Sequencing of Jobs and Time Optimization for Fly-ash Brick Production

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Abstract
To control overall duration, the research used a model based on an algorithm for work scheduling. The association status among tasks arrangement and time of delivery was explored, as was its significant effect on total elapsed time management. Using a survey study design, data were gathered via in-depth observations and interviews of pre- and post-production processes within the chosen fly-ash brick industry. The results demonstrated that the work sequencing model significantly affects total expire time management. The results also showed that the buffer stock could be increased and improved in case of unforeseen future demand, cycle time could be reduced, and the delivery date to the client could be moved forward. The time saved may seem like a freebie, but it will really increase the company's bottom line. Companies should make an effort to use task sequencing model methods throughout their operations and cultivate a culture of teamwork aimed at reducing expenses wherever possible.

Keywords: scheduling, minimizing costs, delay, efficiency.

Introduction

The issue of job sequencing has piqued the interest of management scientists in recent years. Job sequencing refers to the process of selecting the demanded resources for the purpose of a sequence of actions which are needed to be accomplished several service facilities (machines) to be able to the cost of production may be kept to a minimum. Management theorists often define job sequencing as the activity of allocating jobs to workstations and individuals to occupations for designated periods of time. When tasks are scheduled using different techniques, the order in which they run varies, which in turn affects the amount of time those jobs spend waiting (Nong, Xueping, Tony & Xiaoyun, 2005). Businesses nowadays must adapt quickly to a constantly changing environment, and as an open system, this means that several tasks may be performed on a single machine. Without proper planning and management, task sequences and the flow of operations may lead to delays, wasted time, bottlenecks, and the hanging of several jobs, as well as the development of waiting lines.

Not only that, but the process is inherently dynamic, meaning new employment may arrive at any moment. Managers of both small businesses, like food sellers and welders, and major firms, like car manufacturers, cement factories, saw mills, block industries, face increased stress as they strive to maximize output while minimizing expenses and maximize profits. Job sequencing might be different from one factory to the next, yet it still has a significant impact on the total cost of production in the fly-ash block business. Job sequencing directs a manufacturing facility as to when to manufacture, with which people, and on which equipment in order to cut down on production time and expenses. When it comes to time and money, job sequencing is all about getting the most bangs for your buck.

Production managers want to maximize output of high-quality items while keeping expenses to a minimum, therefore it's important to recognize the significance of task sequencing in the context of day-to-day operations. The Ganges river-side area of Budge Budge, West Bengal, India has seen significant economic growth and population expansion since the state's inception, making it an ideal location for the development and expansion of the fly-ash block market and the proliferation of fly-ash block related businesses. The consequence is inefficient use of labor, machinery, and instruments like spades and shovels, as well as the waste of building supplies like sand, water, cement, boards, and other products by the managements of most fly-ash block industries in the region. This results in wasteful spending and a rise in manufacturing costs, which cuts into the company's profit margin.

In addition, a lot of time that could be used for fly-ash brick production is instead of wasted on things like searching for manpower, delivery time of materials, repairing machineries and so on, leading to waiting lines and bottlenecks that drive up costs, reduce sales, and potentially lose customers.

Because all of these issues impede the expansion of fly-ash based brick industries and as an outcome delivery of the product get delayed, unwarranted costs, pitiable product quality, and an inability to fulfill the requirements of customers, the connection between outstanding sequencing of tasks and total elapse time management essential to be established.

Objective of the Study

The goals are as follows:

- Determine how a work sequencing system affects the overall management of time spent.
- Clarify how work sequencing affects your ability to meet delivery deadlines.

Literature Review

In order to improve the manufacturing infrastructure, a number of operations are performed on a set of equipment. The potential for maximum efficiency is restricted in various ways. Now that process scheduling theory has matured, it can take into account almost any outside restrictions (Merten & Muller, 1972). In Process Scheduling, achieving a minimum value for a target measure is the end goal. Many alternative scheduling issues may be defined by changing the machines involved, the restrictions, and the desired outcomes.

What is Sequencing?

The production facilities are improved by performing a number of tasks on a variety of machines. Performance optimization faces a number of challenges. Process scheduling theory has progressed to the point where it can incorporate any available constraints (Merten & Muller, 1972). Finding a Process Scheduling solution that minimizes some metric of interest is the goal. It is possible to formulate a wide variety of scheduling problems by changing the machines involved, the constraints imposed, and the desired outcomes.

