ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

UTILISING A DYNAMIC APPROACH TO REDUCE TARDINESS FOR SCHEDULING ISSUES WITH DISTINCT DUE DATES AND JOB BLOCKING TECHNIQUE TO REDUCE COST OF TARDINESS AND EARLY ARRIVAL

E.JANAKI[1]AND A.MOHAMED ISMAIL[2] ,SINI RAHUMAN[3]

[1]Research Scholar Sathyabama Institute Of Science And Technology,Department Of Mathematics, Chennai, India
[2]Sathyabama Institute Of Science And Technology, DepartmentOf Mathematics, Chennai, India
[3]BahrainTechnical College,Department Of Mathematics, Bahrain
E.Mail: [1]januelango@gmail.com

ABSTRACT

The goal of this work is to reduce the overall earliness cost when scheduling independent jobs with varied due dates on a single machine. Dynamic programming for a single machine and Johnson's method based approach for a flow shop are the two precise solutions suggested for the problem. In the manufacturing and service industries, sequencing and scheduling is the critical part of decision-making. Effective sequencing and scheduling has become a requirement for market survival in today's competitive economy. Companies must adhere to shipping deadlines that have been promised to clients. In this paper, we will discuss about different types of machines for different types of jobs through Phase –I ,Phase–IIand Phase III. The objective ofthis paper to minimize the Tardiness by using Dynamic approach and job blocking method.

Keywords: *Single Machine, Flow Shop, Earliness, Tardiness, Dynamic Approach, Blocking Jobs*

1. INTRODUCTION

Scheduling is the process of allocating tasks to resources over a period of time. Finally, jobs are organized in order of problem performance metric. There may be an influence from several limitations, including activity length, release and due dates, prioritizing restrictions, and resource availability.
At the turn of the century, manufacturers started to take scheduling seriously thanks to the efforts of Henry Gantt and other pioneers. On the other hand, it took a while for the first scheduling publications to appear in the literature of industrial engineering and operations research.

Ye, H., Wang, et al. actively adopted dynamic scheduling when a machine breaks down or needs maintenance during production. Predictive scheduling is also an extension of FSP, and certain actions have been made in the related literature research. [1] Hamdi et al.[2] provided many genetic algorithm versions based on various genetic operators to reduce the makespan in a two-machine cross-docking FSP. By J. Heller, heuristics and meta heuristics have spent decades devoting more attention to discovering accurate solutions in a reasonable amount of time. [4] Genetic algorithms were employed by C. R. Reeves, Y. Zhang, Anna et al. [5,12] to address the flow shop problem. In order to lessen overall weighted earliness, Chen and
Powell [6] examine two parallel machine scheduling
issues.to solve the problem. It was based on a par adigm of mixed integer linear programming
With capacitated machines and hybrid make-to-order and make-to-stock production management policy limits, Abdollahpour and Rezaian [9] addressed the no-wait flexible flow shop scheduling challenge. As objective
functions, they employed the reduction of the total of tardiness, weighted earliness, weighted rejection, and weighted incomplete costs Ali Allah Verdi [10] highlighted the challenge of scheduling three machine flow shops where setup and processing time are treated separately

Journal of Theoretical and Applied Information Technology
15th August 2023. Vol.101. No 15

