International Journal of Engineering Technology and Scientific Innovation

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

OPTIMIZING MAKE-SPAN OF JOB SHOP SCHEDULING PROBLEMS THROUGH DISPATCHING RULES AND HEURISTIC ALGORITHMS

(Case study: SHINTS ETP Garment Plc.)

Negash Lemma

MSc in Industrial Engineering, Post Graduate Program in Mechanical Engineering, School of Mechanical and Industrial Engineering, Addis Ababa Institute of Technology, Addis Ababa University

ABSTRACT

Job shop scheduling is an Np-Hard combinatory in the field of scheduling problem. Due to this reason, SHINTS ETP Garment Company has faced a problem to determine the optimum sequences of jobs on machines that can optimize the make-span. The main purpose of this study is to minimize the make-span of the job shop production system of SHINTS ETP Garment Company production system by using dispatching rule and heuristics algorithm (shifting bottleneck algorithms).

Secondary data was collected from the production log book of six work center (station) were considered during the production of six jobs. The findings of the shifting bottleneck algorithms showed that a 5% reduction for each machines (work center/station) in the total make-span of the company job shop production system. Moreover; the percentage utilization of work-station one, four and six are 55%, work-station two and three 49%, and that of work-station five 51% of their available time.

Keywords: Job shop scheduling problem, dispatching rules, shifting bottleneck algorithms, make span, Lekin software

INTRODUCTION

The job shop-scheduling problem (JSSP) is a practical problem and has many applications in manufacturing and supply chain scheduling problems. JSSP has numerous applications in manufacturing and service sectors. In manufacturing, JSSP is the process that assigns jobs to machines satisfying the precedence and resource constraints over time such that certain objective(s) is optimized. The JSSP is one of the strongest NP-hard problems [1]. In the current markets, manufacturers have to respond orders fast and attain shipping dates promised to the end

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

users, as failure to do so, at least, may result in a significant loss of good will of the manufacturer [2]. Scheduling is assigning of shared (common) resources over time to competing activities to satisfy end users' requirements. It has been the subject of an essential amount of literature in the field of operations research (OR). Emphasis has also been given on examining machine-scheduling challenges where jobs represent activities and machines represent resources so that each machine will process at most one job at a time.

Many production control tools and techniques can be employed to increase the total production out rate, minimize the total time of completion and deliver the product on the promised date. Among the methods to raise production rate of an industry, one is to create proper scheduling for the parts on the available machineries so that the order will finish on time, maximizing the use of the resources and reducing the average waiting time. There is scheduling in most of manufacturing and production facilities. To explore potential capacities of production systems and run production systems orderly, scheduling is necessary in a given firm [3].

Job shop scheduling problem is extremely challenging both in theory and in practice. It is because so many parameters need to be considered when scheduling production. Among the approaches to scheduling problems are; analytical techniques, Meta heuristic algorithms, rule based approaches and simulation approaches. Currently, the conventional analytical models and simple mathematical models are incapable to analyze the complex manufacturing systems. In addition, analytical models often apply mathematical programming techniques and it is not practical for solving a complex scheduling problem. Scheduling gives a basis for assigning jobs to work center. Sequencing (also known as dispatching) clearly specifies the order in which jobs should complete at each center. The case company is a job shop type of manufacturing and is continuously challenged by scheduling problems. The study aims to find an optimum job schedule that will minimize the make span with optimum utilization of limited resources. The study attempts to reduce the total production time of specific jobs by comparing the different dispatching rules. In the case company, six jobs arriving at specific time requiring five machines with specific processing sequences are considered.

