Solving Flow Shop Scheduling Problem Using Genetic Algorithm And Simulated Annealing

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Abstract-*Flow shop scheduling is one of the most interesting NP-hard problems. As the flow shop scheduling is an optimization problem, in this work, Genetic Algorithm (GA) was selected to solve for the benchmark problem to minimize the Makespan. Selection Scheme is one of the important operators of Genetic algorithm. The speed of convergence towards the optimum solution for the chosen problem is largely determined by the selection mechanism used in the Genetic algorithm. Depending upon the selection scheme applied, the population fitness over the successive generations could be improved. The choice of selection schemes are available. In this work, selection schemes namely Stochastic Universal Sampling (SUS), Roulette Wheel Selection (RWS) were chosen for implementation. The characteristic of selection mechanisms of Genetic Algorithm for solving the flow shop scheduling problem were analyzed. The Genetic algorithm with two different selection schemes is tested on instances of benchmark problems of different size. The result shows that the each of the two selection schemes of Genetic algorithm have been successfully applied to the flow shop scheduling problem efficiently and the performance of stochastic universal sampling selection method is better than Roulette wheel selection method.*

Further in the work, Simulated Annealing (SA) was selected to solve benchmark Flow Shop Scheduling problem to compare with Genetic Algorithm. Genetic algorithm to reduce the better makespan and fitness value.

Keywords-Genetic Algorithm, Makespan, Selection Schemes, Simulated Annealing.

I. INTRODUCTION

Booking is the allotment of assets after some time to play out a gathering of assignments. This definition passes on two implications. To begin with, Scheduling is a basic leadership work i.e., procedure of deciding a calendar. Second, booking is an assemblage of hypothesis i.e., it is an accumulation of standards, models, strategies and intelligent conclusions that give knowledge into the planning capacity. Sequencing is the request of preparing an arrangement of assignments (or occupations) over assets (or machines). Planning includes sequencing and in addition the deciding of time of process beginning and finishing, i.e., time tabling. Among the normal objectives of planning issues, amplifying machine usage is a measure of scholastic enthusiasm, as well as helpful and critical by and by. As a basic leadership work, it tries to achieve a nearby or worldwide enhancement of at least one targets. The assets depicted might be men, machines, runways at air terminal and so on and assignment might be operation in a creation procedure, and take-off or arriving in an air terminal and so on. Each assignment may have an alternate need level, soonest conceivable beginning time or date and a due date. The targets might be one or numerous, for example, limiting the culmination times of the individual assignments, or limiting the finishing time of the last errand or notwithstanding limiting the quantity of undertakings for which the fulfillment time surpasses the pre characterized due date. In its general shape, issue of booking exists in most assembling and creation frameworks, data preparing conditions, transportation circulation frameworks and in many administration circumstances. Generation booking is a capacity to decide a genuine (ideal or plausible) usage design as for the time plan for every one of the occupations to be executed.

This is done after item things and generation amounts have been chosen by creation arranging and generation forms have been chosen by process arranging. In any association or framework, the planning capacity interfaces with numerous different capacities. In an assembling framework, orders are discharged and are to be meant employments with related due dates. The employments are to be handled by machines in a work focus in a particular request or grouping. Occupations may must be sitting tight to process on machines that are occupied, and in genuine practice pre-emption may happen when higher need employments land at the inside. In every one of these cases, booking of errands successfully helps in keeping up a productive and viable control of operations on the shop floor. The starting point of the wording of booking is from the assembling frameworks. Assembling frameworks can be grouped into jobshops, flowshops, programmed exchange lines, adaptable exchange lines, cell producing frameworks, adaptable assembling frameworks, gathering shops, adaptable get together frameworks, different cell frameworks, without a moment to spare assembling frameworks and so forth.

