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OPTIMIZE REACTIVE JOB SHOP SCHEDULE TO IMPROVE PRODUCTION THROUGH HEURISTIC METHODS (CASE STUDY AT HMMBI)

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Original research

A B S T R A C T

In most of the manufacturing units job shop scheduling is a difficult task due to the complexity of the system. If the company maintains good job shop scheduling, can save time and money. And can improve the utilization of the machine. The case study was conducted in Hibert Manufacturing and Machine Building Industry (HMMBI), for five jobs and five machines Reactive job shop schedule. most of the time the company scheduling methods is depending on the first come first serve principles the existing make-span of the jobs is high around 803 minutes, due to this there is low machine utilization and dissatisfaction of customer in the company to minimizing this problem we have to look different scheduling techniques by using LEKIN scheduling software and arena simulation software to show the existing scheduling system. The results indicate heuristic methods like Shifting Bottleneck /Tmax and others can reduce the make-span from 803 minutes to 707 minutes around 96 minutes reduce and the machine utilization sum can be increased from 1.9029 to 2.1736 around 0.2707=27.1%..

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1. INTRODUCTION

Production sequencing and scheduling are some of the most important activities in production planning and control (Morton & Pentico, 1995). Scheduling and sequencing are both associated with the job shop process. Scheduling can be defined as a problem of finding an optimal sequence to execute a finite set of operations satisfying most of the constraints. Sequencing is for each machine in the shop one has to establish the order in which the jobs waiting in the queue in front of that particular machine have to be processed.

Scheduling is the allocation of start and finishes time to each particular order. Scheduling is the allocation of resources over time to perform a collection of tasks. Scheduling is an important tool for manufacturing and engineering, where it can have a major impact on the productivity of a process. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility when to make, with which staff, and on which equipment. Production scheduling aims to maximize the efficiency of the operation and reduce costs. A job is characterized by its route, its processing requirement, and its priority. In shop scheduling, the key issue is to decide how and when to schedule (Alharkan, 2005).

Job shop scheduling is one of the widely studied and most complex combinatorial optimization problems. A vast amount of research has been performed in this particular area to effectively schedule jobs for various objectives. A large number of small to medium companies still operate as job shops (Lin et al., 2010). In Hibret Manufacturing and Machine Building Industry (HMMBI), there are different kinds of machines like - lathe, milling, shaper

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machine router machine plasma cutting, and laser cutting, etc., and use different kinds of jobs scheduling depending on the order of product types. Among them, Job shop scheduling is the one.

In these scheduling and sequence operations, improper utilization of the machine is the major challenge and problem of the company for different kinds of jobs. Because for reactive scheduling or control which is performed every day or every three days like hot jobs down machines and late material etc. Most of the time the company job shop scheduling plan is depending on the first comes first serve principle (dispatching rule of FCFS). To proper utilization of the machine for customer satisfaction by minimizing the due date of the order, minimizing makes span, and for good production planning control we try to look at other sequencing and scheduling algorism.

The main objective of this work is to find the schedule of the machine, taking into account the precedence constraints, which minimizes the makespan, i.e., the finish time of the last task completed in the schedule or total completion time of the job. In Hibret Manufacturing and Machine Building Industry (HMMBI).Through heuristics methods. Both primary and secondary data collection use and to analyze the collected data, the mathematical tools, and techniques of scheduling is used. Scheduling is the process of allocating available production resources to complete a certain set of tasks in a given period, to minimum total penalty cost a well as higher utilization of machines (i.e. Minimum machine idleness). There are different kinds of scheduling techniques use in the FMS manufacturing company. But in Hibret Manufacturing and Machine Building Industry (HMMBI), machine scheduling techniques are the traditional way most of the time they use first come first serve principle because of this there is high machine waiting job, high material handling and machine idleness in the company.

The general objective of this project is to optimizing reactive job shop scheduling time to improve production by using different scheduling techniques by comparing the existing using scheduling techniques in the company.