LITERATURE REVIEW

In the field of scheduling problem, job shop scheduling is an Np-Hard combinatory [4]. It is probably one of the most computationally combinatorial problems considered intractable so far. The job shop is defined as a group of manufacturing operations where the productive resources are organized according to function and the work passes through in varying lots and routings. Job Shop production is characterized by the manufacture of one or few numbers of a single product designed and manufactured strictly according to customer's specifications, within, the given period [5]. A basis for assigning jobs to a work center with a time table is provided by

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

scheduling technique. Sequencing specifies the order in which jobs should be processed at each work center. The sequencing methods are referred to as priority rules for sequencing jobs to a work center. In the manufacturing world, scheduling problems are extensively implementing the dispatching rules with procedures designed to provide good solutions to complex problems in a real-time production environment [6]. Generally, JSP uses various representations in its model. In a manufacturing facility, let a job shop consists of a set of M_i machines where i=1, 2... m, n jobs, and a predefined plan which states the assigning of these jobs in different machines in some desired sequences (constraints). Each job has a specified number of operations to be performed in different machines, with individual setup times, processing times, a due date, etc. The job shop-sequencing problem deals with the search of an optimal sequencing of the operations in different machines within the specified sequences [4]. A job shop differs from a flow - shop in which jobs are processed in same order. In a job-shop, jobs can be processed on machines in any order. From research stand point, the common job shop is one in which there are "m" machines and "n" jobs to be performed on the machines. Each job requires m operations, one on each machine, in a specific order, but the order can be different for each job [4].In the past different methods were applied to JSSP and different job shop type manufacturers use the different method. According to different researchers, the methods are mainly categorized into three.

- ✓ First approach is exact methods, such as branch and bound, relaxation and linear programming. These exact methods guarantee global convergence and have been successful in solving small instances. However, they require a very high computing time as the size of problem increases and they are not capable of dealing with stochastic problems.
- ✓ Second method is approximation methods, such as the shifting bottleneck approach, particles warm optimization, and colony optimization, simulated annealing, genetic algorithm, neural network, immune algorithm, different evolution and others.
- ✓ The third one is dispatching rules and simulation based approaches. [7][8][9].

The sequencing methods are referred to as priority rules for sequencing or dispatching jobs to a work center. In the manufacturing world, scheduling problems are extensively implementing the dispatching rules. One of the most commonly used methods to schedule manufacturing systems is to use priority dispatching rules (pdrs) [10]. The procedure is designed to provide good solution to complex problems in a real time production environment. Most of the previous researchers, until this current time, are using dispatching rules to optimize the job shop-scheduling problem. These rules are classified into static and dynamic rules. Static rules are the ones in which the job priority values do not change as function of the passage of time, i.e. they do not depend on time (not time dependent). They are just a function of a job and/ or machine data. Dynamic rules are time dependent [11].

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

PROBLEM DESCRIPTION

In the job shop scheduling-problems (JSSP) there are "m" machines and "n" jobs. Each job has a fixed processing route that visits some or all the machines in a predetermined order. In this study, six jobs required five machines (workstation) are sampled from the company. The goal of the study is to reduce the higher make span faced by the case company resulting customers' delivery complains and lower machine resource utilization. The following assumptions are taken in to account to model the problem.

- ✓ Processing times are deterministic
- ✓ Each machine can carry out only a single operation at a time
- ✓ Each machine is used by each job once at most
- ✓ The machines are continuously available.
- ✓ There is only one machine of each type of machines.
- ✓ Process time includes the set-up times
- ✓ Preemption of operations are not allowed

METHODOLOGY

In this study, Secondary data are collected from production department of the case company for six jobs competing for six machines. A few visits were organized to the firm to study their production line layout (workstation) and process flows. The objective of the problem is to minimize make span, which is the elapsed time between the start of the first operation of the first scheduled job and the finish of the last operation of the last scheduled job. This order is considered in order to determine the minimum make span.

ANALYZING DATA AND RESULT DISCUSSION

Processing time is the time it takes the machines or an operators to finish assigned tasks and has a known probably distribution. Processing time of individual order in each section is considered and process completion time of a given job is the sum of the time it takes during operation in each work center. The rules of dispatching used by the researcher are; FIFO (first in fist out), SPT (shortest processing time, CR (Critical ratio), and EDD (earliest due date) and also the heuristics algorithm (such as General SB Routing, Shifting Bottleneck/ $T_{max,}$ Shifting Bottleneck /C_{Max} .and Local search /C_{Max}). The performance measures selected for comparison of the dispatching rules and heuristics algorithm are; flow time (make span), and Tardiness. Data are collected from the case company representing the six jobs such as, Makes patterns and digitize patterns to CAD (**J_1**), Checking of Greige and finished fabric (**J_2**), Cutting of fabric (**J_3**), Removing dust and tracing mark (**J_4**), Stitching the fabric (**J_5**), and checking of garment ironing and packing(**J_6**)**.**The jobs require the following six workstation; Fabric department (**R_1**),