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

and only the start and end times are known. As a result, he proposed the dominance relation, which aids in reducing the size of the dominant schedule. Taillard35 offered 120 standards, which he split into 12 groups based on their sizes. The sizes of these difficulties were larger than the few published instances and corresponded to real-world industrial problem. Using the minimization of the maximum task completion time constraint, Framinan and Nagano [14] proposed a innovative solution for the am m machine no-wait flow shop problem. They focused on getting the best response in the quickest amount of time possible. For this, they compared the problem to the TSP problem. JacekBłażewicz [15] explained the difficulties of open shop scheduling due to limited machine availability. Polynomial-time algorithms based on the two-phase technique for pre-imputableworkloads. Deepak Gupta [16] uses parallel machines at each stage, including the time spent traveling. Johnson [17] was the first to investigate the permutation flow-shop problem. The flow-shop scheduling problem (PFSP), an NP-hard task, has gotten a lot of attention in the multi objective field .For more than two decades, the Nazwa-Enscore-Ham (NEH) [18] heuristics had been a well-known approach for makespan minimization. The PFSP's goal is to optimize the performance measure by determining the order in which jobs are processed in all machines. To handle a complicated multi product scheduling problem with a no wait constraint, Liang et al[19].Ko-Wei Huang [20]used a simulated annealing algorithm for local search to following the PSO search procedure, enhance the best solution. Y. Chen, X. Li, R. Sawhney,[21]used bounded processing time to solve the flow shop scheduling problem .A number of effective heuristics and optimal algorithms have been created by Kedad-Sidhoum, S. and Sourd, F.[22] developed a hybrid algorithm based on GA and SA. To effectively deal with FSP, Costa et al.[23] presented a hybrid meta heuristic process combining features from genetic algorithms and random sample search methods. Xie and Wang [24] introduced and compared a unique approach known as the Minimum Deviation Algorithm (MDA) for the no-wait two-stage flexible flow shop problem, which uses the minimization of maximum job completion time. E. Janaki &*A. Mohamed Ismail,*(25) studied job block criteria for three machine flow shop problem. In single-machine environments, problems with earliness costs and tardiness costs have been thoroughly investigated by J. Kanet and V. Sridharan[26]. Furthermore, the unit earliness or tardiness cost for task j in the single-machine decision variable of machine I is retrieved from the dual variable is described by P.L. Maggu and G. Das[27]obtained from this repetition. Baker[3] and Trietsch[28] discovered that they all exceeded all expectations, with expected makespan values that were on average within 1% of the best value found. Baskar A, Anthony XaviorM[29] discussed about scheduling problem for batch processing industry and used Taillard bench mark problem. Reeves [30] shown the viability of utilizing GA to solve such problems by developing a functional algorithm. Because of its simplicity, adaptability, and durability, GA has since become one of the most common algorithms for job shop scheduling problems.

The temperature housing sensor is a part which is used in cable harners assembly. The part which consist of milling operation it in side grooving drilling, chamfering operation. It is a small part, in this we planned to reduce tardiness and earliness by machine setting loading time and unloading time.

Special fixture is made were 10 raw material in a wise and done the CNC programming according to it where we produce mass production and meet our delivery on time. Which has Three phase one is machining part and remaining is probable harness.

In machinery we planned to reduce Tardiness and earliness by which we can increase the production , reduce the cost to company , on time delivery , customer satisfaction Inventory control etc,. The tool room is the location where tools are stored, prepared, repaired, and machined. Depending on the types of tool room machines and applications, the surface size can be adjusted. In this paper we will discuss about different types of machines for different type of jobs through Phase –I ,Phase-II and Phase –III.

Phase –I consists of Milling Operations which is Machined for Tool Room Jobs for the Production Part. In Tool Room job were machining the Holding , Jaws, Wedges for Clamping the part in datum point First Machine will do different jobs like Jaws, Wedges, Bolt &Nut, Fixture and Jigs with different processing time. Phase-II &III Consists Cutting machine, and Flow shop machine like Crimping, solder, Testing machine

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

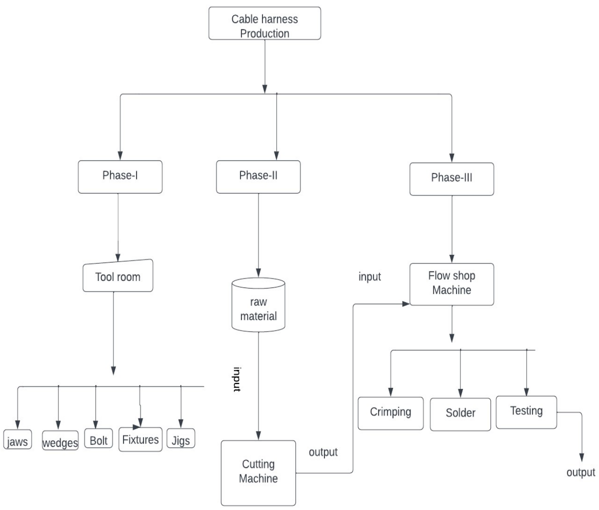

Fig.1. Flowchart of Cable Harness Production

I. PHASE –I

A. Proposed Algorithm

A special apparatus is created where raw materials are used wisely and CNC programming is done in accordance with it so that we can produce bulk quantities and achieve our delivery deadlines. Which contains three phases, the first of which is part-machining; the second is cable harnes

Making Toolroom Jobs is what we have planned for this Phase. Jobs in the tool room include Jigs (Jg), Wedges (W), Bolt & Nut (B), Fixture (F), and Jaws (J). Find out which work is processed first and then the sequence in which each job is processed.