2. LITERATURE REVIEW

The main products of Hibret Manufacturing and Machine Building Industry are the following

- Shafts,
- Bush for gear box,
- Helical gear,
- Pulley,
- Compression spring,
- Sun gear,
- Key,
- Piston ring,
- Bevel gear,
- Pretension bolt,
- Nut,
- Spindle big,
- Rotter set,
- Hub with nut,
- Clamp,
- Cover,
- Steal gear,
- Washer,
- Spring shaft,
- Cotter pin,
- Ring.

Job-shop scheduling is one of the most important industrial activities, especially in manufacturing planning. Job-shop is a system that processes n number of tasks on m number of machines. Constraints involved in a job shop scheduling problems are:

- A job should not visit the same team more than once
- Presence of no precedence constraints on operations of different jobs.
- Operations ones started can't be interrupted.
- Each machine can process only one job at a time.
- Each job must go through a particular predefined sequence of operations.

Scheduling algorithm: there are different algorism used for job shop scheduling used review by different literature depending on methodology analyzing the main objective of the writer is to Minimization of Make-span time and optimizing and Balancing workloads algorism there are different method (Masuda & Ishii, 1994; Vaessens et al., 1996; Brucker et al., 1997; Brasel et al., 1999; Kassu & Eshetie, 2015; Pradeep, 2016; Mohammed, 2016; Zhang et al., 2019) like:

1. Exact optimization method like - efficient rule approach, mathematical programming approach or linear programming and branch and bound methods so on...
2. Approximated methods like- constructive method, artificial intelligence methods, local searching methods, metaheuristics methods soon.
3. Simulation methods

The main difference between the literature depending on the point of:

1. Methodology used in resolving the problem;
2. Applications viewpoint;
3. Time horizon considered and
4. FMS factors considered

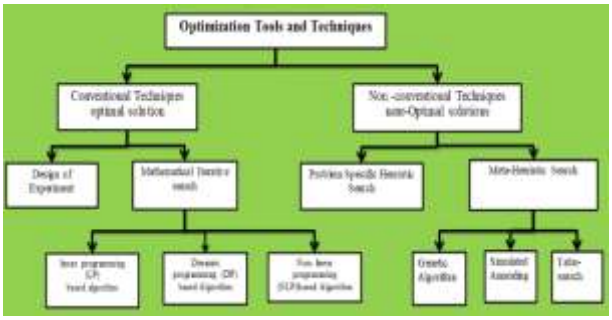

Figure 1. Optimization tools and techniques in the summary of the literature review

Optimization tools and techniques in the summary of the literature review are presented on Figure 1.

3. METHODOLOGY

1. Literature Survey: different literatures which are relevant to the topic under investigation are reviewed. These include scheduling related books, web pages, research papers and journals.

2. Data collection: data is collected from the company using both primary and secondary data sources.

3. Data analysis:- in order to analyze the collected data, the mathematical tools and techniques of scheduling is used. Excel spreadsheet, LEKIN scheduling software are some of the methods that used in this paper.

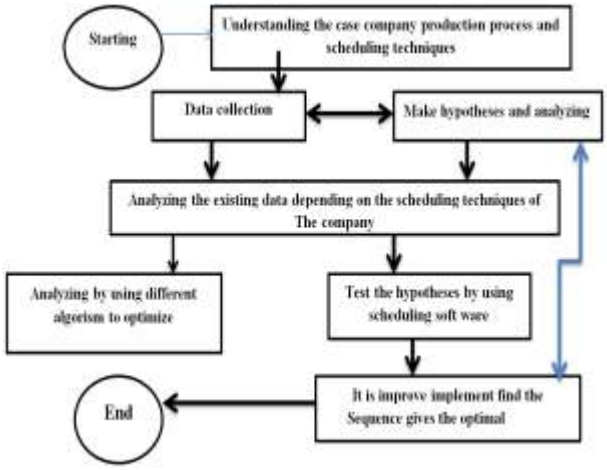

Figure 2. Flow diagram of study methodology

Flow diagram of study methodology is presented on Figure 2.

