A PROJECT REPORT

ON

"SEQUENCING: A CASE STUDY OF A COMPANY"

Submitted by

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In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Dr. Prof. ASIF GANDHI

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

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KALSEKAR TECHNICAL CAMPUS NEW PANVEL

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CERTIFICATE

This is to certify that the project entitled

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

Internal Examiner | **External Examiner**

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Head of Department | **Principal**

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APPROVAL OF DISSERTATION

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(Internal Examiner) **(External Examiner)**

____________________ ____________________

Date: 29/05/2021

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ABSTARCT

The purpose of this project is to determine the optimal sequence that is used in a company to get more profit and compare these profits with other's sequences that could be used for the process and see the differences in terms of profit. Johnson's algorithm is used to make this happen and reveal the optimal sequence among the different possible sequences. During this process the obtain data is firstly solved it with conventional methods and then it is been calibrated with Johnson's Algorithm. By applying various sequences, we concluded which will be the best sequence to perform the work. This sequence will lead to minimize ideal time between two machine and can increase the no jobs to be repaired increase in no jobs will lead to maximum profit

The results indicate that if the company would follow the optimal sequence of jobs to get processed then they would lead to earning more profit rather than following the bad sequence. This paper is based on the company that is used to repair different sizes of motors but which sequence they would follow that deals in this paper to obtain more profit on a real- time basis. This is a reviewed type paper where the use of Johnson's algorithm is introduced and shows the benefits of using optimal sequence.

Chapter 1

Introduction

1.1 Importance of Sequencing

1.2 What is Sequencing?

Introduction

In a production industry, where the production of various types of product is to be carried out required needs to be optimized so that they would earn more profit. The process of production from raw material to finished good undergoes different stages and various things incorporated in that and we need to consider every aspect in that, for examples, things incorporated in production is Forecasting, Aggregate planning, Inventory Control, Process planning, Line balancing, Scheduling, and Sequencing, etc. This paper is merely focused on the Sequencing of a job.

In the field of production planning and control, the concept of sequencing plays an important role to provide the optimal makespan. The case study is based on the company (Ultra Marine Pvt. Ltd.) producing the continuous production of the same type say jobs (J) that need to optimize to produce more profit in less or in optimal time. The research is based on finding the optimal sequence that is which job should be placed in which sequence to obtain more profit and eliminate or minimize the time elapsed.

Johnson's algorithm (1954) is one of the best theories where sequencing is introduced. It is followed since so many years back where we required to find out the optimal sequence for more productivity and more benefits. Johnson's algorithm helps to find out which job should be placed first and which job should be placed at last, so that the industry will follow the optimal sequence and produce more optimal output. But which theory is applicable in the problem is the most important criteria when using Johnson's algorithm theory for getting the correct results. In this paper, we will show the case study of a company (Ultra Marine Pvt. Ltd.) based on the problem with real-time data and we will provide the best optimal sequence against every possible sequence so that once get compared with other and see the results which one is optimal sequence and why Johnson's algorithm is very useful in sequencing concept.

The Company is used to repair the Motors of different sizes, categories as Heavy Motors (J1), Medium Motors (J2), and Small Motors (J3). The data obtained from the company is based on the time required for each job (J1, J2, and J3) at each process and we will use these data to find out the optimal sequence of the jobs so that we will able to see the total time elapsed for each sequence and which one gives optimal sequence and we will compare this with others sequences.

Before we dig down more into the calculation parts we will first see Johnson's theory applicability, how does it helps for selecting optimal sequence, and what assumptions are made in Johnson's rule.

1.1 IMPORTANCE OF SEQUENCING

Job sequencing problem has important applications in Production Industry and real world. In day-to-day life we come across the situation where one needs to save the time required for processing the products on different machines. Job sequencing plays an important role to find optimal job sequence to reduce the total time required when different products are processed on more than two machines. Job sequencing problem is to find the sequence of jobs which minimizes the time required for completing all the jobs. In general, different choices of job sequences1 are possible when we want to process n jobs on m machines. Hence it needs more time for calculations. In this case the sequencing technique becomes very effective as it reduces calculation work and time. There are many algorithms proposed for job sequencing problem. Johnson's algorithm is most commonly used for job sequencing but it has restricted application for n jobs m machines problem.

1.2 WHAT IS SEQUENCING?

Definition 1: *(Processing time)* Processing time required for a job to process on a particular machine.

Definition 2: *(Total Elapsed time)* Total elapsed time is the total time required to complete the jobs from start of first job to end of last job in a sequence.

Definition 3: *(Idle time)* Idle time is the time when there is no job to process on a machine. i.e., it is the time for which the machine remains free

Chapter 2

Literature Review

2.Literature Review

Sequencing problems in various manufacturing environments have been attracting many researches due to their computational complexity. They are coming under NP (Non deterministic polynomial time) hard class of problems. Among that, sequencing problems aiming at setup minimization have been undertaken in many literatures. P.R.McMullen (2001)[1] has provided an ant colony optimization approach for addressing JIT sequencing problem with multiple objectives as setup reduction and material utilization. A simulated annealing approach for set up coordination problem with multi criteria had been discussed by S.A. Mansouri [2] in 2006. Here the two objectives considered were maximization of overall utility and achievement of setup balance. Detti, Meloni and Pranzo (2007) considered the problem with the same objectives and they have provided a metaheuristic approach for the problem[3]. The studied problem can also be viewed as a special case of the tool-switch problem in a flexible machine (Tang and Denardo 1988, Crama 1997), in which the tool magazine can accommodate a limited number of elements of two different classes.

In particular, over the past few decades there have been significant efforts associated with reducing the time required to perform setups and developing suitable changeover modeling processes. This process can be quite complicated, but yields important benefits when planning and scheduling a production system improving both its production capacity and its manageability. An important survey on setup problems was given by Allahverdi et al. (2015)[3] and Mercado Detti. and Bard (1998) offer a review of the heuristics for setup problems in serial systems. P.R. Mcmullen (2001) has provided an efficient frontier approach for addressing JIT sequencing problem with set ups via search heuristics[4]. In this case three different algorithms i.e. genetic algorithm, simulated annealing and tabu search has been discussed to attain optimal results to a problem with multiple objectives in which setup reduction and material utilization were considered.