A sequential decision-making technique that makes use of a broad optimization strategy is called dynamic programming. For instance, we need to decide which task comes first, then which, and so forth. relates to problems that can be broken down into smaller problems that each involve a smaller number of choices, keeping in mind the following optimality assumption. It's time to make the remaining k decisions now that we've already chosen the first k

The sub problem that requires (n -k) decisions can be optimized by examining only that sub problem. When the objective function is additive, the optimality principle is satisfied in sequencing. Let K be some subset of the tasks and p(K) denote the total time required to process the jobs in set K to apply dynamic programming to our sequencing problem. To make things easier, we'll call the set K with the element k deleted (K- k). Assume a sequence in which the jobs in set K come first, followed by the rest of the jobs. This method reduces Tardiness Comparing all other Algorithms

B. Notations

K - Subset of the jobs

P(K) - Total time required to process jobs in K

$K-k$ - The set containing jobs after removing k jobs

$B(K)$- Minimum total cost for the Set K

$b_k(p(K))$- Expenses incurred as a result of the jobs K

$B(K-k)$-Expenses incurred as a result of the remaining jobs

$E(P(K))$- Expected processing Time

D_k – Due date of the given jobs

EDD - Earliest Due Date

MDD - Modified Due Date

RD- Jobs taken randomly (1, 2&3)

GAM- Genetic Algorithm

C. **Procedure**

(i) P(K) –total time required The technique starts with the value of B for a subset of size zero, and continues with the value of G for a subset of size one, and so on.

(ii) Calculate the value of B for the empty set

$$B(X) = \min_{k\in X}\{b_k(p(K)) + B(X-k)\}$$

Where $b_k(P) = \max\{0, E(\text{Pk}) - D_k\}$

$$b_k(P) = \max\{0, E(\text{Pk}) - D_k\}$$

(iii) Identify which job should occur in the last position. Continue this process for all possible subset

(iv) After finding B, we can keep records of where minima occur on every stage

Journal of Theoretical and Applied Information Technology
15th August 2023. Vol.101. No 15

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table 1: Processing Time for Task

Numerical Example Job	*Task1*	*Task 2*	*Task3*	*Task 4*	*Task 5*
Processing Time	40	50	80	70	60
Due Date	15	12	20	10	15
Probability	0.3	0.2	0.2	0.1	0.2

Table 2: Iteration1 for finding Minimum Total cost

Job set(KK)	{1)	{2)	{3)	{4)	{5)
$EP(K)$	12	10	16	7	12
D_k	15	12	20	10	15
$k \in K$	1	2	3	4	5
$b_k(p(K))$	0	0	0	0	0
$B(K-k)$	0	0	0	0	0
$B(K)$	0	0	0	0	0

Table 3: Iteration II for finding Minimum Total cost

Job set(KK)	{1,2)		{1,3)		{1,4)		{1,5)		{2,3)		{2,4)		{2,5)		{3,4}		{3,5}		{4,5}	
$EP(K)$	22		28		19		24		26		17		22		23		28		19	
$k \in K$	1	2	1	3	1	4	1	5	2	3	2	4	2	5	3	4	3	5	4	5
D_k	15	12	15	20	15	10	15	15	12	20	12	10	12	15	20	10	20	15	10	15
$b_k(p(K))$	7	10	13	8	4	9	9	9	14	6	5	7	10	7	3	13	8	13	9	4
$B(K-k)$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$\sum$	7	10	13	8	4	9	9	9	14	6	5	7	10	7	3	13	8	13	9	4
$B(K)$	7			8	4		9			6	5			7	3		8			4

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table 4: Iteration III for finding Minimum Total cost