Principal assumptions of sequencing

There are a few presumptions that must be made when trying to solve a sequencing problem.

- Just one task at a time can be handled by a single machine.
- As soon as a process is initiated, it must be finished before moving on to the next.

- In order to move on to the next step, the one before it must first be finished.
- Since processing time is fixed and well-defined, we can ignore the delay introduced by jobs being moved between machines.
- The various machines available for use.

The objectives behind the Job Sequencing Process

- **Reducing the Amount of Work Already Underway**: A key objective of effective production management is the reduction of WIP. Work in progress necessitates extra room for warehousing, stands in for cash that can't be invested elsewhere, and exposes finished goods to the danger of spoiling before their time.

- **Preserving a constant minimum of the production's average flow time:** In a company setting, almost all activities have their task times tracked. However, the most prevalent use of this concept is in manufacturing, namely in the lines of production that transport productsconsecutively through a sequence of workstations. Due to the linear nature of the product flow, delays at any of the stations that take longer than expected to complete are immediately apparent. Likewise, unreliable stations (those prone to breakdowns, etc.) stand out in a crowd.

- **Keeping manufacturing costs to a minimum at all times:** When businesses aim to reduce expenses, they may realize substantial savings across the board, including product costs, manufacturing costs, and life cycle costs.

- **Maximizing utilization of production resources:** Machines, people, cash, and supplies will all be put to good use and organized in the most efficient way possible. The ability to sequence tasks permits them to be completed in the order in which they were planned.

- **Targeted output achieved as specified:** Products delivered are more likely to fulfill consumers' expectations when supply chain management is included, as final product, inventory, and demands for volume and timeliness are met when suppliers provide materials required timely& manufacturing is carried according to the specifications.

Classification of Job Sequencing Algorithms/ Models

Listed below are many strategies and methods that may be used to address work sequencing concerns:

Algorithm - TABU Search

TABU searching method for the job shop issue was described by Eugeniusz and Czesl (2015). It introduced a novel approximation approach based on the huge valley phenomena, using a technique known as route relinking and some novel theoretical features of neighborhoods. The model proved to be an effective method for addressing the makespan condition in the context of the job shop dilemma. When compared to other well-known methods, its precision was excellent, and it could be executed quickly on a current personal computer. The algorithm's basic principle might be used to solve various scheduling issues, such as the flow shop problem.

Fuzzy Topsis Method

Two academics [4] proposed the Fuzzy based model for the problems of Job Sequencing. When there are a large number of tasks to be completed by a succession of machines, each with its own unique time requirements, a scheduling difficulty arises. To solve these issues, they established a protocol for carrying out a set of tasks over a variable set of resources.

There is an assumption of imprecision in the processing time on these machines for the tasks (Rao et al, 2013). Each device was assigned a weight that reflected its relative efficiency. To reduce the total amount of time spent waiting, we will first define and then compute the gap distance between each task.

Payoff "System / Model"

In order to construct a compensation system for the difficulties connected with job scheduling, Joss modified the concept that had previously been established by Hart, Colell in 2011.In doing so, Joss sought to provide a solution to the challenges that are presented by job scheduling. The model's central tenet is that work orders should be distributed among available production resources based on the relative value of each task.

Johnson's Sequencing Rule

In order to establish a plan for the issues related to scheduling, Joss in the year 2011 revised the notion of potential that had been introduced by Hart & Colell.

The model's central tenet is that work orders should be distributed among available production resources based on the relative value of each task.

Model for Sequencing for N number of tasks between 2 Machines Using the rule of Johnson:

We might characterize these issues as follows:

(i) This just involves the machines P and Q.
(ii) The order in which jobs are completed is PQ and

Processing times anticipated P1, P2, P3, etc. Following is a list of all the known values for n Q1, Q2, Q3,... Qn.:

Job	1-n	2-n	3-n	…	n-n
P_{i-i}	P_{1-n}	P_{2-n}	P_{3-n}	...	P_{n-n}
Qi-i	Q_{1-n}	Q_{2-n}	Q_{3-n}	…	Q_{n-n}

Johnson's Rule

Since Johnson and Bellman (1953) devised the method for handling similar issues, the method described below is often referred to as the rule of Johnson for scheduling.

Step 1. Choose the processing period that lasts the smallest amount of time from P_1, P_2, P_3, and Q_1, Q_2, and Q_3… Q_n. In the event of a tie, choose the option with the shortest processing time.