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

Technical/ pattern making department (**R_2**),Cutting department (**R_3**), Sewing department (**R_4**), Washing department (**R_5**) and Finishing department (**R_6**). Based on their respective sequences in the factory and each section holds different types of machines which are already fixed in sequential orders. Department **R_1**, department **R_2** and department **R_3** contains 2, 8 & 3 machines respectively, department **R_4** contains 60 machines, department **R_5** contains 4 machines, and department **R_6** contains 20 machines.

In this paper processing time of one piece of clothes on each work center was collected from the company's production log book and six work centers were considered during the production of six jobs. Currently the case company is operating in 8 hours per a day. Processing time in each work center is given in minutes as below table.

Table 1: Routing matrix

Job	***Jobs Processing time(minutes)***					
J1	M_2(7)	M_3(3)	M_1(3)	M_5(5)	M_4(3)	M_6(2)
J2	M_1(5)	M_3(5)	M_4(6)	M_5(4)	M_6(7)	M2(3)
J3	M_3(3)	M_4(4)	M_5(5)	M_6(3)	M1(4)	M2(3)
J4	M_1(5)	M_3(4)	M_4(6)	M_5(4)	M_6(7)	M2(2)
J5	M_4(5)	M_5(3)	M_6(3)	M2(5)	M1(4)	M3(3)
J6	M_5(3)	M_6(4)	M2(3)	M3(5)	M4(2)	M1(5)

(Source: Shints ETP Garment Company's report, 2011)

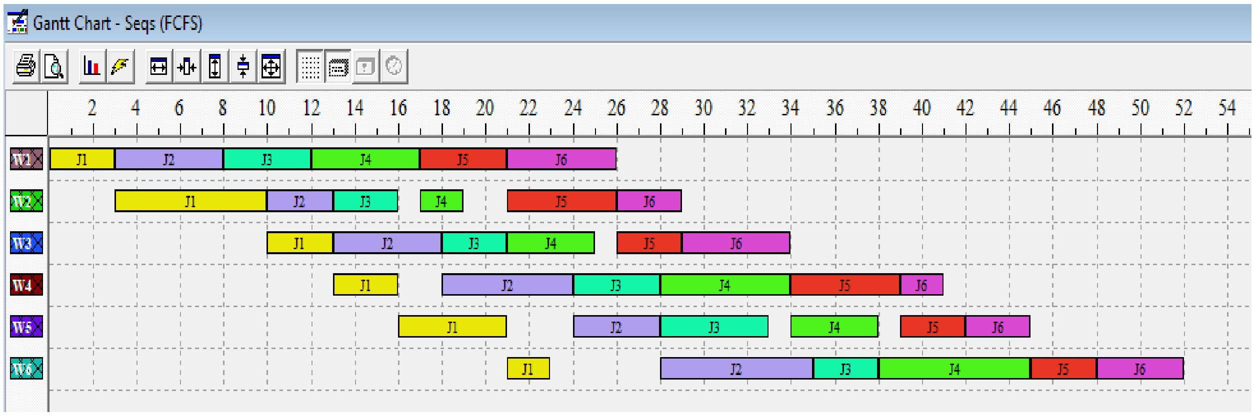
By using the following dispatching rules(FCFS, EDD, SPT and CR) and heuristics algorithms such as General SB Routing, Shifting Bottleneck/ T_{max}, Shifting Bottleneck /C_{Max} .and Local search /C_{Max} to determine the optimum make span of job shop scheduling problems.