The use of regular improvement procedures has numerous intrinsic restrictions. They incorporate complex scientific calculations, advancement of summed up programming arrangements, acquisition and utilization of issue particular data and computational unpredictability. The examination plans to investigate the situation with an endeavor to advance distinctive execution parameters for stream shop planning. The utilization of Simulated Annealing diminishes the computational multifaceted nature. This additionally analyzes the effectiveness of streamlining devices in taking care of planning issues.

II. PROBLEM DEFINTION

The Flow Shop Scheduling (FSS) issue comprises of "n" occupations and "m" operations on each of the employments and it is hardest combinatorial enhancement issues for which it is extremely intricate to discover ideal arrangements. In late year, much consideration has been given to general heuristics procedure, for example, Genetic calculation, Ant Colony Optimization, Tabu Search and Simulated Annealing for explaining through streamlining of this sort of combinatorial enhancement issues. In this paper we exhibit how the versatile hunt calculations to be specific Simulated Annealing Search strategy is connected to illuminate Job shop planning (JSS) issue. The technique utilizes dispatching standards to get an underlying arrangement and looks for new arrangements in an area in view of the basic ways of the occupations. A few benchmark issues are tried utilizing this calculation for the best make traverse and the got comes about are giving empowering comes about which contrasted and benchmark esteems.

The Salient Features of flow Shop Scheduling Problem Scheduling is an essential stage in Production Planning. It concern the distribution of restricted assets to errands after some time and concentrates on how best to utilize the current parts, considers specialized generation limitations. The goal of this issue is to discover ideal calendar by limiting the makespan. In late years, numerous heuristic strategies were made, for example, Genetic calculation, and Simulated Annealing and so forth., to comprehend this kind of combinatorial improvement issues

III. PROPOSED WORK

An improved genetic-simulated annealing algorithm is proposed for solving energy-aware scheduling in a flexible flow shop. There are many meta-heuristic algorithms that have been implemented in an FS, such as the genetic algorithm (GA), the simulated-annealing algorithm (SA), the particle swam optimization, the ant colony optimization, etc. GA can reach the optimization solution quickly, but it has a fatal shortcoming—it is liable to be trapped in a local optima (i.e., premature convergence). Fortunately, SA has the ability to jump out of the local optimization and search for the best solution. Therefore, this paper proposes to incorporate the strengths of a genetic algorithm into a simulated annealing algorithm. GA is developed to rapidly search for an optimal or near-optimal solution among the solution space, and then SA is utilized to seek a better one on the basis of that solution. In addition, a novel annealing rate function, which is inspired from a hormone modulation mechanism, is adopted to further improve the efficiency of the exploration.

The encoding representation

Based on the elements and their corresponding positions in a matrix that describes the constraints between jobs, an encoding approach for the energy-aware FS is presented. In this representation, each chromosome represents a feasible schedule. Suppose that N jobs are to be processed on a set of machine tools, and each job is required to pass S stages. There are Ms (s=1; 2; …;) unrelated parallel machine tools at each production stage.

The fitness function

The genetic-simulated annealing algorithm assesses the solutions based on the fitness function. The greater fitness an individual has, the higher the chance it has to be chosen in the next generation. In general, the fitness is relative to the objective function. In this paper, the above-mentioned objective function (i.e., Eq. (21)) can be transformed into the fitness function for solution k as follows: $F(k)=1/U(k)$.

The GA operation phase of the FS

In the GA operation phase, an initial population is yielded randomly. Using basic genetic operations (i.e., selection, crossover and mutation), the GA operates to produce a new population. These three operations are described in detail as follows: The Selection operation: On the basis of the fitness of the individual, the selection operator chooses individuals that are used for crossover and mutation. Often the fitness value is not the best one. Several selection schemes have been developed to determine a good solution space. A '2/4 selection' is adopted to preserve the fittest individuals at each generation and to also maintain the diversity of the population. The crossover operation: According to the encoding rule, combining genes of selected solution to generate a new solution is legal, only if the condition a(i; j)∈(1; Ms + 1) is satisfied. Therefore, it is necessary to implement two-point crossover at each segment of a chromosome with a crossover probability and pick intersections randomly. The mutation operation: As the crossover operation cannot yield solutions with new information, a mutation operation with a specified probability (Pm) for every segment is necessary in order to be able to obtain the solutions with the greatest fitness. If the specified probability (Pm) is greater than a random number generated on the interval 0 to 1 by using a uniformly distributed rule, the mutation operation is executed.