Step 2. (i) It is best to start with the r^{th} task and work your way down the list if the shortest processing time is Pr.

(ii) If Qs, then the s^{th} task should be completed at the very end of the process.
(iii) In the event of a minimum $P_r = Q_S$ tie, the r^{th} task will be completed before the sth job.
(iv) In the event of a tie for the bare minimum among P_r's, the order of execution does not matter; the first one to be completed wins.
(v) To break a tie for fewest Q_S's, finish with the one you like least.

Step 3. Methods 1 and 2 must be repeated. Keep on until an "optimal sequence" has been determined for each task.

Sequencing of N- Jobs through three Machines:
If any of the following is true, then Johnson's technique may be generalized to the three-machine case: The shortest amount of time a work can take on P machine is larger or may be equal to the lengthiestquantityof time it can take on Machine Q to complete the same task. The least amount of time a work can take to complete in the machine mentioned as P is actually further than or the same to the longest amount of the time a job may take to complete on machine Q. Addressing such issues is comparable to solving the problem of n tasks shared between two different machines. These two (imaginary) different machines, α andβ, are being offered as a donation, and their respective processing times, α_i and β_i, are being determined.
$\alpha_i = P_i + Q_i$
$\beta_i = B_i + R_i$

Sequencing of N-Jobs through M-Machines:
Let a table like the one below reflects the anticipated processing times in this sort of scenario:

“**Job**	**Machine times for n-jobs and m-machines**				
	P_1	P_2	P_3	**…**	P_m
1	P11	P12	P13	…	P1m
2	P21	P22	P23	…	P2m
:	: :	: :	: :	: :	: :
N	Pn1	Pn2	Pn3	…	Pnm”

Only if all of the following hold true can this issue be solved. Maximum processing time on machines P2, P3, and P1 is more “than or equal to the shortest processing time on machine” P1 or Machine processing time is minimized. The time on the machine at am is more than or equal to P_2, P_3, ..……, P_m -1.

The following procedures were taken in order to acquire the optimal sequence: First, check whether the aforementioned requirements have been met.

Step 2: If the precondition is met, the next step will be taken. Unless certain conditions are fulfilled, the procedure will not work.

Step 3: You can solve the machine issue by splitting it into two halves, machine α and machine β, with the same constraints.

$P_iM = A_i1 + A_i2 + \ldots\ldots + P_im$ excluding the last machine time $P_iN = P_i2 + P_i3 + \ldots\ldots +$ Pim with the first machine hours discarded. The ideal order to do m jobs on two machines must then be determined using the optimal sequence approach.

Elapsed Time Management
For any given machine or set of facilities, elapsed time is measured from the moment the first scheduled task begins to the moment the final task is finished. Everything counts, even if a

machine is idle. Total elapsed time management refers to how well time is planned, scheduled, and controlled.

The amount of time between the time slots of executing the first job in the ideal sequence on the machine referred as P and finishing the tasks successfully on the machine Q is basically the total amount of time that has transpired.

Empirical Review

A series of tasks are carried out on a collection of machines in order to enhance the manufacturing facilities. There are a lot of requirements and goals that need to be met for optimal performance. Authors have conducted extensive research on the importance of process scheduling in order to maximize efficiency and account for all potential constraints. The purpose of Process Scheduling is to find a solution that minimizes some metric of interest.

Scheduling Methods That Are Commonly Used and How They Measure Up

Comparison of Well-Known Scheduling Methodologies is a study that was conducted in 2010 by Tadsanee and Jirarat. The focus of the research was to look at the distinctions and parallels that exist between some of the more common approaches to scheduling, such as first-come, first-serve, the approach with the least amount of idle time, EDD, and the speediest processing procedure. These two rule-based scheduling approaches have developed throughout the course of time as a result of the fact that scheduling can be done in line with the rules of tasks and orders. The two approaches become mutually exclusive. A case study of a Thai electronics manufacturer sees the eight approaches put to use. Rules that are based on jobs are always preferable than rules that are based on orders, and EDD and the minimal processing time are the two techniques that are the most successful.

We examination of scheduling of tasks strategies for minimizing wait times is a micro-level effort that takes into account a single resource. The article backs a larger initiative to provide QoS for critical operations on an industry infrastructure from end to end for each individual task. To this end, quality-of-service (QoS) models for use in varying geographic contexts. The goal of a quality of service (QoS) model at the local level is to guarantee reliable service based on specific infrastructure. The process of guaranteeing quality of service on a global and regional scale is made easier in this way.