Job set	{1,2,3}			{1,3,4}			{1,4,5}			{2,3,4}			{2,4,5}			{3,4,5}		
$EP(K)$	38			35			31			33			29			35		
$k \in K$	1	2	3	1	3	4	1	4	5	2	3	4	2	4	5	3	4	5
D_k	15	12	20	15	20	10	15	10	15	12	20	10	12	10	15	20	10	15
$b_k(p(K))$	23	26	18	20	15	25	16	21	16	21	13	23	17	19	14	15	25	20
$B(K-k)$	6	8	7	3	4	8	4	9	4	3	5	6	4	7	5	4	8	3
$\sum$	29	34	25	23	19	33	20	30	20	24	18	29	21	26	19	19	33	23
$B(K)$			25		19		20				18				19	19		

Table 5: Iteration III For Finding Minimum Total Cost

Job set	{1,2,5}			{1,3,5}			{1,2,4}			{2,3,5}		
$EP(K)$	34			40			29			38		
$k \in K$	1	2	5	1	3	5	1	2	4	2	3	5
D_k	15	12	15	15	20	15	15	12	10	12	20	15
$b_k(p(K))$	19	22	19	25	20	25	14	17	19	26	18	23
$B(K-k)$	7	9	7	8	9	8	5	4	7	8	7	6
$\sum$	26	31	26	33	29	33	19	21	26	34	25	29
$B(K)$	26				29		19				25	

Table 6: Iteration IV For Finding Minimum Total Cost

Job set	{1,2,3,4}				{1,3,4,5}				{1,2,4,5}				{1,2,3,5}				{2,3,4,5}			
$EP(K)$	45				47				41				50				45			
$k \in K$	1	2	3	4	1	3	4	5	1	2	4	5	1	2	3	5	2	3	4	5
D_k	15	12	20	10	15	20	10	15	15	12	10	15	15	12	20	15	12	20	10	15
$b_k(p(K))$	30	33	25	35	32	27	37	32	26	29	31	26	35	38	30	35	33	25	35	30
$B(K-k)$	18	19	19	25	19	20	29	19	19	20	26	19	25	29	26	25	19	19	25	18
$\sum$	48	52	44	60	51	47	66	51	45	49	57	45	60	67	56	60	52	44	60	48
$B(K)$			44					47	45						56			44		

Table 7: Iteration V For Finding Minimum Total Cost

Job set(KK)	{1,2,3,4,5}				
$EP(K)$	72				
$k \in K$	1	2	3	4	5
D_k	15	12	20	10	15
$b_k(p(K))$	57	60	52	62	57
$B(K-k)$	44	47	45	56	44
$\sum$	101	107	97	118	101
$B(K)$			97		

Identify which job should occur in the last position. Continue this process for all possible subset

Lowest tardiness is achieved when job 3 comes last
Now consider the remaining jobs {1,2,4,5}
From the Iteration IV, job 5 takes 4th place .
For remaining jobs {1,2,4}
From the Iteration III Job 1 takes in the third place .
Now consider the remaining jobs {2,4}.Job 2 takes in the fourth place from the right.
Hence the optimal sequence is 4-2-1-5-3 Total Tardiness $\sum T_k = 82 \sum T_k = 82$
Subset K reduces all possible jobs that could come last since the computational power required for dynamic programming grows in proportion to $n2^n$.

Table 8: Comparison With Various Algorithm

S.No	Algorithm	Sequences	Tardiness
1	Proposed	4,2,1,5,3	82
2	GAM	4,2,1,5,3	82
3	EDD	4,2,1,5,3	82
4	SPT	4,2,1,5,3	82
5	MIN U	2,1,5,3,4	103
6	RD1	3,5,1,2,4	123
7	RD2	2,4,1,3,5	88
8	RD3	1,3,5,2,4	118
9	MDD	4,2,1,5,3	82

Journal of Theoretical and Applied Information Technology
15th August 2023. Vol.101. No 15

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Fig 2: Tardiness of job

D. PHASEBLOCKING JOBS

Geometric and electrical constraints are frequently taken into account while designing cable harnesses. After that, a diagram for assembly preparation and assembly is provided
Using a specific wire-cutting machine, the wires are first cut to the correct length. The wires can alternatively be printed on by a separate machine or by a special machine during the cutting process. After that, the wires' ends are stripped to reveal the wires' metal which is then fitted with any necessary terminals or connection housings. To make the cable harness s, the cables are assembled and clamped together on a special workstation or onto a cork board according to the specified requirements.
After setting Tool room job, Work pieces are processed into Cutting Machine .To Minimize total Earliness and Tardiness cost, Idle Time has been considered. Although the optimal sequence without idle time isn't always the greatest sequence after idle time is included,A schedule can be divided into blocks, which are groups of jobs that are all scheduled at the same time. Between blocks, but not within blocks, idle time is injected. We can imagine the schedule as jobs being made available to the shop in batches at various times.