3. RESULTS AND DISCUSSIONS

Techniques of the company depending on job shop scheduling techniques I try to collect the processing time of the job of the current product in different machines. These product types need three lathe machines and two milling machines for five different jobs (the jobs are all of the shafts), the processing time is in minute average and take the assumption of job shop scheduling.

Job shop problem can be represented in different methods: - Consider 5 jobs and 5 machines problem with the operation sequence and the processing time for each operation have been determined in Table 1. And Table 2 the combination of the two.

Table 1. Operation and sequence of the manufacturing process of the products

Jobs/Machine	Sequence 1	Sequence 2	Sequence 3	Sequence 4
Shaft collars	Power hacksaw	Lathe machine	Deburring Machine	Milling machine
Pulley	Power hacksaw	Lathe machine	Drilling Machine	Milling machine
Helical Gear	Power hacksaw	Lathe machine	Milling machine	Deburring machine
Shaft	Power hacksaw	Lathe machine	Milling machine	Drilling machine
Bevel Gear	Power hacksaw	Lathe machine	Milling machine	Deburring machine

Machine types

1. Power hacksaw machine
2. Lathe machine
3. Milling machine
4. Deburring machine
5. Drilling machine

Table 2. Operation process time and machine combination on the sequencing (i,j in minute)

	Sequence 1	Sequence 2	Sequence 3	Sequence 4
Shaft collars	M1(117)	M2(57)	M4(74)	M3(60)
Pulley	M1(120)	M2(45)	M5(78)	M3(31)
Helical Gear	M1(119)	M2(130)	M3(68)	M4(23)
Shaft	M1(128)	M2(34)	M3(58)	M5(67)
Bevel Gear	M1(126)	M2(130)	M3(30)	M4(33)

Conjunctive arcs represent the job shop scheduling (Figure 3):

S= starting node and F= finishing node and There exists a node for each operation (i,j)

Conjunctive arcs A represent routes of the jobs:-Arc (i, j) (k, j) denotes that operation (i, j) precedes (k, j) (Defined for two operations of the same job)

We can extend to Disjunctive arcs represent the sequence of jobs on a machine Arc (i,j) (i, k) denotes that operation (i, j) precedes (i, k)

Arc (i,j) (i, k) denotes that operation (I , k) precedes (i,j)

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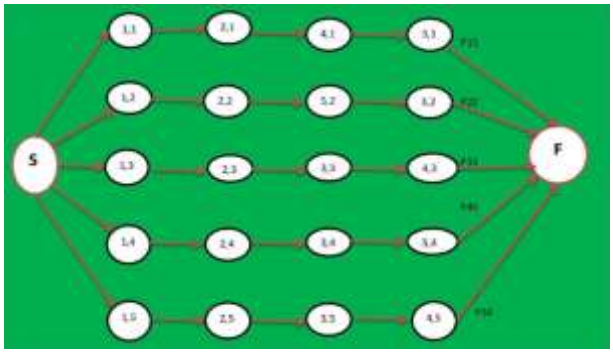

Figure 3. The conjunction arcs set (routes of the job) of the problem

General mathematical model formulation of job shop scheduling 5 jobs with 5 machines Let ti,j…

Be the start time of job j that is performed on the machine i

fi,j… Be finish time of job j that is performed on the machine i

pi,j… Be processing time of job j that is performed on the machine i

$Cmax$…make-span (finish time of latest job)

di…..due date of machine I and rj ….release date of job j

Objective function---------Min $Cmax$

Subject to: - …… th,j - ti,j ≥ Pi,j …For all set of (i= 1-5, j=1-5) rooting constraints

$Cmax - ti, j \geq Pi,j$ …For all set of (i= 1-5, j =1-5) operation

$ti,j - ti,k \geq Pi,k$ **Or** $ti,k - ti,j \geq Pi,j$…..(i=1-5, j=1-5)

$ti,j + Pi,j \leq di$

$ti,j \geq rj$

Non-negativity restriction ti,j

The company job shop scheduling methods are first to come first services.