After plotting across the mean of all possible sequences for a collection of activities, a pattern that could be used to assess the cost associated with waiting time diminution efforts was discovered. This research focused on a single resource and a single set of tasks, both of which were evaluated based only on processing speeds. It is a work scheduling challenge to minimize the variation in waiting times for a lot of n number of jobs waiting which are needed to be serviced by a solitary resource. Providing Quality of Service in many businesses relies on solving the well-known scheduling challenge of minimizing Work in Progress. Reducing the variability of task wait times in computer networks may help bring about consistent and predictable performance throughout the network.

Methodology

Research Design

In this study, we employed a survey to gather information. We looked at the fly-ash brick making process. Devoid of modifying the parameters in thiswork, it allows carrying on the work to collect information on the processes, times, and costs involved in producing the three different types of fly-ash blocks (5-inch, 10-inch, and unique fly-ash brick). Research was conducted on the fly-ash brick manufacturing process.

Sampling Strategies and Procedures

Sampling procedures are the means through which individuals from a research population are selected as samples. This led the researcher to use quite straightforward methods. The fly-ash brick industry was chosen using a proportional random selection method that took into account the workforce's activities and population in the chosen sector.

Instrumentation

The "observation and investigation technique" was used as the research tool, allowing the researcher to get familiar with both the respondents and the operations of the block business.

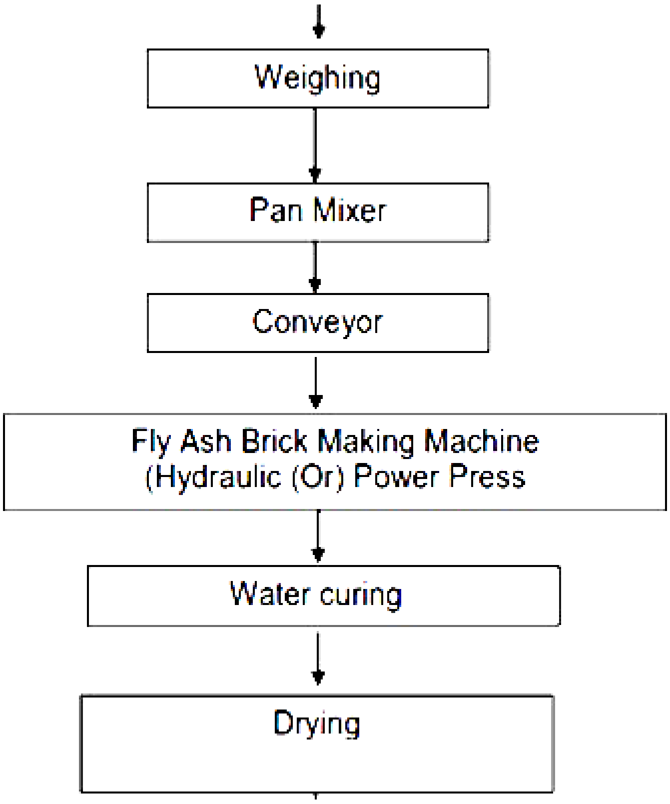
Section A – observation: The first part of the report included the company's workforce, time spent on each procedure, manufacturing method, and equipment inventory.

Section B – investigation: In the second part, we looked at the manufacturing costs involved. The price of one bag of cement, as well as the cost of sand, water, labor, fuel, and other incidental costs.

Procedures for Managing the different Machines

We took meticulous notes on our findings. We reached out to the industrial manager of the chosen fly-ash brick to solicit advice and help during their fieldwork. Managers helped provide necessary facts to justify the observation and maintain interest and support. Respondents were fully briefed on the inquiry and assured that their answers would remain private. The manager's assistance, however, made it easy for us to pose her queries. After spending an average 3 hrs each day, we finally had all the data needed.

Fig 1: The fly-ash brick Production Process for an explanation of this illustration.



Five-inch bricks, Ten-inch bricks, and other specialty bricks are all products of the brick industry.

The no of fly-ash bricks produced from per cement bag:

PRODUCTION	"QUANTITY PER BAG OF CEMENT"
"5 inches brick	35
10 inchesbrick	17
Specialbrick	20" 20

How long it takes the company, on average, to utilize one bag of cement to produce one kind of block

Machine

Machine P is the weighing device, Machine Q is the Pan mixer,, Machine R is the conveyor machine, Machine S is the power press, Machine T is the water curing machine, and Machine U is the drying machine.