E. Procedure

(i) Arrange the jobs in Earliest Due Date(EDD)

(ii) The process begins by allocating the first job to the first block and scheduling it to finish on time or to begin at time zero if that is not possible.

(iii) After then, jobs are examined in the order in which they appear in the list.

(iv) If job j is completed early when added to an existing block, it is rescheduled to complete on its due date, resulting in the creation of a new block.

F. Real Time Application

10 jobs have to be processed into a single machine for cutting and scripping to do this process use job block criteria

Table 9-porocessing time and due date for given jobs

JOB	1	2	3	4	5	6	7	8	9	10
PRO	1	6	3	2	8	4	5	7	2	1
DUE	4	8	10	19	30	31	38	45	48	48

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Initially Starts at time t=0

t	job	P_j	D_j	C_j	E_j	T_j
0	1	1	4	1	3	0

Table 10

job1 finish earlier hence job 1 starts late by 3 units also put this job in to Block-I

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
3	1	1	4	4	0	0	
4	2	6	8	10	0	2	6

Table 11

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
2	1	1	4	3	1	0	
3	2	6	8	9	0	1	5

Table 12

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
1	1	1	4	2	2	0	
2	2	6	8	8	0	0	4

Table 13

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
1	1	1	4	2	2	0	
2	2	6	8	8	0	0	
8	3	3	10	11	0	1	7

Table 14

late by one unit hence start block one at t=0

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
0	1	1	4	1	3	0	
1	2	6	8	7	1	0	
7	3	3	10	10	0	0	8

Table 15

Total cost increased by one unit hence block–I starts at t=1.Now include job 4 ,Earliness arises. Consider new block II.

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
1	1	1	4	2	2	0	
2	2	6	8	8	0	0	
8	3	3	10	11	0	1	
11	4	2	19	13	6	0	

Table 16

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
17	4	2	19	19	0	0	
19	5	8	30	27	3	0	

Table 17

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
22	5	8	30	30	0	0	
30	6	4	31	34	0	3	9

Table 18

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
21	5	8	30	29	1	0	
29	6	4	31	33	0	2	8

Table 19

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
20	5	8	30	28	2	0	
28	6	4	31	32	0	1	7

Table 20

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
20	5	8	30	28	2	0	
28	6	4	31	32	0	1	
32	7	5	37	37	0	0	7

Table 21

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
20	5	8	30	28	2	0	
28	6	4	31	32	0	1	
32	7	5	37	37	0	0	
37	8	7	45	44	1	0	5

Table 22

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
38	8	7	45	45	0	0	
45	9	2	48	47	1	0	

Table 23

Journal of Theoretical and Applied Information Technology
15th August 2023. Vol.101. No 15

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

t	job	Pj	Dj	Cj	Ej	Tj	E&TCost
46	9	2	48	48	0	0	
48	10	1	48	49	0	1	3

Table 24

By job blocking procedure reduced a Earliness and Tardiness cost

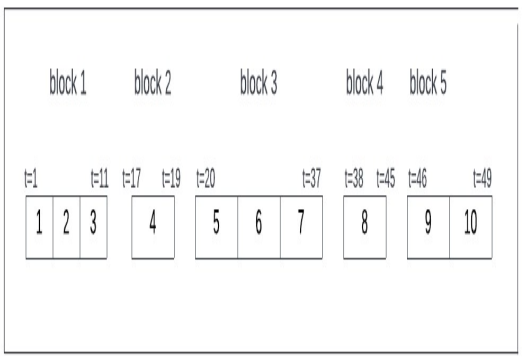

Fig 4: Job Block

Now consider each block act as a job.