In the last decade a good number studies were undertaken by many researchers in varying shop floor environments. Angel-Bello et al. studied (2011)[5] sequence dependent setup minimization problem and proposed a MIP model and used a metaheuristic algorithm based on GRASP to solve it. Iranpoor (2012)[6] presented a travelling salesman formulation for setup reduction problem in which minimization of total tardiness was also achieved. He developed a branch and bound algorithm to attain the results. Lin and Hsieh (2014)[7] studied a similar problem under parallel machine environment and developed a MIP model. Aydilek and Allahverdi (2013) addressed a sequence independent problem under flow shop environment and proposed a few polynomial time heuristics to solve the problem. Shen(2014) presented a tabu search based approach for setup problem in job shop condition where additionally completion time was also minimized. More recently Kress and Pesch (2018)[8] provided an approximate algorithm for a single machine setup problem to minimize total setup cost in the presence of a deadline.

A few reviews were gathered together as a part of project

Author of "Finding an Optimal Sequence in the Flow shop Scheduling Using Johnson's Algorithm" Prabhu M.S, Sankar D and Paramguru stated that the study for two machine and more than two machine problems Johnson and Extended Johnsons Algorithm are used to find the make span and idle time for a particular factorial series.

Author of "Application of Johnson's Algorithm in processing jobs through two-machine system" Modestus Okwu and Ikuobase Emovon stated that Johnson's algorithm has been effectively demonstrated as an effective technique for accurately scheduling and optimizing time.

Author of "Johnson Algorithm: A key to solve optimally flow shop scheduling problems with unavailability periods" Hamid Allaoui and Abdel Hakim Artiba stated that It is most classical algorithm in scheduling area that gives optimal solution to the two-machine flow shop to minimize the makespan in polynomial time

2.1 COMPANY REVIEW

Under Water Ship Repair Services, Marine Repair Services & Marine Engines Repair Services Service Provider offered by Ultra Marine from Mumbai, Maharashtra, India.

Ultra Marine (Engineers & Ship Repairers) was established in the year 2009 with an aim to provide complete customized solutions and quality services in the field of engineering and ship repairs. Since inception Ultra Marine have Been continuously expanding apart from our Head office at Mumbai, we have extended our services at Karwar, Visakhapatnam with well-established workshop, site office at CSL-Kochi and branch office at Chennai and work force that are well experienced and acquainted with Naval environment.

Further, following are indicative of our technical expertise and quality of works.

- We are proud winner of 2016 MSME award for outstanding performance in marine fabrication engineering and allied services.
- We are also certified by BMS for ISO 9001 : 2015, 14001: 2015 and 45001: 2018
- We have been evaluated for SMERA MSE 2 by SMERA indicative of high financial strength and high operating performance.
- We can undertake any kind of works pertaining to marine fabrication, engineering and allied services.

1. **Hull/Vessel Structure: -** Structure fabrication, installation, and repair on ships & in submarines, all Deck Machineries, Hull outfitting titanium welding, etc..,

2. **Engineering: -** Executing of Engineering projects, Restoration of all equipment's like shaft, propellor, diesel engine and gear box, boiler system, turbines, stearing hydraulic systems, valves, piping in Ships, Submarines etc.,

3. **Electrical: -**Radars, Missile launchers, Internal communication systems, Laundry/Galley, Motors/alternators, control panels and starters.

Chapter 3

Problem Definition

3.1 Johnson's Theory Assumptions

3.2 Data Collected from the Company

Problem Definition

In company there was repairing of motor which is categorized in three different sizes such as Heavy, Medium & Small so during our visit we gone through various process which include during its assembly and dismantling.

So according to Johnson's Algorithm to reduce elapsed time we need to note the time require for all process which is used during the repairing and make use of this data for calculating less ideal time

Once the data is collected in tabulated form in minute basis, we were ready to apply it. For ease of understanding and calculation we denoted various process by small alphabetical order and the motor is denoted with J1, J2 & J3 for Heavy, Medium & Small respectively

All the collected real time data was noted in minute basis. Further this data is used in calculation to find out optimal sequence so as to reduce less ideal time between two machines by applying various sequence we found out the best sequence for the work

3.1 Johnson's Theory Assumptions

The Johnson's algorithm is one of the best methods for finding the optimal sequence among several different choices of sequencing processes. It is not only saving the time for selecting best sequence but also provide the accurate solution for finding optimal sequence to reduce or optimize total makespane. It has widely been used and accepted since so many years back in the production industries for getting best results and saving times so that to produce a greater number of products in less time and to increase productivity to earn more profit for the company.

It is only applicable in the areas where continuous number of products is to being produced. But it has some limitations it can only work optimally between two work station problems and we can have the following choices of products being processed under the machines are,

i. N jobs with One machine

ii. N jobs with Two machines.

iii. N jobs with Three machines.

iv. Two jobs with M machines.

v. N jobs with M machines.

We have to select the appropriate methods of above listed to apply Johnson's algorithm theory. But in industries we can have M numbers of machine for the product to get processed in order to obtain final result of products so can assume or convert these M machine problems into two machines/work center problem by using Johnson's algorithm. For example, if there are four machines then the sum of process time of the first three machines would be considered as for the first machine and the sum of process time of the last three machines would be considered as for the second machine. The job process with the shortest time at first work center should be placed at first and if the shortest time for job process is from second work center then the job should be placed at last.

3.2 Data Collected from the Company

The following (Table 1) recorded the times required to get each process done for there jobs (J1-Heavy Motors, J2- Medium Motors, J3-Small Motors) are in minutes. Following notation were used in the table for there processes,

a	Painting
b	Insulation
c	Winding Preparation
d	Winding Insertion
e	Connection
f	Varnish
g	Bearing Mounting
h	Rotor Fitting
i	Final Fitting (Fastening)
a_i, bi,.....i_i	Process time for each job through each process
M1	First work center
M2	Second work center

Table 1. Data from the company (Times in minutes)

Table 1. Data from the company (Times in minutes)

Jobs	a	b	c	d	e	f	g	h	i
J1	5	24	83	100	120	5	15	10	60
J2	4	18	60	80	95	3	10	8	45
J3	2	8	30	30	40	2	7	5	20

Chapter 4

Findings and Calculation

4. Findings and Calculation

In this chapter we will use conventional method of solving problem by knowing each process elapsed time. Applying various sequences in conventional method we will get elapsed time for various sequences then all these sequences we will compare with each other and take out the process which have minimum elapsed time than other.