SA operation phase of the FS

In the process of the genetic-simulated annealing algorithm, the good individuals generated by the GA are sent to the SA for improvement. The SA can avoid falling into a local optimum by accepting some probability. However, the search efficiency of the SA is not high. Therefore, some parameters related to the SA should be studied, including the neighbourhood structure, the initial temperature, the annealing rate, and the termination condition.

IV. RESULT AND ANALYSIS

The implementation work is carried out using Matlab software. In order to analyze the result of Genetic algorithm and Simulated annealing algorithm. The benchmark problems namely Tailord,s EJOR A1, EJOR A2, EJOR C1, EJORB1 are tested to measure these factor. In this paper, the following factors are taken to be measure for

- ✓ Average fitness value
- ✓ Average makespan value

Stochastic Universal Sampling Result:

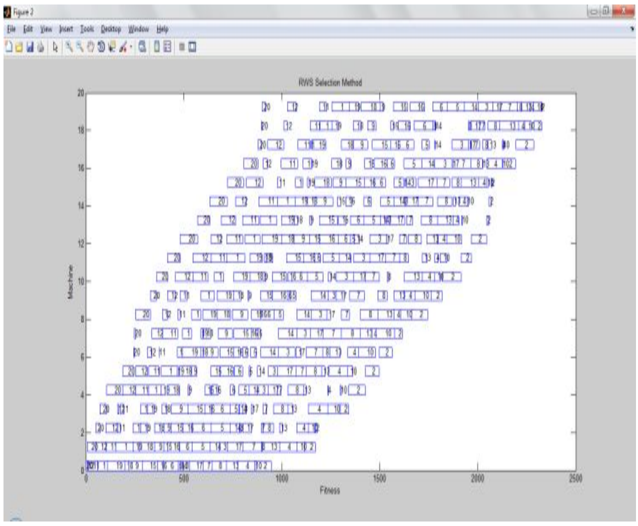


Fig -1.SUS result

Roulette Wheel selection result:

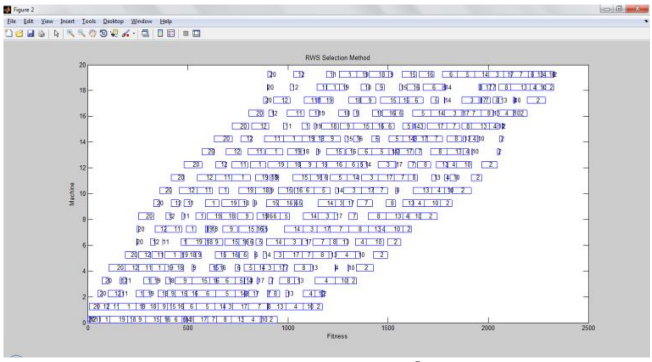


Fig-2. RWS Result

Comparison of SUS and RWS mean fitness:

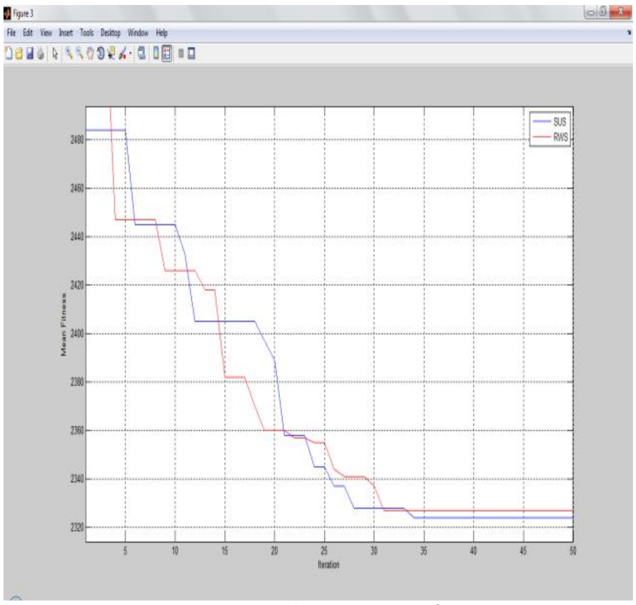


Fig-3. SUS and RWS mean fitness

Time comparison chart SUS and RWS:

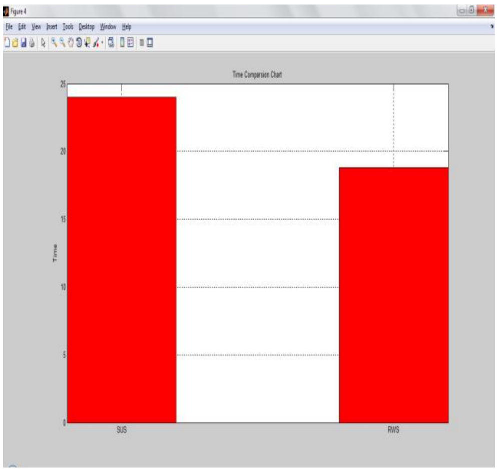
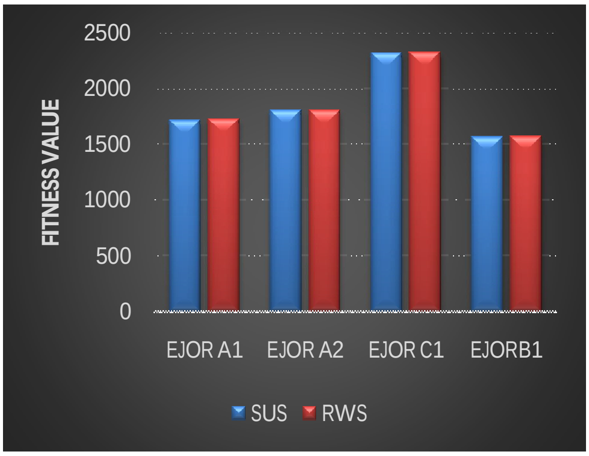


Fig-4. SUS and RWS time comparison

Optimum fitness for GA:



BENCHMARK PROBLEM

Fig-5. Average fitness value

Quality solution of GA

The quality of solution is used to measure the deviation of obtained solution from the average fitness value. The result obtained for this factor is given in Table 1. The figure is drawn using the data given in the Table 1.

S.No	Problem Name	No of jobs	No of machine	SUS Fitness value	RWS Fitness value	Average fitness value
1	Tailord's EJOR A1	20	10	1716	1730	1716
2	Tailord's EJOR A2	20	10	1805	1805	1805
3	Tailord's EJOR C1	20	20	2324	2327	2324
4	Tailord's EJOR B1	20	5	1568	1571	1568

Table-1. Average Fitness value

Simulated annealing result:

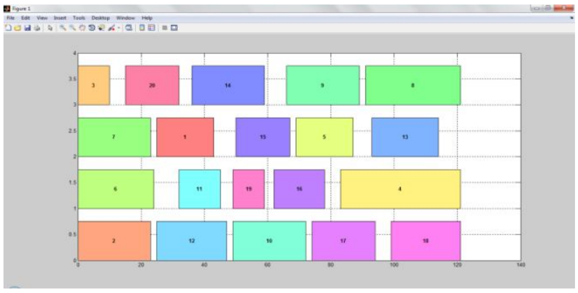


Fig-6. SA result

Average fitness value:

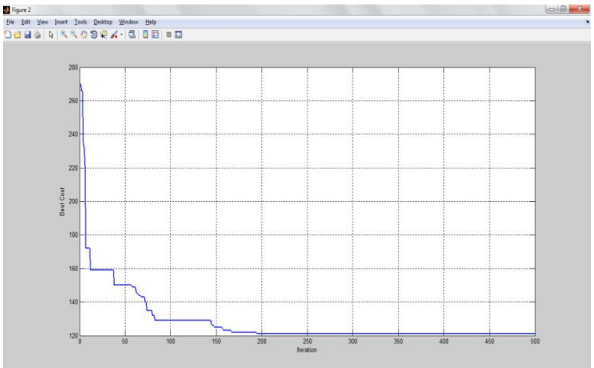


Fig-7. SA Average Fitness value

Comparison of GA and SA Result:

The above figure denotes the comparison of benchmarks for basic flow shop sequencing 10 jobs and 10 machines scheduling problem with result for genetic algorithm and simulated annealing

S.No	**GA fitness value**	**SA fitness value**
1	**833**	**1160**

Table-2. Fitness value

S.No	**GA Makespan(seconds)**	**SA Makespan**
1	**2.35 s**	**81.65 s**

Table-3. Makespan value

Average fitness value GA and SA**:**

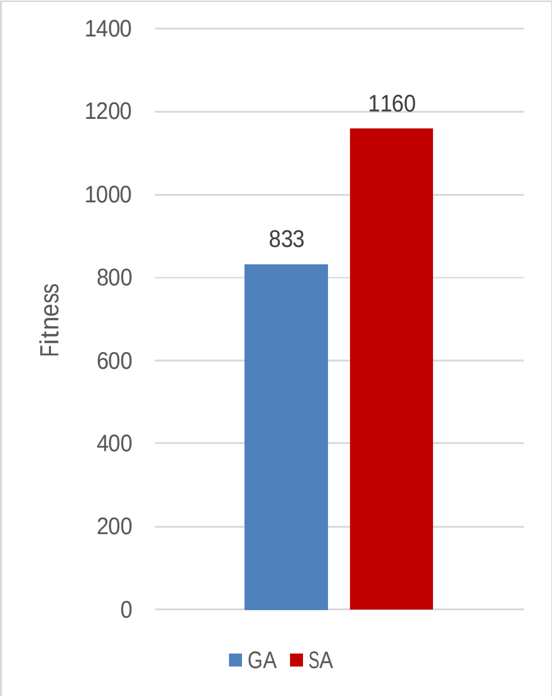


Fig-7. Average fitness value GA and SA

Average makespan chart GA and SA:

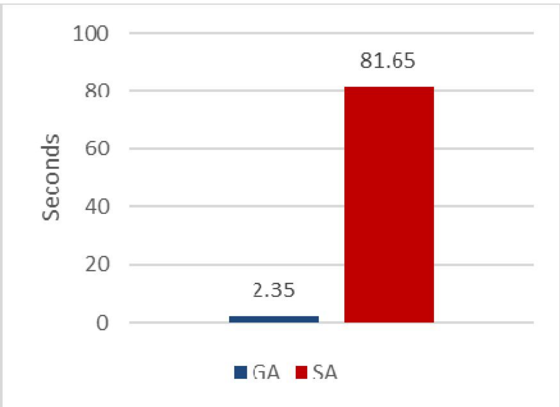


Fig-8. Average makespan GA and SA

V. CONCLUSION

From the experimental work, it is concluded that out of the two selection schemes for the tested benchmark problem using Genetic Algorithm. The Stochastic Universal Sampling selection scheme give the minimum fitness and minimum makespan. The performance of stochastic universal sampling method is better than Roulette wheel selection.

Also same problem is compared with Simulated Annealing algorithm. Further in this work, it is concluded that Genetic Algorithm gives the minimum Fitness and minimum Makespan.

FUTURE WORK

As a future work, different selection method and technique can be used to solve Flow shop scheduling problems.

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