Table 25 –Maximum Due Date

.S. No	Job	Processing Time	Max Due Date
1	J_1=$\alpha\alpha$(1,2,3)	10	10
2	J_2=4	2	19
3	J_3= $\beta(5,6,7)$ $\beta(5,6,7)$	17	38
4	J_4=8	7	45
5	J_5= $\gamma(\gamma($9,10)	3	48

Now this five jobs to be processed into a single machine for cutting and Scrapping. By Comparison Method select suitable algorithm

Table.26 E& T Cost

s.no	Algorithm	E&T cost	Job order
1	SPT	225	2-5-4-1-3
2	EDD	68	1-2-3-4-5
3	RD1	155	2-4-1-3-5
4	RD2	135	3-2-1-4-5
5	RD3	303	5-3-4-1-2
6	GAM	68	1-2-3-4-5

EDD and Genetic algorithm provide better result .Hence optimal sequence is 1-2-3-4-5 and Earliness and Tardiness cost is 68

2. PHASE III

G. Flow Shop Machine

After completion of this work all the jobs should be processed into Crimping Terminal machine,Solder Machine and Testing Machine in a Flow shop manner and whose processing times are given

CM- Crimping Machine
SM-Solder Machine
TM-Testing Machine
DM1- Dummy Machine-I
DM2- Dummy Machine-2

Table 27-Processing time different machine

Task	CM	SM	TM
1	5	4	2
2	10	2	3
3	7	3	5
4	8	5	10
5	6	4	4
6	10	1	6
7	6	5	3
8	7	2	10
9	8	2	2
10	6	4	7

Since the processing time of CM is greater than or equal to SM, Hence the given problem converted into 2-machine Problem by assuming dummy machine

Table 28-Processing time dummy machine

Task	DM1	DM2
1	9	6
2	12	5
3	10	8
4	13	15
5	10	8
6	11	7
7	11	8
8	9	12
9	10	4
10	10	11

Task	CM	SM	TM	C1	C2	C3
8	5	4	2	5	9	11
10	10	2	3	15	17	20
4	7	3	5	22	25	30
3	8	5	10	30	35	45
5	6	4	4	36	40	49
7	10	1	6	46	47	55
6	6	5	3	52	57	60
1	7	2	10	59	61	71
2	8	2	2	67	69	73
9	6	4	5	73	77	82

Now Apply Johnson's Algorithm

(i)SET-I={4,8,10}.SET-II={1,2,3,5,6,7,9}
(ii)Arrange SET-I in(DMI) SPT and SET-II in (DM2)LPT
SET-I={8,10,4}.,SET-II={3,5,7,6,1,2,9}
(iii) Optimal Sequence is {8,10,4,3,5,7,6,1,2,9} and Cmax= 82