FCFS (First Come First Servers)

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

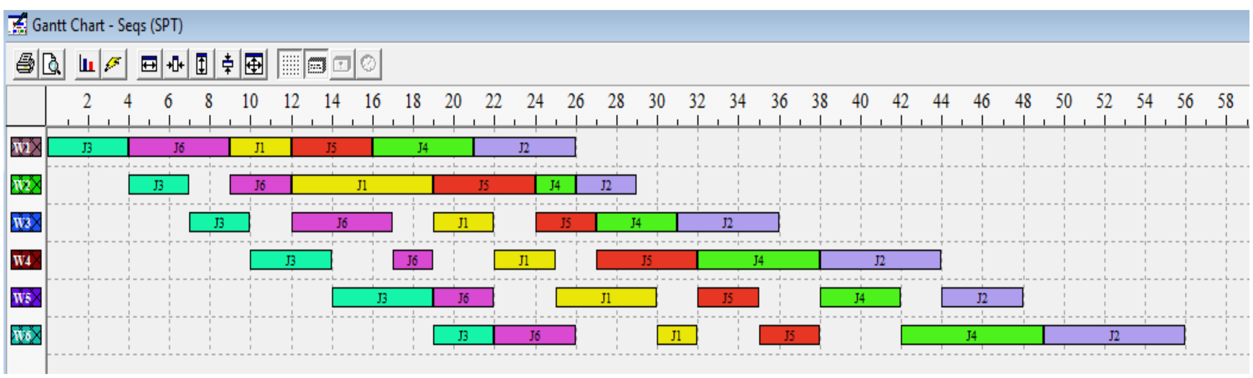
Figure 1: Gantt-chart for optimum job sequences of FCFS



(source: own)

SPT (shortest processing time)

Figure 2: Gantt-chart for optimum job sequences of SPT



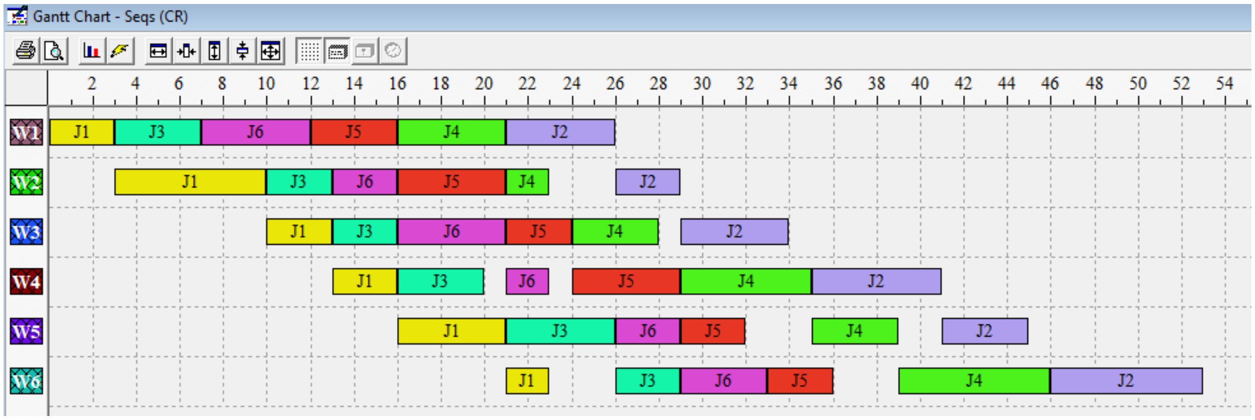
(source: own)

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

CR (Critical Ratio)