MACHINES TASK	"P	Q	R	S	T	U	TOTAL TIME USED PER TASK
1	15	17	20	45	200	60	357
2	15	17	25	50	200	60	367
3	15	17	20	55	200	42	" 349
1073							

Job
The square dimensions of the fly-ash brick used in Job 1 are 5 inches, whereas those used in Job 2 are 10 inches, and the blocks used in Job 3 are Special Bricks.

Predicted Production Time
It takes around 357 minutes of labor to make one 5-inch fly-ash from one bag of cement. For every bag of cement used, the time required to make a fly-ash brick that is 10inches is estimated to be 367 minutes. For every bag of cement used, the manufacture of specialized blocks is projected to take 349 minutes. Each bag of cement takes around 1073 minutes to use up in the three different varieties of block.

STEP 1**:** Comparison of time
First
MinMP ≥ MaxMQ√
MinMP ≥ MaxMR×
MinMP ≥ MaxMS×
MinMP ≥ MaxMT√
Last
MinMU ≥ MaxMQ√
MinMU ≥ MaxMR×
MinMU ≥ MaxMS×
MinMU ≥ MaxMT√

STEP 2: Compress
Mi – The final machine is fulfilled, Mj – The first machine is fulfilled.

TASKS / MACHINES	1 - 3	2 - 3	3 - 3
M1	297	307	307
M2	340	350	332

STEP 3: Progression Sequence
The least amount of time, 297 minutes, is allotted to Task 1.

1		

JOBS / MACHINES	2-2	3-3
M1	307	307
M2	350	332

Only 307 minutes are available for Job 2 and Job 3.

J1	J3	J2

STEP 4: As a result, the order of operations will be JOB number-1, JOB number-3, and JOB number- 2.

MACHINES	**P**		**Q**		**R**		**S**		**T**		**U**		**IDLE TIME**					
JOBS	**IN**	**END**	**IN**	**END**	**IN**	**END**	**IN**	**END**	**IN**	**END**	**IN**	**END**	**P**	**Q**	**R**	**S**	**T**	**U**
1	0	15	15	32	32	52	52	97	97	297	297	357	-	15	32	52	97	297
3	15	30	30	47	47	67	67	122	122	322	322	366	-	-	-	-	-	-
2	30	45	45	62	62	87	87	137	137	337	337	397	-	-	-	-	-	-

IN “represents start time and END **represents** finish time”
Total “elapsed time = 397minutes (optimal time used for the production)
Idle time for Machine P = (397- 45) = 352minutes
Idle time for Machine Q= (397- 62) = 335minutes
Idle time for Machine R = (397 -87) = 310minutes
Idle time for Machine S = 9397 – 137) = 260minutes
Idle time for Machine T= (397 – 337) = 60 minutes
Idle time for Machine U” = (397 – 297) =100minutes
The manufacturing of blocks takes 1073 minutes every day.
The time spent, assuming correct Job scheduling, is actually 397 mins.

Conclusion and Recommendations:

According to this research work-based study that was conducted on the fly ash brick business, one bag of cement may produce thirty-five bricks measuring 5 inches, 17 bricks measuring 10 inches, and twenty bricks that do not fit any of these categories. This process takes around 1073 minutes. The production of thirty-five 5-inch bricks, seventeen 10-inch bricks, and twenty special bricks using a bag of cement for each type of block can be accomplished in the block industry with the application of proper job sequencing in about 397 minutes, during which time machine P will be idle for about 352 minutes, machine Q for about 335 minutes, machine R for about 310 minutes, machine S for about 260 minutes, machine T for about 60 minutes, and machine U for about 100 minutes. In the fly-ash brick manufacturing sector, choosing a range of tasks to be carried out over a number of service facilities decreases production schedules, which has a positive impact on the overall time reduction. By reducing the number of resources that should have been given to the period, the aforementioned result demonstrates the connection between efficient work sequencing and time reduction. The customer's deadline for delivery will be reached, and the cycle time or delivery time will be shortened, the time savings. This realization ensures that the entire elapsed time is at its optimum, which in turn strengthens and increases the buffer stock for unforeseen future need. Though the time savings will increase the bottom line, they will come at a cost. In a study conducted, we found evidence supporting their claim that proper task sequencing may significantly cut down on and control production's overall lag time. Companies should make an effort to adopt the techniques of the task sequencing model into their processes and establish collaborative efforts aimed at reducing expenses across the board.