Table 29-Completion time of Machine

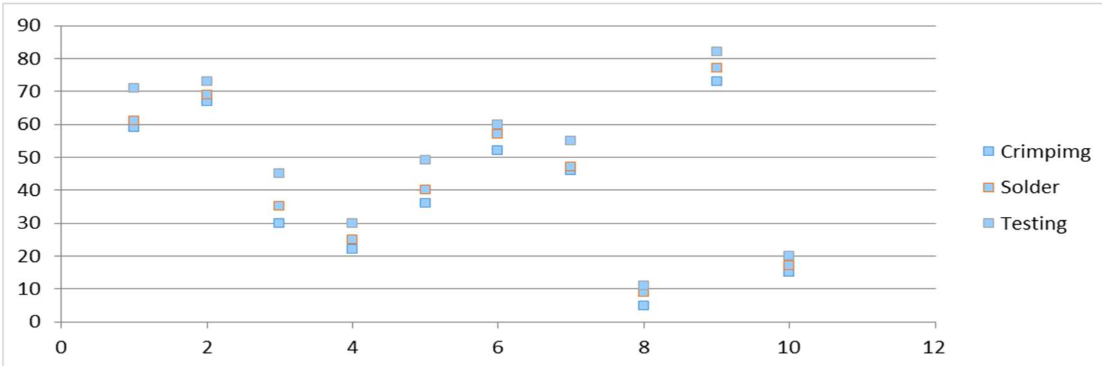

Fig.5- Completion Time Of Jobs

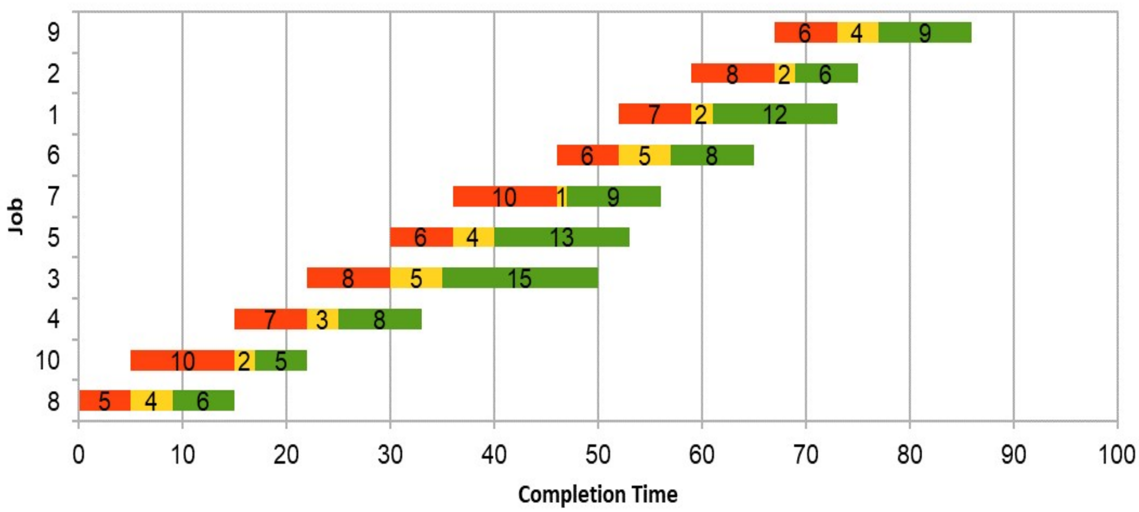

Fig-6: Gantt Chart For Completion Time

3. ACKNOWLEDGEMENTS

This work was supported by Geebon small scale Industry, Chennai -56

4. CONFLICT OF INTERESTS

There is no conflicts of interest

5. CONCLUSION

The objective to minimize the Tardiness by using Dynamic approach and job blocking method is achieved. Using the Dynamic approach the cost to the company has been reduced in a sustainable way. The company is able to provide the delivery on time and the feedback from the customers are very good. Currently the company has been using the approach and improvised their profit. In order to discover the sequential order of the jobs with distinct due dates, and to apply the job blocking method for a single machine, this paper covers the single-machine scheduling problem. It also discusses the flow shop model. To provide insights that may ultimately be helpful in research on more complex models, this work proposes solution approaches and attributes of an ideal schedule.As a future improvement, stochastic flow shop will be implemented to work on the random processing time.

REFERENCE

[1]. Ye, H., Wang, X. & Liu, K. Adaptive preventive maintenance for flow shop scheduling with resumable processing. IEEE Trans. Autom. Sci. Eng. 18, 106–113 (2021).