Once this minimal elapsed time sequence is founded, we will apply the well trusted algorithm i.e., Johnson's Algorithm on that process just to calibrate the conventional method results are matching with the algorithm results as both the results is matched then we get the best sequence for the complete process that will lead to less elapsed time and an optimal sequence

4.1 Sequence J1-J3-J2

Jobs	a		b		c		d		e	
	In	Out	In	Out	In	Out	In	Out	In	Out
J1	0	5	5	29	29	112	112	212	212	332
J3	5	7	29	37	112	142	212	242	332	372
J2	7	11	37	55	142	202	242	322	372	467

Jobs	f		g		h		i	
	In	Out	In	Out	In	Out	In	Out
J1	332	337	337	352	352	362	362	422
J3	372	374	374	381	381	386	422	442
J2	467	470	470	480	480	488	488	**533**

Total time elapsed = last job (J1) out – first job (J3) in

=

Total time elapsed = minutes.

4.1.1 Idle time for Process J1-J3-J2

Idle time for Process A:

= 533 - 11 = 522 minutes

Idle time for Process B:

= 5 + (29 - 29) + (37 - 37) + (533 - 55) = 483 minutes

Idle time for Process C:

= 29 + (112 - 112) + (142 - 142) + (533 - 202) = 360 minutes

Idle time for Process D:

=112 + (212 - 212) + (242 - 242) + (533 - 322) = 323 minutes

Idle time for Process E:

= 212 + (332 - 332) + (372 - 372) + (533 - 467) = 278 minutes

Idle time for Process F:

= 322 + (372 - 337) + (467 - 374) + (533 - 470) = 513 minutes

Idle time for Process G:

= 337 + (374 - 352) + (470 - 381) + (533 - 480) = 501 minutes

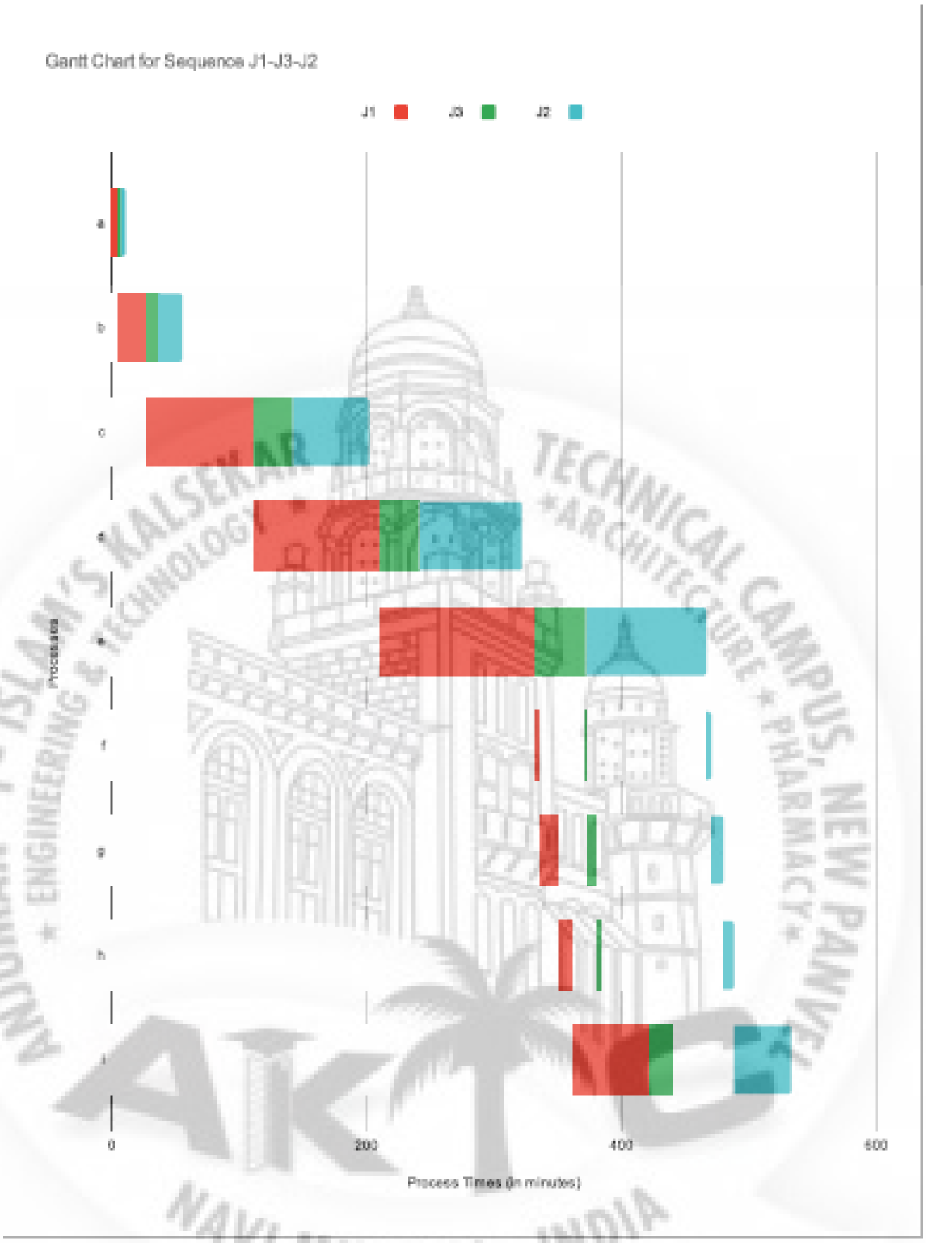
Idle time for Process H:

= 352 + (381 - 362) + (480 - 386) + (533 - 488) = 510 minutes

Idle time for Process I:

= 362 + (422 - 422) + (488 - 442) = 422 minutes

4.1.2 GANTT CHART FOR J1 J3 J2



4.2 Sequence J1-J2-J3

Jobs	a		b		c		d		e	
	In	Out	In	Out	In	Out	In	Out	In	Out
J1	0	5	5	29	29	112	112	212	212	332
J2	5	9	29	47	112	172	212	292	332	427
J3	9	11	47	55	172	202	292	322	427	467

Jobs	f		g		h		i	
	In	Out	In	Out	In	Out	In	Out
J1	332	337	337	352	352	362	362	422
J2	427	430	430	440	440	448	448	493
J3	467	469	469	476	476	481	493	**513**

4.2.1 Idle time for Process J1-J2-J3

Idle time for Process A:

= 513 - 11 = 502 minutes

Idle time for Process B:

= 5 + (29 - 29) + (47 - 47) + (513 - 55) = 463 minutes

Idle time for Process C:

= 29 + (112 - 112) + (172 - 172) + (513 - 202) = 340 minutes

Idle time for Process D:

=112 + (212 - 212) + (292 - 292) + (513 - 322) = 303 minutes

Idle time for Process E:

= 212 + (332 - 332) + (427 - 427) + (513 - 467) = 258 minutes

Idle time for Process F:

= 322 + (427 - 337) + (467 - 430) + (513 - 469) = 493 minutes

Idle time for Process G:

= 337 + (430 - 352) + (469 - 440) + (513 - 476) = 481 minutes

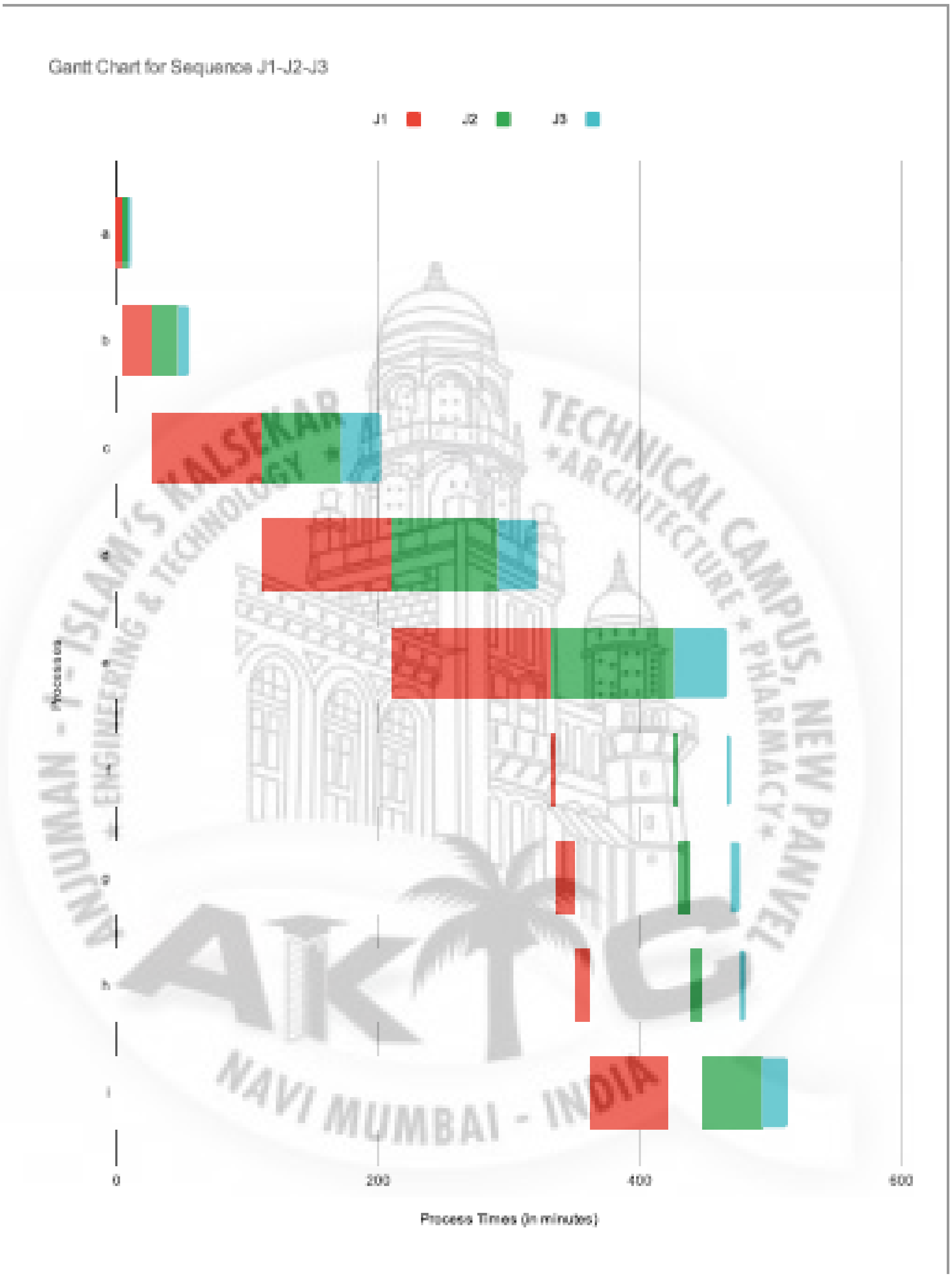
Idle time for Process H:

= 352 + (440 - 448) + (476 - 488) + (513 - 481) = 364 minutes

Idle time for Process I:

= 362 + (448 - 422) + (493 - 493) = 388 minutes

4.2.2 Gantt Chart for J1-J2-J3



4.3Sequence J2-J3-J1

Jobs	a		b		c		d		e	
	In	Out	In	Out	In	Out	In	Out	In	Out
J2	0	4	4	22	22	82	82	162	162	257
J3	4	6	22	30	82	112	162	192	257	297
J1	6	11	30	54	112	195	195	295	297	417

Jobs	f		g		h		i	
	In	Out	In	Out	In	Out	In	Out
J2	257	260	260	270	270	278	278	323
J3	297	299	299	306	306	311	323	343
J1	417	422	422	437	437	447	447	**507**

4.3.1 Idle time for Process J2-J3-J1

Idle time for Process A:

= 507 - 11 = 496 minutes

Idle time for Process B:

= 4 + (22 - 22) + (30 - 30) + (507 - 54) = 457 minutes

Idle time for Process C:

= 22 + (82 - 82) + (112 - 112) + (507 - 195) = 334 minutes

Idle time for Process D:

= 82 + (162 - 162) + (195 - 192) + (507 - 295) = 297 minutes

Idle time for Process E:

= 162 + (257 - 257) + (297 - 297) + (507 - 417) = 252 minutes

Idle time for Process F:

= 257 + (297 - 260) + (417 - 299) + (507 - 422) = 477 minutes

Idle time for Process G:

= 260 + (299 - 270) + (422 - 306) + (507 - 437) = 463 minutes

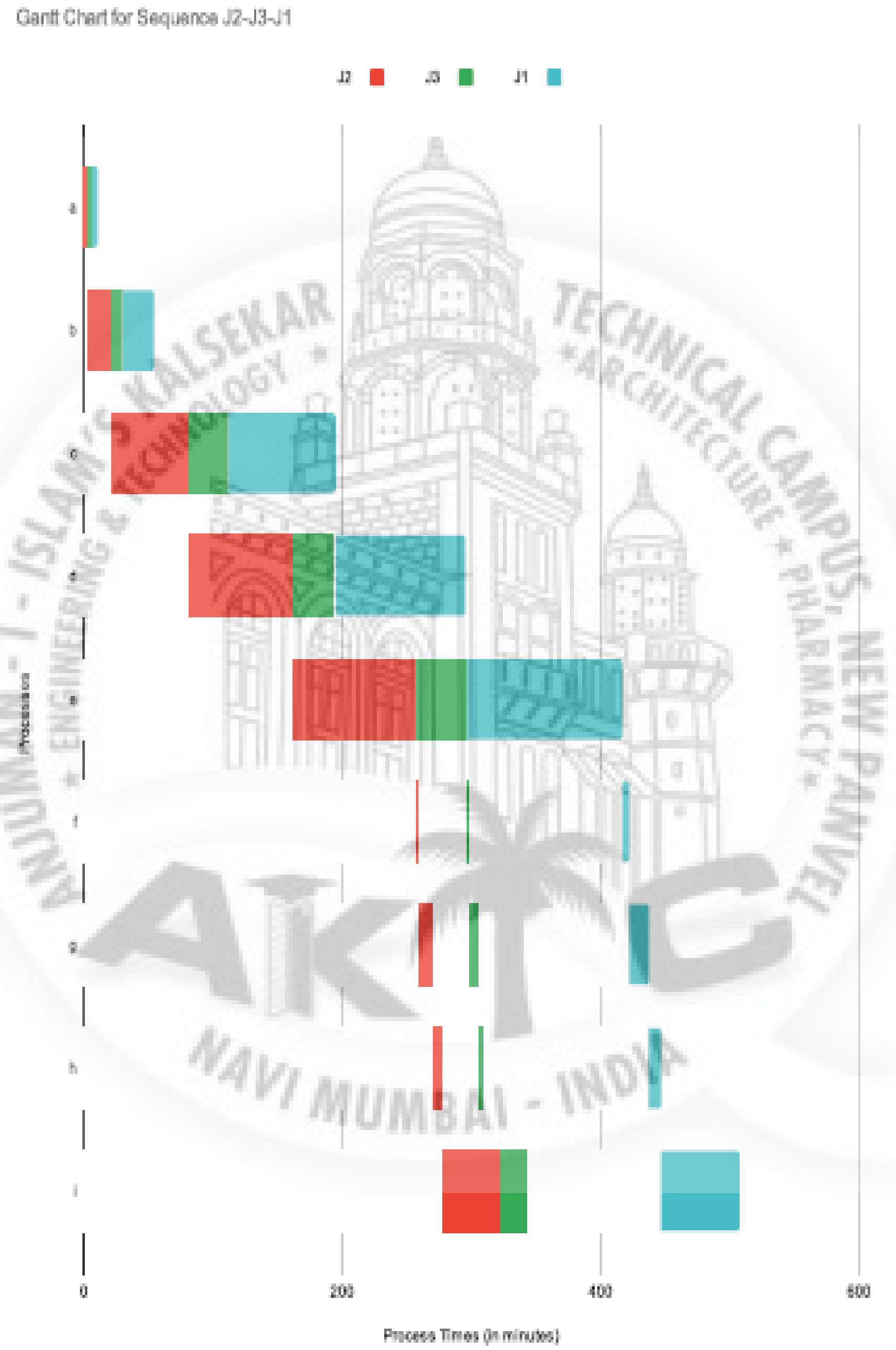
Idle time for Process H:

= 270 + (306 - 278) + (437 - 311) + (507 - 447) = 484 minutes

Idle time for Process I:

= 278 + (323 - 323) + (447 - 343) = 382 minutes

4.3.2 Gantt Chart for J2-J3-J1



4.4 Sequence J3-J1-J2

Jobs	a		b		c		d		e	
	In	Out	In	Out	In	Out	In	Out	In	Out
J3	0	2	2	10	10	40	40	70	70	110
J1	2	7	10	34	40	123	123	223	223	343
J2	7	11	34	52	123	183	223	303	343	438

Jobs	f		g		h		i	
	In	Out	In	Out	In	Out	In	Out
J3	110	112	112	119	119	124	124	144
J1	343	348	348	363	363	373	373	433
J2	438	441	441	451	451	459	459	**504**

4.4.1 Idle time for Process J3-J1-J2

Idle time for Process A:

= 504 - 11 = 493 minutes

Idle time for Process B:

= 2 + (10 - 10) + (34 - 34) + (504 - 52) = 454 minutes

Idle time for Process C:

= 10 + (40 - 40) + (123 - 123) + (504 - 183) = 331 minutes

Idle time for Process D:

= 40 + (123 - 70) + (223 - 223) + (504 - 303) = 297 minutes

Idle time for Process E:

= 70 + (223 - 110) + (343 - 343) + (504 - 438) = 249 minutes

Idle time for Process F:

= 110 + (343 - 112) + (438 - 348) + (504 - 441) = 494 minutes

Idle time for Process G:

= 112 + (348 - 119) + (441 - 363) + (504 - 451) = 472 minutes

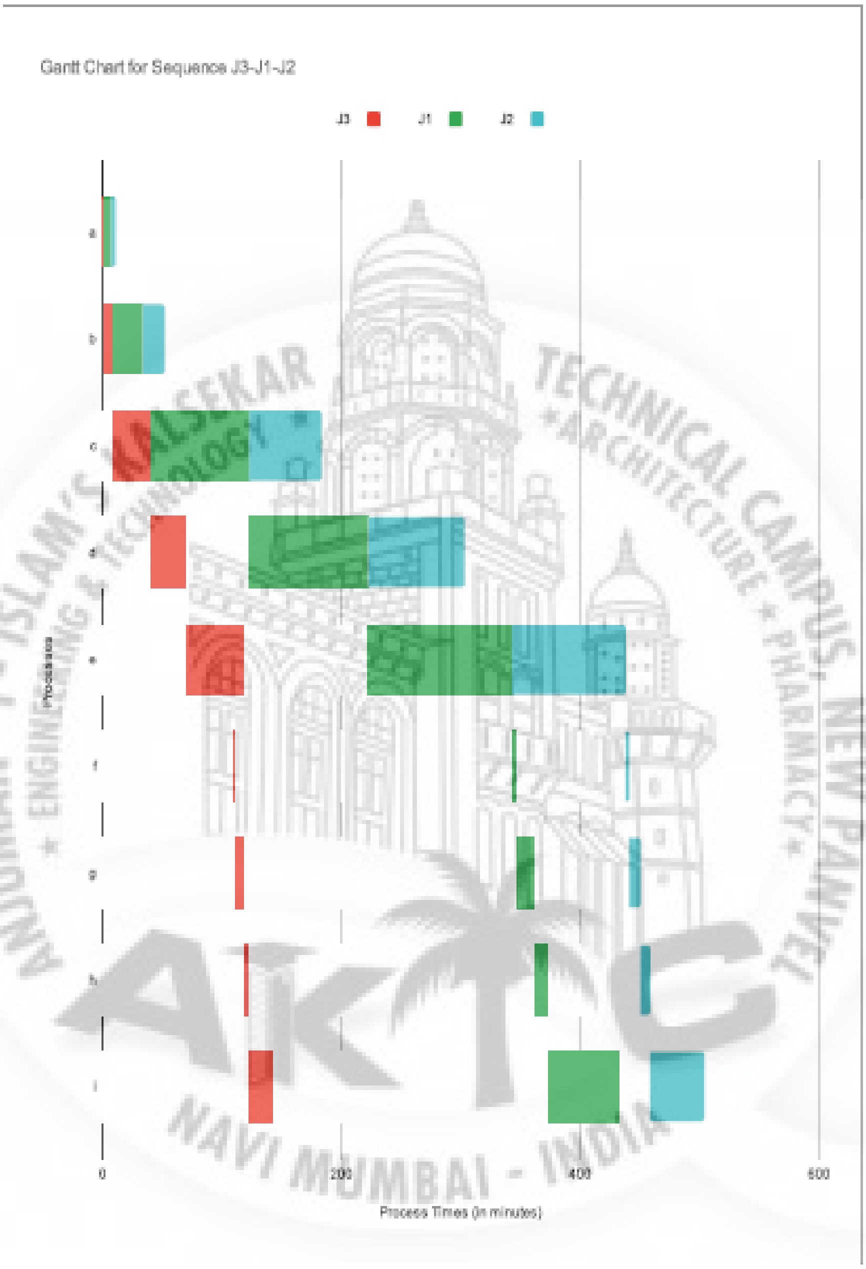
Idle time for Process H:

= 119 + (363 - 124) + (451 - 373) + (504 - 459) = 481 minutes

Idle time for Process I:

= 124 + (373 - 144) + (459 - 433) = 379 minutes

4.4.2 Gantt Chart for J3-J1-J2



4.5 Sequence J2-J1-J3

Jobs	a		b		c		d		e	
	In	Out	In	Out	In	Out	In	Out	In	Out
J2	0	4	4	22	22	82	82	162	162	257
J1	4	9	22	46	82	165	165	265	265	385
J3	9	11	46	54	165	195	265	295	385	425

Jobs	f		g		h		i	
	In	Out	In	Out	In	Out	In	Out
J2	257	260	260	270	270	278	278	323
J1	385	390	390	405	405	415	415	475
J3	425	427	427	434	434	439	475	**495**

4.5.1 Idle time for Process J2-J1-J3

Idle time for Process A:

= 495 - 11 = 484 minutes

Idle time for Process B:

= 4 + (22 - 22) + (46 - 46) + (495 - 54) = 445 minutes

Idle time for Process C:

= 22 + (82 - 82) + (165 - 165) + (495 - 195) = 322 minutes

Idle time for Process D:

= 82 + (165 - 162) + (265 - 265) + (495 - 295) = 285 minutes

Idle time for Process E:

= 162 + (265 - 257) + (385 - 385) + (495 - 425) = 240 minutes

Idle time for Process F:

= 257 + (385 - 260) + (425 - 390) + (495 - 427) = 485 minutes

Idle time for Process G:

= 260 + (390 - 270) + (427 - 405) + (495 - 434) = 463 minutes

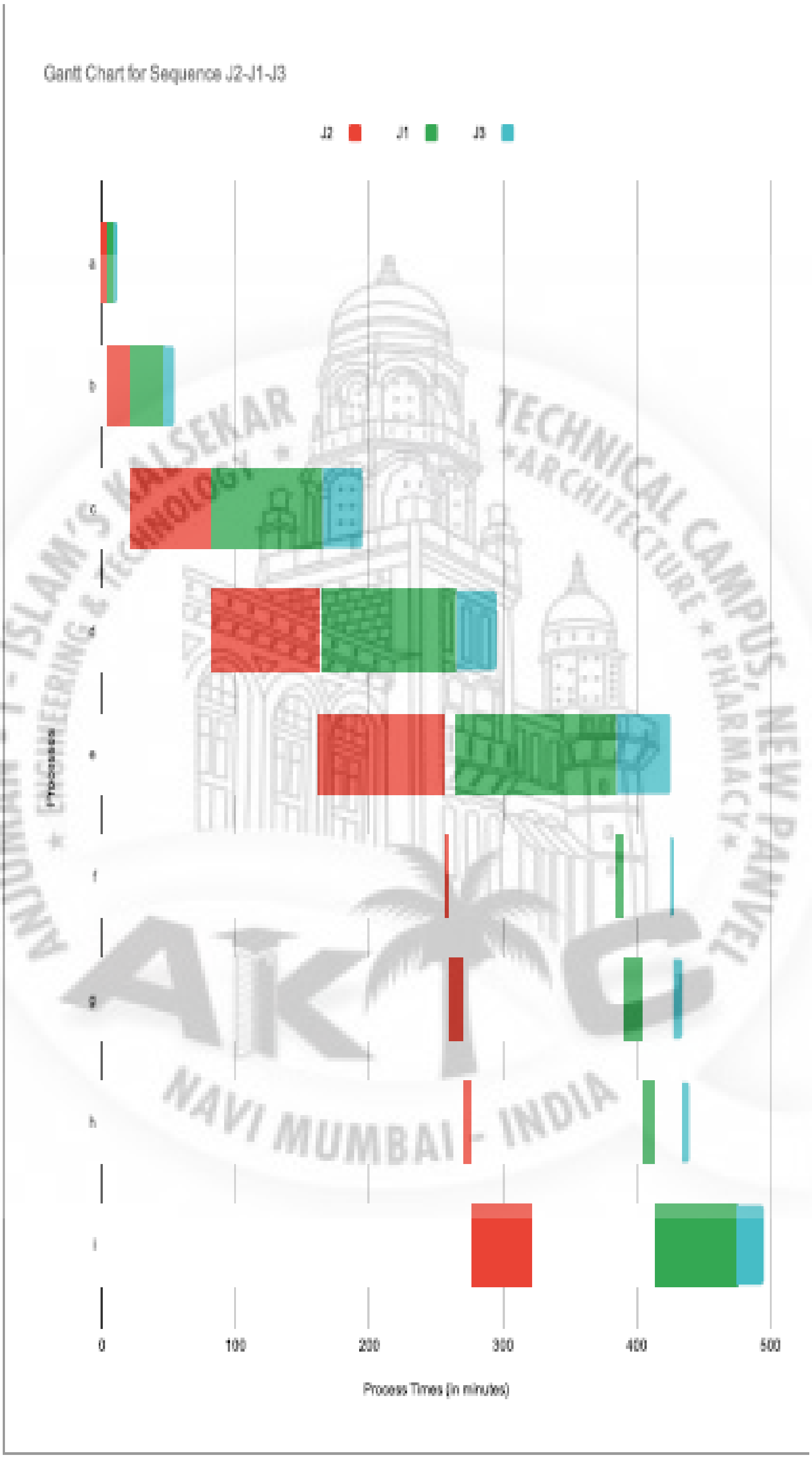
Idle time for Process H:

= 270 + (405 - 278) + (434 - 415) + (495 - 439) = 472 minutes

Idle time for Process I:

= 278 + (415 - 323) + (475-475) = 370 minutes

4.5.2 Gantt Chart for J2-J1-J3



4.6 Sequence J3-J2-J1

Jobs	a		b		c		d		e	
	In	Out	In	Out	In	Out	In	Out	In	Out
J3	0	2	2	10	10	40	40	70	70	110
J2	2	6	10	28	40	100	100	180	180	275
J1	6	11	28	52	100	183	183	283	283	403

Jobs	f		g		h		i	
	In	Out	In	Out	In	Out	In	Out
J3	110	112	112	119	119	124	124	144
J2	275	278	278	288	288	296	296	341
J1	403	408	408	423	423	433	433	493

4.6.1 Idle time for Process J3-J2-J1

Idle time for Process A:

= 493 - 11 = 482 minutes

Idle time for Process B:

= 2 + (10 - 10) + (28 - 28) + (493 - 52) = 443 minutes

Idle time for Process C:

= 10 + (40 - 40) + (100 - 100) + (493 - 183) = 320 minutes

Idle time for Process D:

= 40 + (100 - 70) + (183 - 180) + (493 - 283) = 293 minutes

Idle time for Process E:

= 70 + (180 - 110) + (283 - 275) + (493 - 403) = 238 minutes

Idle time for Process F:

= 110 + (275 - 112) + (403 - 278) + (493 - 408) = 483 minutes

Idle time for Process G:

= 112 + (278 - 119) + (408 - 288) + (493 - 423) = 461 minutes

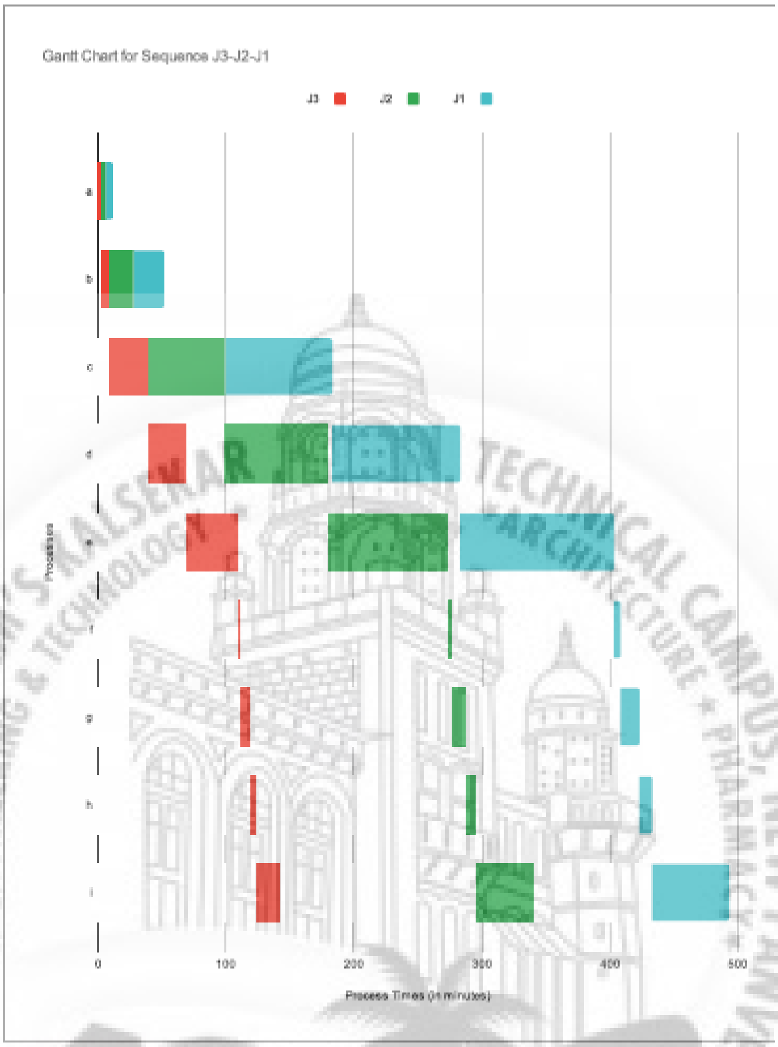
Idle time for Process H:

= 119 + (288 - 124) + (423 - 296) + (493 - 433) = 470 minutes

Idle time for Process I:

= 124 + (296 - 144) + (433 - 341) = 368 minutes

4.6.2 Gantt Chart for J3-J2-J1



Chapter 5

Benefits of Johnson's algorithm over conventional process

Benefits of Johnson's algorithm over conventional process

Johnson's algorithm is become an important for finding the optimal sequence among several different choices of combination. In previous chapter we present the way to find out the optimal sequence by following and finding total elapsed time for each process. But in actual practice it won't be useful in industrial applications because it demands large amount of time for computation that is not desirable for any industry. We can do it by manually but in case of large amount of jobs would be there then human mind feels difficulty for doing and finding the total elapsed time for each processes and comparing the results with others sequences. For avoiding that difficulties Johnson's rule plays an important role for finding the optimal sequence among the several sequence just because it saves time and that leads to earn more profit for there industries. The next section discuss the methods of finding the optimal sequence by using Johnson's algorithm, how does it works and why it is widely accepted since so many years back?

5.1 Methods to solve problem by using Johnson's algorithm

The data obtained from the company were processing of three jobs (i.e. Heavy motors (J1), Medium motors (J2), and Small motors (J3)) through nine machines and this follows the case of processing n jobs through m machines. The time required for each job through each process is recorded in the following (Table 1).