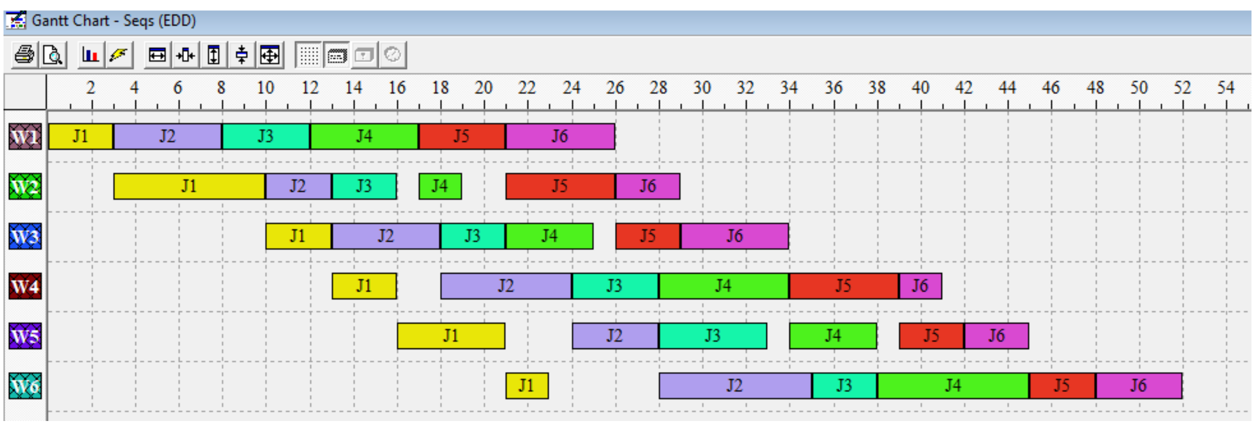
Figure 3: Gantt-chart for optimum job sequences of CR



(source: own)

EDD (Earliest Due Date).

Figure 4: Gantt-chart for optimum job sequences of EDD

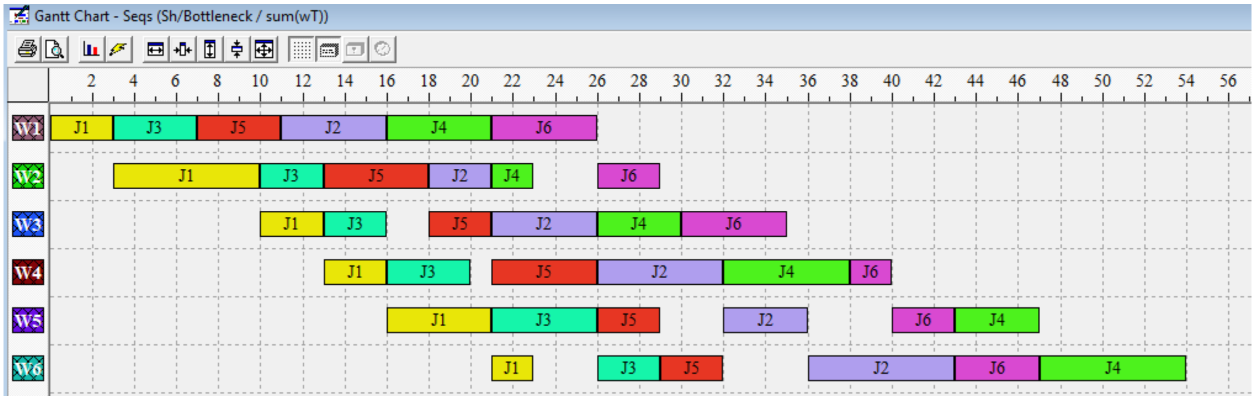


(source: own)

ISSN: 2456-1851
Volume: 04, Issue: 06 "November-December 2019"

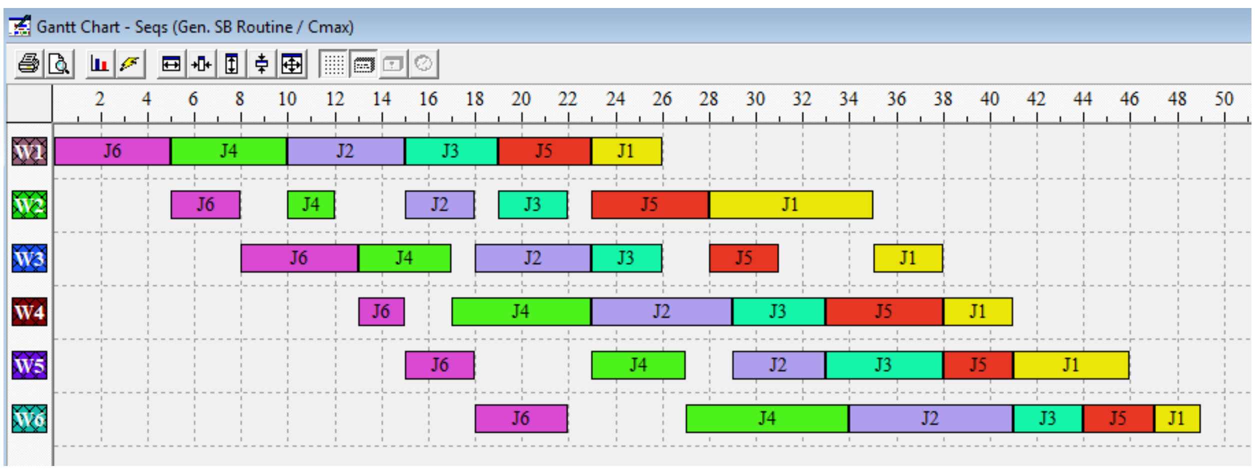
Shift bottleneck/ sum (wT)

