks or a process in an embedded avionics application.

**Hassan Gholizadeh et al., [15]** had made an attempt on the flow shop scheduling problem with sequence-dependent setup times and periodic maintenance activity. consider the sequence-dependent setup times and the study has presented a new mathematical model for a flow shop with both sequence-dependent setup times and machine unavailability, a hybrid GA/SA algorithm has been used to solve the given problem. The computational results have shown that the GA/SA algorithm has had a better output and also the deviation of its objective value from mean has been lower than the traditional GA. In the proposed GA/SA algorithm, the model has accepted a higher answer by a random probability and it makes possible to search the other areas in feasible space. SA has been used here to develop the divergence of the traditional GA algorithm.

### III. METHODOLOGY

The initial population for the genetic algorithm used in this work is generated by different methods such as NEH heuristic, earliest due date algorithm(edd), shortest processing time algorithm (spt),weighted earliest due date algorithm (wedd),NEH combined with edd.

#### A. Genetic Algorithm:

Genetic algorithm (GA) for flow shop scheduling is an optimization method of searching based on evolutionary process which works with a population of solutions. In the proposed GA, a population of solutions was considered and the fitness of each solution was evaluated by using a problem specific objective function after crossover as well as mutation operations. Then the best solution among all solutions was selected and this ensures that a better solution.

The various stages of GA are described here under,

- **Chromosome representation-** A chromosome consists of 'M' parts; each part corresponding to each machine and consisting of 'N' bits that represent the order of jobs on that machine.
- **Fitness function-** A fitness value was found for each chromosome or schedule which was the weighted sum of makespan, and it evaluates the performance measures to be optimized.
- **Initial population-** The sequence from the heuristic is taken as initial solution.
- **Selection-** The better chromosome is selected by comparing the parent and daughter chromosomes under each stage.
- **Crossover-** The crossover operator randomly chooses a locus and exchanged the sub-sequences before and after that locus between two chromosomes.
- Thus two new children chromosomes were developed from two parent chromosomes by crossover.
- **Mutation-** If a random number generated was less than the mutation probability then mutation would be carried out.

### IV. OBJECTIVE OF PRESENT WORK

In this paper an attempt is made to optimize the makespan of a number of jobs in a flowshop scheduling environment with multiple objectives.

The least average value or optimised value is found by using MatLab software.

**A. Main objectives:** The main objectives considered in this work are as follows,

- minimizing of weighted sum of total weighted squared tardiness, makespan, total weighted squared earliness and number of tardy jobs.

Total weighted squared tardiness is given as:

$$\sum_{j=1}^n (W_j) T_j^2$$

$$\text{Where } T_j = (C_j - d_j) \quad \text{if } C_j - d_j \geq 0 \\ = 0 \quad \text{other wise}$$

Second performance measures for scheduling is makespan ( $C_{max}$ ) which has been used for maximum utilization of resource to increase productivity and stated as maximum completion time of last job to exit from the system.

$$(C_{max}) = \text{Max } (C_1, \dots, C_n)$$

The third criterion is total weighed squared earliness which has been given as :

$$\sum_{j=1}^n (W_j) E_j^2$$

$$\text{Where } T_j = (d_j - C_j) \quad \text{if } d_j - C_j \geq 0$$

$$= 0 \quad \text{other wise}$$

The fourth criterion for scheduling is to minimization of number of tardy jobs. Associated with each job  $j$  is a due date  $d_j > 0$ . The total number of tardy jobs ( $N_t$ ) is defined as

$$N_t = \sum_{j=1}^n U_j$$

Then the multi objective function is given by adding the total all criterions and it is given by

$$\text{Min } [\alpha \sum_{j=1}^n W_j T_j^2 + \beta C_{max} + \gamma \sum_{j=1}^n W_j E_j^2 + \delta (N_t)]$$

Where  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$  are the weight values for the considered objective functions having constraints

$$\alpha \geq 0, \beta \geq 0, \gamma \geq 0, \delta \geq 0$$

and

$$\alpha + \beta + \gamma + \delta = 1$$

**B. Assumptions:** The general and some important assumptions considered to solve the problem are as follows,

- Machines never breakdown unless the scheduled job is completed on it.

- The processing time is considered on the machine is known, finite and deterministic.
- Each and every machine is continuously available throughout the completion of task.
- Each job is processed through each machine only once in the total process.

## 5. DATA USED IN THIS WORK

- **Processing Times** for 20 jobs on 10 machines were generated randomly in the uniform distribution between 300 to 10000.
- **setup time:** the setup times on 10 machines are generated randomly in the uniform distribution between the values of 20 to 120.
- **Due dates** are generated randomly in the uniform distribution between 4500 to 45000.
- weightages of objectives are as follows,

$$\text{first objective} \quad a_1 = 0.1000$$

$$\text{second objective} \quad a_2 = 0.4000$$

$$\text{third objective} \quad a_3 = 0.3000$$

$$\text{fourth objective} \quad a_4 = 0.2000$$

## 6. RESULTS AND CONCLUSIONS

**6.1 Results:** The work was coded in MATLAB (R2013a) and each algorithm was run for 5 times and the average values are considered. The obtained result are as mentioned in Table-I. The values of Process times, setup times and Due dates are considered randomly for analysing the concept.

### 6.2 Conclusions:

- A multi objective flow shop scheduling was proposed in this work.
- The objectives considered are minimization of weighted sum of Tardiness, Earliness, makespan, number of tardy jobs.
- The initial problem population was generated by five different heuristics such as NEH, EDD, NEHEDD, SPT & WEDD algorithms.
- The work was coded in MATLAB and the result shows from Table 6.1 as NEHEDD shows the lowest time.
- The NEHEDD Algorithm shows the least value of 1.76E+10 than the other Algorithms. The WEDD Algorithm shows the highest value of 2.05E+10 than the other Algorithms.

TABLE- I AVERAGE VALUES OF MATLAB ALGORITHM

RUN NUMBER	ALGORITHM FOR INITIAL POPULATION				
	NEH	EDD	NEHEDD	SPT	WEDD
1	1.86E+10	1.93E+10	1.76E+10	1.93E+10	2.02E+10
2	1.89E+10	1.94E+10	1.76E+10	2.08E+10	2.17E+10
3	1.92E+10	2.16E+10	1.76E+10	1.95E+10	2.03E+10
4	1.92E+10	2.06E+10	1.76E+10	2.11E+10	2.00E+10
5	1.90E+10	2.07E+10	1.76E+10	2.12E+10	2.04E+10
<b>average</b>	<b>1.90E+10</b>	<b>2.03E+10</b>	<b>1.76E+10</b>	<b>2.04E+10</b>	<b>2.05E+10</b>

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