Table 3. Existing scheduling techniques outputs (FCFS Principle).

PRODUCTS TYPES	**M 1**	**M 2**	**M 3**	**M 4**	**M5**	$C1,1$	$C1,2$	$C1,3$	$C1,4$	$C1,5$
Shaft collars	117	57	60	74	0	117	174	234	308	308
Pulley	120	45	31	0	78	237	282	313	313	391
Helical Gear	119	130	68	23	0	356	486	554	577	577
Shaft	128	34	58	0	67	484	520	612	612	679
Bevel Gear	126	130	30	33	0	610	740	770	803	**803**

Existing scheduling techniques outputs (FCFS Principle) is presented in Table 3. Depending on this principle the make-span will be 803 minutes. The total completion time of the products is 803minutes around 13.39 hours. Because of this, the company faces a lot of machine idleness and ineffective productivity. To minimize this problem we have to look at other scheduling techniques.

Time of completing all jobs (C_max): It is the total time of completing all jobs

C_max Of the selected products is 890 minutes

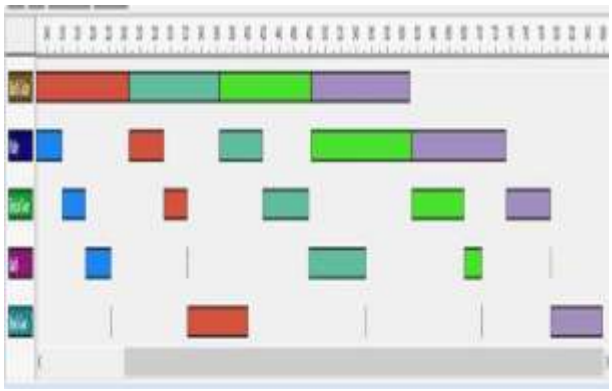

Figure 4. Existing scheduling techniques Gant chart using Lekin scheduling software

In order to minimize the completion time we have to use different scheduling techniques (Figure 4 and Figure 5).

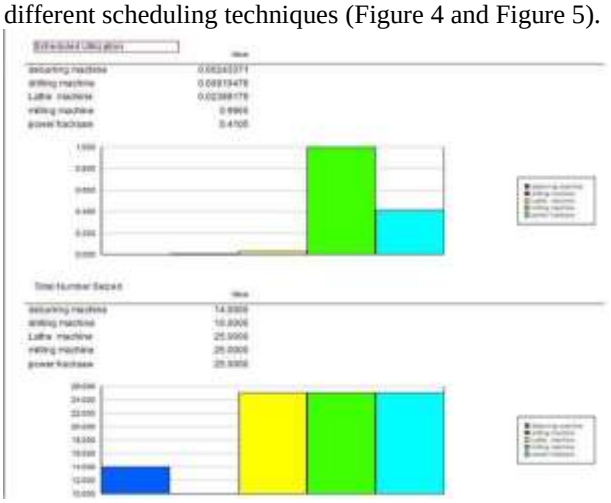

Figure 5. Easting machine utilization after analyzing arena simulation software

After analyzing with LEKIN job shop scheduling software we try to summarizing the output in the following tables: 4 and 5.

Table 4. Performance evaluation comparison of different dispatching scheduling techniques

		Performance Analysis Methods							
		Priority sequencing rules							
No's	Performance Measurement Characteristics	**FCFS**	**SPT**	**LPT**	**EDD**	**CR**	**ATCS**	**MS**	**WSPT**
1	Make-Span Cmax	803	859	707	733	859	859	707	859
2	Max Tardiness	803	859	707	733	859	859	707	859
3	Number Of late Jobs	5	5	5	5	5	5	5	5
4	Total flow time	2741	2738	2951	2741	2738	2738	2738	2738
5	Total Tardiness	2741	2738	2951	2741	2738	2738	2738	2738
6	Total weighted flow time	2741	2738	2951	2741	2738	2738	2738	2738
7	Total weighted Tardiness	2741	2738	2951	2741	2738	2738	2738	2738