Figure 5: Gantt-chart for optimum job sequences of shifting bottleneck/Sum (wT)



General SB Route/Cmax

Figure 6: Gantt-chart for optimum job sequences of General SB Routing/C_{max})



(source: own)

Shifting bottleneck/ Tmax

Figure 7: Gantt-chart for optimum job sequences of DASH

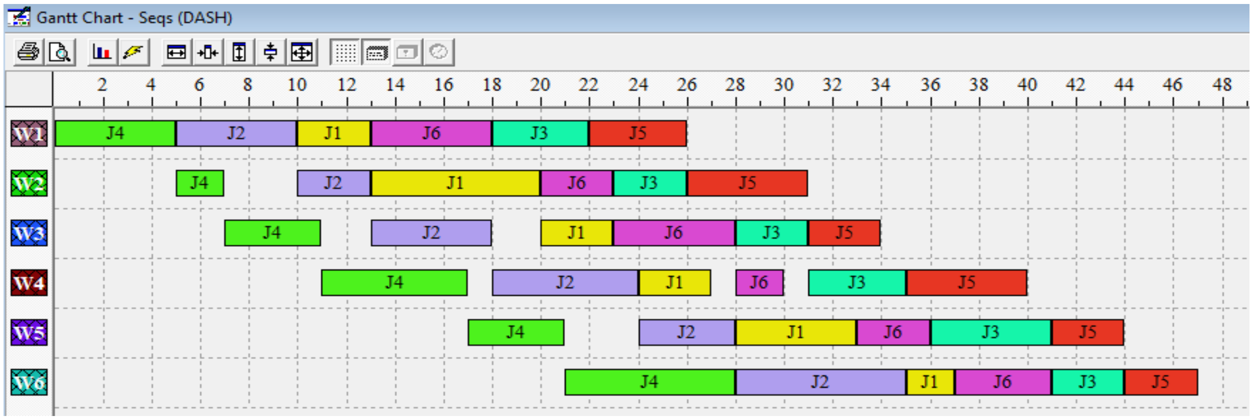
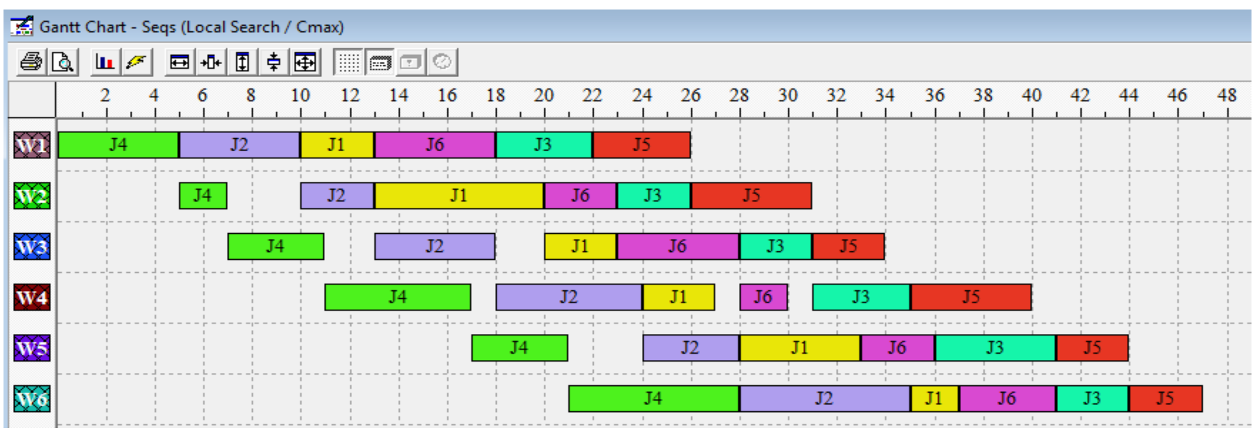