(Table 1) represents the processing times of each job through each process and we are required to find out the optimal sequence of jobs J1, J2, and J3. First, we need to convert these nine processes into two work center process that could be done by the following method;

M1 = ai + bi + ci + di + ei + fi + gi + hi

M2 = bi + ci + di + ei + fi + gi + hi + ii

(Table 2) represent the processing of *n* jobs (i.e., three jobs) through two work centers, now the Johnson algorithm can be applied to determine the optimal sequence.

Jobs	M1	M2
J1	362	417
J2	278	319
J3	124	142

From (Table 2) to determine the optimal sequence as per Johnson's rule placed the job of shortest time at first if it is from the first work center and the job of shortest time if it is from second work center then placed it at last. In our case,J3 is of shortest process time from the first work center the placed J3 at first in our sequence and eliminate this row from the further calculation. Next, the shortest process time is J2 from the first work center placed J2 to the second in our sequence and eliminate this row from the further calculation. Now, only J1 is left then placed it at last in on our sequencetable

For example, the job with shortest process time is 124 minutes from first work center, therefore it should be place at first

J3	**?**	**?**

Now eliminate J3 from further consideration

Jobs	M1	M2
J1	362	417
J2	278	319

Now job with shortest process time is 278 minutes from first work center, therefore it should be place at second place and eliminate J2 from further consideration Now we will have only J1 left therefore J1 should be placed at last.

J3	**J2**	**J1**

Hence by applying line Johnson's Algorithm we got the optimal sequence as **J3 J2 J1.** That is why Johnson Algorithm plays an important role in sequencing problem to save time.

Chapter 6

Results and Discussion

Results and Discussion

Total time elapsed followed by sequence J3-J2-J1 is 493 minutes (i.e. 8hours and 13minutes) which is the optimal sequence that we find by Johnson's algorithm but we need to check whether this sequence is optimal or not. This can becompared by referring to (Table 4). This table gives the comparison of the total time elapsed with another sequence i.e.sequence J1-J2-J3, J1-J3-J2, etc.

We can compare the results that if we follow the optimal sequence then which benefits are there, we can see if we followthe first sequence i.e., J1-J3-J2, then only 18 jobs going to produce in a month rather than if we follow the optimal sequence i.e., J3-J2-J1, we can produce 20 jobs in a month of each type (i.e., Small motors, Medium motors, and Heavy motors).

It is obviously seen that we can produce 20 jobs by following the sequence J2-J1-J3 and J3- J1-J2 but following these sequences we can have less time left in a month as compared to the optimal sequence. This left time in a month can be saved and it is always desirable for any industry to save more time so that they would utilize those time for other production.

Table 4. Result of various sequences

Sequence	**Elapsed Time**	**Output** (Assume 7 hours per day)	**No. of Jobs in a month (Assume 6 days per week)**	**Time left in a month**
J1-J3-J2	8hrs 53min	1Day 1hrs 53min	18	8hrs 6min
J1-J2-J3	8hrs 33min	1Day 1hrs 33min	19	5hrs 33min
J2-J3-J1	8hrs 27min	1Day 1hrs 27min	19	7hrs 27min
J3-J1-J2	8hrs 24min	1Day 1hrs 24min	20	0
J2-J1-J3	8hrs 15min	1Day 1hrs 15min	20	3hrs

J3-J2-J1	**8hrs 13min**	**1Day 1hrs 13min**	**20**	**3hrs 40min**

(Table 5) Compares the results in terms of profit they would earn on a monthly basis by following the bad sequence andthe optimal sequence and how much percentage of time they would save by following the optimal sequence. So that, they will be able to produce more jobs with saving more times to obtain more profit.

Table 5. Result of various sequences on monthly basis

Sequence	Profit rate (%)	Profit Value (Assume Rs1000 for each)	Saving Time (%)
J1-J3-J2	90	54000	4.82
J1-J2-J3	95	57000	3.3
J2-J3-J1	95	57000	4.43
J3-J1-J2	100	60000	0
J2-J1-J3	100	60000	1.78
J3-J2-J1	100	60000	218

Chapter 7

Conclusion

Conclusion

Referring various papers and their reviews we concluded that for finding out optimal sequence for the batch productionor continuous production Johnson's algorithm is widely accepted hence by applying Johnson's algorithm in a real timedata which we recorded in Ultra Marine Pvt. Ltd., while applying the algorithm we tried various sequence of operationfor example, J1-J2-J3, J2-J1-J3, J1-J3-J2, etc. to find out optimal sequence. Hence by changing various sequence we satisfactorily got an optimal sequence as **J3-J2-J1** in our finding so that if this sequence is applied there will be a less ideal time and a greater number of products will be going to repair in workshop. This increase in number of jobs repairthat will lead to improve the productivity of plant and increase in profit

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Chapter 8

References

References

[1] Johnson's algorithm: A key to solve optimally or approximately flow shop scheduling problems with
unavailability periods, Int. J. Production Economics 121 (2009), 81–87.

[2] Operation Research by Er. Prem Kumar Gupta and Dr. D.S. Hira, S. Chand & Company Pvt. Ltd. (An ISO 9001: 2008 Company), Seventh Editions, 445 – 493.

[3] Lee, C.Y., 1999. Two-machine flowshop scheduling with availability constraints. Eur. J. Oper. Res. 114 (2), 198–207.

[4] Kuik, R., Salomon, M., Van Wassenhove, L.N., 1994. Batching decisions – Structure and models,European Journal of Operational Research 75, 2, 243–263.

[5] Efficient sequencing of industrial robots through optimal control, Staffan Björkenstam et al. / ProcediaCIRP 23 (2014) 194 – 199.

[6] Lee, C.Y., Vairaktarakis, G.L., 1994. Minimizing makespan in hybrid flowshops. Oper. Res. Lett. 16, 149–158.

[7] Job sequencing problem using deviation technique, Research Journal of Mathematical and Statistical Sciences Vol. 5(5), May (2017), 9-13.

[8] Kumar Sandeep and Jadon Pooja (2014). A Novel Hybrid Algorithm for Permutation Flow Shop Scheduling. Int. J. of Comp. Sci. and Info. Tech. (IJCSIT), 5(4), 5057-5061.

[9] Singh Kumar Punit and Kumar R. (2012). Path Optimization Algorithm for Network Problems using Job Sequencing Technique. Int. J. of Dist. and Para. Sys (IJDPS), 3(3), 301-309.

[10] Gupta Srikant, Ali Irfan and Ahmed A. (2016). A New Algorithm for Solving Job Shop Sequencing Problem Int.J of comp sci Engg(IJCSE), 5(2), 93-100
Int. J. of Comp. Sci. Engg.(IJCSE), 5(2), 93-100.