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[2]. Hamdi, I. & Tekaya, M. F. A genetic algorithm to minimize the makespan in a two-machine cross-docking flow shop problem. J. Oper. Res. Soc. China 8, 457–476 (2020).
[3]. K.R. Baker and G.D. Scudder, Sequencing with earliness and tardiness penalties: A review, Oper Res 38(1) (1990), 22–36.
[4]. J. Heller. "Some numerical experiments for an M× J flow shop and its decision-theoretical aspects." Operations Research 8.2 (1960): 178–184
[5]. C. R. Reeves, "A genetic algorithm for flowshop sequencing," Computers and Operations Research., vol. 22, pp. 5–13, January 1995
[6]. Z.-L. Chen and W. Powell, A column generation based decomposition algorithm for a parallel machine just-in-time scheduling problem, European J Oper Res 116(1) (1999), 220–232.
[7]. C. Sung and J. Min, Scheduling in a two-machine flowshop with batch processing machine(s) for earliness/tardiness measure under a common due date, European J Oper Res 131(1) (2001), 95–106
[8]. Mina Mahabadpour, BahmanNaderi* and Mohammad Mohammadi " An effective model and algorithm for two-stage assembly flow shop problems "Int. J. Services and Operations Management, Vol. 35, No. 1, 2020
[9]. Abdollahpour, S., &Rezaian, J. (2016). Two new meta-heuristics for no-wait flexible flow shop scheduling problem with capacitated machines, mixed make-to-order and make-to-stock policy. Soft Computing, 1-19.
[10]. Ali Allahverdi "Three machine flow shop scheduling problem to minimize total completion time with bounded setup and processing times" Decision making in manufacturing and services, Vol 1 2007,No.1-2 pp.5-23
[11]. Taillard, E. D. Benchmarks for basic scheduling problems. Eur. J. Oper. Res. 64, 278–285 (1993).
[12]. Y. Zhang, X. Li, and Q. Wang, "Hybrid genetic algorithm for permutation flowshop scheduling problems with total flow time minimization, "European Journal of
[13]. Operational Research, vol. 196, no. 3, pp. 869–876,2009
[14]. Anna Ławrynowicz "Genetic Algorithms For Solving Scheduling Problems In Manufacturing Systems " Foundations of Management, Vol. 3, No. 2 (2011), ISSN 2080-7279
[15]. Framinan, J. M., & Nagano, M. S. (2008). Evaluating the performance for makespanminimisation in no-wait flowshop sequencing. Journal of materials processing technology, 197(1), 1-9.
[16]. JacekBłażewicz and PiotrFormanowicz "Scheduling jobs in open shops with limited machine availability"AIRO-Oper. Res.Volume 36, Number 2, April-June 2002 Page(s) 149 – 156
[17]. (2018) Gupta D., Goel S. "Three stage flow shop scheduling model with equipotential machines" International Journal on Future Revolution in Computer Science & Communication Engineering, 4(3), pp.269 – 274
[18]. S. M. Johnson, "Optimal two- and three-stage production schedules with setup times included," Naval Research Logistics Quarterly, vol. 1, pp.61–68, 1954.
[19]. M. Nawaz, E. E. EnscoreJr, and I. Ham, "A heuristic algorithm for them-machine, n-job flow-shop sequencing problem," OMEGA, vol. 11,no. 1, pp. 91–95, 1983.
[20]. Liang, Z., Liu, M., Zhong, P., Zhang, C. & Wang, X. Hybrid algorithm based on genetic simulated annealing algorithm for complex multiproduct scheduling problem with zero-wait constraint. Math. Probl. Eng. 2021, 1–21 (2021).
[21]. Ko-Wei Huang "A Two-Phase Hybrid Particle Swarm Optimization Algorithm for Solving Permutation Flow-Shop Scheduling Problem " International Journal of Computer Applications (0975 – 8887) Volume 48– No.1, June 2102

[22]. Y. Chen, X. Li, R. Sawhney, Restricted job completion time variance minimization on identical parallel machines, European Journal of Industrial Engineering3(2009)261–276

[23]. Kedad-Sidhoum, S. and Sourd, F. (2010). Fast neighborhood search for the single machine earliness tardiness scheduling problem. Computers& Operations Research, 37(8):1464–1471.

[24]. Costa, A., Cappadonna, F. A. & Fichera, S. A hybrid genetic algorithm for minimizing makespan in a flow-shop sequence dependent group scheduling problem. J. Intell. Manuf. 28, 1269–1283 (2017).

[25]. Xie, J., & Wang, X. (2005). Complexity and algorithms for two-stage flexible flowshop scheduling with availability constraints. Computers & Mathematics with Applications, 50(10), 1629-1638.

[26]. E.Janaki A.Mohamed Ismail,Flow Shop Scheduling Model for Three Machine without Job Block Criteria Using Branch& Bound Technique Jour of Adv Research in Dynamical & Control Systems, Vol. 10, 05-Special Issue, 2018

[27]. J. Kanet and V. Sridharan, Scheduling with inserted idle time: Problem taxonomy and literature review, Oper Res 48(1) (2000), 99–110..

[28]. P.L. Maggu and G. Das, On 2×n sequencing problem with transportation times of jobs, Pure and Applied Mathematical Sciences, Volume 12, pages 1- 6, 1980.

[29]. Baker, K.R. and D. Trietsch (2010). Three Heuristic Procedures for the Stochastic, Two-Machine Flow Shop Problem. Journal of Scheduling. DOI 10.1007/s10951-010-0219-4

[30]. Baskar A, Anthony Xavior M,Analysis of a Few Simple Heuristics for the Permutation Flow Shop Scheduling Problems for any Batch Processing Industry Materials Today: Proceedings 5 (2018) 11762–11770

[31]. Reeves, C. R. A genetic algorithm for flowshop sequencing. Comput. Oper. Res. 22, 5–13 (1995).