Figure 8: Gantt-chart for optimum job sequences of Local Search/C_{max}



(source: own)

The optimum make-span or minimum flow time selected by comparison of the dispatching rules and heuristics algorithm as below table: where;

C_{max} =make-span

T_{max}=Maximum tardiness

$\sum Uj$ =Total number of late jobs

$\sum Cj$=Total flow time

$\sum TJ$=Total tardiness

$\sum WjCj$=Total weighted flow time and

$\sum WjTj$=Total weighted tardiness

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

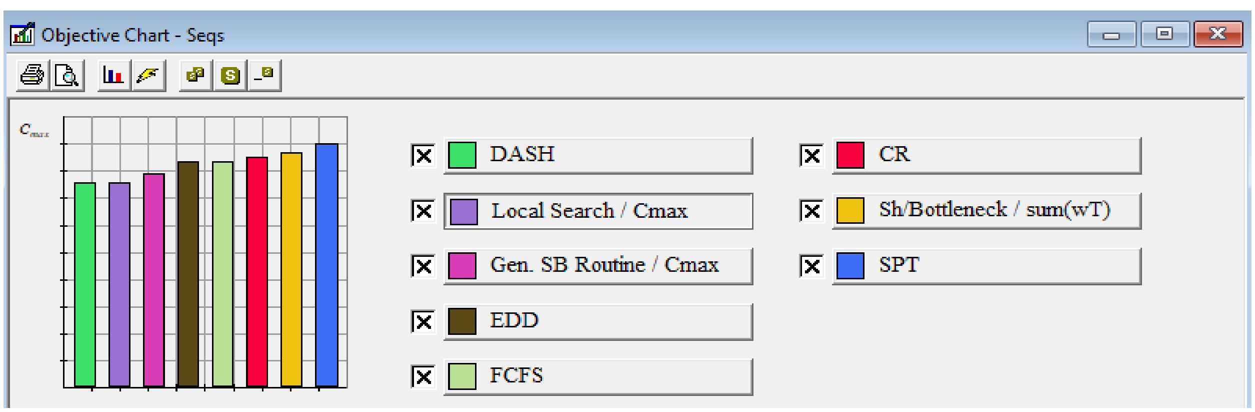
Table 2:- Log book sequencing or scheduling based on make-span by Lekin software

Log Book - Seqs *

Schedule	Time	C_{max}	T_{max}	ΣU_j	ΣC_j	ΣT_j	$\Sigma w_j C_j$	$\Sigma w_j T_j$
DASH	1	47	47	6	232	232	232	232
Local Search / Cmax	1	47	47	6	232	232	232	232
Gen. SB Routine / Cmax	1	49	49	6	237	237	237	237
EDD	1	52	52	6	241	241	241	241
FCFS	1	52	52	6	241	241	241	241
CR	1	53	53	6	220	220	220	220
Sh/Bottleneck / sum(wT)	1	54	54	6	228	228	228	228
SPT	1	56	56	6	223	223	223	223

(source: own)

Figure 9: Objective chart of sequence by Lekin software



(source: own)

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

Based on the above table, the researcher calculate the percentage for each machines, as below