Source: LEKIN Scheduling technique's analysis software

Table 5. Show performance evaluation comparison of different heuristic scheduling techniques

		Performance Analysis Methods			
		Heuristic methods			
No's	Performance Measurement Characteristics	**General SB Routine**	**Shifting Bottleneck /sum(WT)**	**Shifting Bottleneck /Tmax**	**Local search**
1	Make-Span Cmax	707	834	707	707
2	Max Tardiness	707	834	707	707
3	Number Of late Jobs	5	5	5	5
4	Total flow time	3015	2742	2795	3460
5	Total Tardiness	3015	2742	2795	3460
6	Total weighted flow time	3015	2742	2795	3460
7	Total weighted Tardiness	3015	2742	2795	3460

Source: LEKIN Scheduling technique's analysis software

Depending on the result given the Lekin scheduling software, the best optimal solution is to find both Priority sequencing rules and Heuristic methods rather than the company used methods. Gant chart using Lekin scheduling software is presented on Figure 6.

The optimal solutions are: - LPT, MS General SB Routine, Shifting Bottleneck /Tmax and Local search the total completion time is 707 minutes, Relatively the difference between the company used methods is 96 minutes.

Bevel gear (J5)-Helical gear (J3)-pulley (J2)-Shaft collar (J1) –Shaft (J4)

Figure 6. Gant chart using Lekin scheduling software

The sequences of the jobs are presented on figure 6.

Table 6. Scheduling techniques

Existing scheduling techniques Make-span	Proposed scheduling techniques Make-span	Machine types	Existing utilization	Proposed utilization
By using FCFS **=803 minutes**	By using Heuristic methods **=703 minutes**	Power hacksaw Machine	0.7596	0.8677
		Lathe machine	0.4932	0.5633
		Milling machine	0.3076	0.3514
		Deburring machine	0.1619	0.1849
		Drilling machine	0.1806	0.2063

The efficiency of the machine can increase by 27% (Table 6).

The next figure show us the different scheduling techniques depending on the general output of the software (Figure 7).

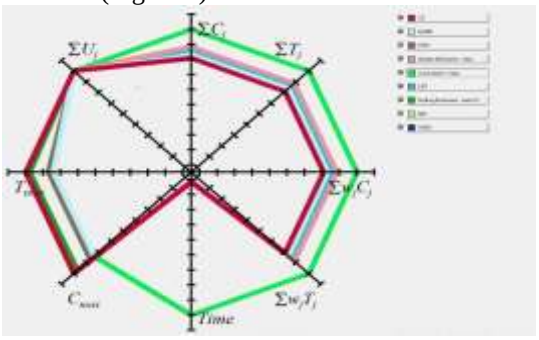

Figure 7. Value of the different scheduling methods using Lekin scheduling software

Simulation arena soft ware

Area simulation software is the most power full software used for scheduling and other purposes in the future we can use this for analysis of the job shop scheduling (Figure 8).

Figure 8. Job Shop Scheduling

For this term paper use this to show the existing scheduling techniques only and to show machine utilization of the existing scheduling techniques.

4. CONCLUSION

By comparing the existing scheduling techniques used in the company with different scheduling methods, With LEKIN scheduling software and arena simulation software to show the existing scheduling system

The shifting bottleneck heuristic and others are an efficient method to find Cmax and Lmax objectives in a job shop scheduling, regarding the reduction of the total completion time or make-span can reducing around 96 minutes and the machine utilization can increase around 27.1%.

But depending on the Gant chart result showing there is the same machine idealness in the company. To minimizing the idealness the company needs to focuses this area for day to day activity.

If the company following the same scheduling techniques for common products, productivity can increase from time to time

The company needs proper time study for the different product completion time to develop effective scheduling techniques in the company because there is a lack of organized way completion time of the product records.

The production planning and control department need to developed the culture of optimized scheduling techniques selection methods with the help of machine scheduling software.

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