References:

[1] Nasr Al-Hinai, Tarek Y. ElMekkawy, "Solving the Flexible Job Shop Scheduling Problem with Uniform Processing Time Uncertainty", In Proceedings of World Academy of Science, Engineering and Technology, 2012.

[2] Julia Chuzhoy, Rafail Ostrovsky, Yuval Rabani, "Approximation Algorithms for the Job Interval Selection Problem and Related Scheduling Problems", In proceedings of mathematics of operations research,2006.

[3] Sayedmohammadreza Vaghefinezhad, Kuan Yew Wong, "A Genetic Algorithm Approach for Solving a Flexible Job Shop Scheduling Problem, International Journal of Computer Science Issues (IJCSI), Vol. 9, Issue 3, May 2012.

[4] Pragati Jain, and Manisha Jain, "Fuzzy TOPSIS Method in Job Sequencing Problems on machines of unequal efficiencies", Canadian Journal on Computing in Mathematics, Natural Sciences, Engineering and Medicine, Vol. 2, No. 6, June 2011.

[5] S. M. Kamrul Hasan, Ruhul Sarker, and David Cornforth, "GA with Priority Rules for Solving Job Shop Scheduling Problems", In proceeding of: Evolutionary Computation, 2008.

[6] Eugeniusz Nowicki and Czesl Aw Smutnicki, "An Advanced Tabu Search Algorithm for the Job Shop Problem", Journal of Scheduling, Vol. 8, pp.145–159, 2005.

[7] Eugeniusz N. & Czesl S. (2005). An Advanced Tabu search Algorithm for The Job Shop Problem, Journal of Scheduling, 8,145–159.

[8] Joss Sanchez-Perez, (2011). A Payoff System for Job Scheduling Problems. Journal of Applied Mathematical Sciences,5, (19), 911 – 920.

[9] Kalavathy S. (2008). Operations Research 2nd ed. New Delphi Vikas Publishing House Pvt. Ltd.

[10] Merten A. G, Muller, M.E. (1972). Minimization in Single Machine Sequencing Problems. Management Science; 18 (5), 18–28.

[11] Nong Y., Xueping L., Toni F., Xiaoyun X., (2005). Job Scheduling Methods for Reducing Waiting Time Variance. Information and Systems Assurance Laboratory, Arizona State University, USA 875906, Tempe, AZ 85287-5906.

[12] Pragati J, & Manisha J. (2011). Fuzzy TOPSIS Method in Job Sequencing Problems on machines of unequal Efficiencies, Canadian Journal on Computing in Mathematics, Natural Sciences, Engineering and Medicine, 2, (6).

[13] Punit K, & Rakesh K. (2012). Path Optimization Algorithm for Network Problems Using Job Sequencing Technique. International Journal of Distributed and Parallel Systems (IJDPS),.3, (3), 301-309.

[14] Rao, N. Raju N. & Babu, R. (2013). Modified Heuristic time deviation technique for job sequencing and computation of minimum total elapsed time. International Journal of Computer Science & Information Technology (IJCSIT). 5. (3) 67-77.

[15] Debasis Mishra, Bharath Rangarajan, "Cost Sharing in a Job Scheduling Problem", ACM Conference on Electronic Commerce, 2005.

[16] Jacek Btaewicz, Wolfgang Domschke, Erwin Pesch, "The job shop scheduling problem: Conventional and new solution techniques ", European Journal of Operational Research, pp.1-33, 1996.

[17] Yu, J.-M. & Lee, D.-H. Scheduling algorithms for job-shop-type remanufacturing systems with component matching requirement, Computers & Industrial Engineering, Vol. 120, pp. 266-278, ISSN 0360-8352(2018).

[18] Velaga, P. (Optisol.biz) Various Approaches to Production Scheduling in Job Shops, Available from: https://optisol.biz/job_shop_scheduling.html, Accessed: 2018- 08-25(2018).

[19] Zhang, H. & Zhang, Y. Q. A discrete job-shop scheduling algorithm based on improved genetic algorithm. International Journal of Simulation Modelling, Vol. 19, No. 3, pp. 517-528, ISSN 1726-4529(2020).