Table 3:-percentage utilization comparison

Algorithm	Jobs sequence	Make-span	Processing time of each machines						Percentage of each machines					
			M 1	M 2	M 3	M 4	M 5	M 6	M1 %	M2 %	M3 %	M4 %	M5 %	M6%
FCFS	J1-J2-J3-J4-J5-J6	52	26	23	23	26	24	26	50%	44%	44%	50%	46%	50%
SPT	J3-J6-J1-J5-J4-J2	56	26	23	23	26	24	26	46%	41%	41%	46%	43%	46%
CR	J1-J3-J6-J5-J4-J2	53	26	23	23	26	24	26	49%	43%	43%	49%	45%	49%
EDD	J1-J2-J3-J4-J5-J6	52	26	23	23	26	24	26	50%	44%	44%	50%	46%	50%
Sh/Bot/Wt	J1-J3-J5-J2-J4-J6	54	26	23	23	26	24	26	48%	43%	43%	48%	44%	48%
Gen/SB/Cmax	J6-J4-J2-J3-J5-J1	49	26	23	23	26	24	26	53%	47%	47%	53%	49%	53%
DASH	J4-J2-J1-J6-J3-J5	47	26	23	23	26	24	26	55%	49%	49%	55%	51%	55%
Loc.search/Cmax	J4-J2-J1-J6-J3-J5	47	26	23	23	26	24	26	55%	49%	49%	55%	51%	55%

CONCLUSION

Job-shop scheduling is an NP-complete combinatorial optimization problem which comprises m machine and n jobs. This research paper aims at scheduling of 6-machines and 6-jobs using dispatching rules and heuristic algorithm methods by using Lekin scheduling software based on secondary data collected from SHINTS Garment production system. The findings of the study showed that the DASH and Local search/ C_{max} resulted in a total make-span of 47 minutes with the jobs sequence of J4-J2-J1-J6-J3-J5. The optimum sequence has improved the make-span of Shints garment industry by 5% for each machine as compared to the current scheduling system that operates in its production line.

Accordingly, the percentage utilization of machine one, four and six are 55%, machine two and three 49%, and that of machine five 51% of their available time.

FUTURE WORK

ISSN: 2456-1851

Volume: 04, Issue: 06 "November-December 2019"

This research is limited to scheduling/sequencing and analysis of job shop problems encountered in a specific time during the research period. It is the researcher's plan to deal with both the batch production and mass production schedules of the case company in its different plants. Other researchers can attempt to model and simulate the different production shops of the case company to get a better schedule optimizing different performance measures as prioritized by the case company.

REFERENCES

1. E. W. S. H. Prof. Dr. Gamal M. Nawara, "Solving the Job-Shop Scheduling Problem by Arena," vol. 2 , no. 2, 2013.
2. P. Y. o. M. E. B. Amr Arisha, "Job Shop Scheduling Problem: an Over view," Dublin, 2001.
3. J. K. &. B. Eshetie, "JobShop Scheduling Problem for Machine Shop with Shifting," vol. 15, no. 1, 2015..
4. P. Dileepan and M. Ahmadi, "Scheduling rules for a small dynamic job-shop: a simulation approach," International Journal of Simulation Modeling, vol. 9, no. 4, pp. 173-183, 2010.
5. A. K. Gupta and A. I. Sivakumar, "Job shop scheduling techniques in semiconductor manufacturing," International Journal of Advanced Manufacturing Technology , vol. 27 , no. 11-12, pp. 1163-1169, 2006.
6. C. W. Rui Zhang, "Bottleneck machine identification method based on constraint transformation for job shop scheduling with genetic algorithm," vol. 188, Information Sciences, 2012.
7. C. A. C. Antonin Ponsich, A hybrid Differential Evolution—Tabu Search algorithm for the solution of Job-Shop Scheduling Problems, Applied Soft Computing, vol. 13, 2013
8. Abbas Ebadi, "An optimal method for the preemptive job shop scheduling problem, Computers &," vol. 40, 2013, p. 13.
9. N. M. a. A. Shahzad, "Correlation among tardiness-based measures for scheduling using priority dispatching rules," International Journal of Production Research, vol. 51, no. 12, p. 3688–3697, International Journal of Production Research.
10. E. W. S. H. Prof. Dr. Gamal M. Nawara, "A Simulation Model for the Real-Life Job-Shop," vol. 2, no. 2, 2013.
11. P. D. R. Z. Shantanu Kolharkar, "Scheduling in Job Shop Process Industry," Vols. 5Issue 1 (Jan. - Feb. 2013), PP 01-17, no. 1, 2013.

