OPTIMIZATION OF TIME AND COST IN MANUFACTURING INDUSTRY USING ASSIGNMENT, TRANSPORTATION MODELS AND SEQUENCING AND SCHEDULING AT ABHI- TECH FAB & MACHINING PVT. LTD.

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Abstract –*Cost optimization using different models like transportation model, Assignment model and sequencing and scheduling is studied. Each level in industry from storing the component to transportation of finished components is analyzed and suitable model applied for it.*

Key Words: *Assignment Model, Sequencing And Scheduling Model Transportation Model, Voggel's Approximation method, stepping stone method , Johnson method, Hungerian method, shortest process time*

1. INTRODUCTION

ABHI TECH industry is major forging company in Pune have assemblies in different parts of Maharashtra. Raw material for machining is received in the form of casting. Raw material is then undergoing through turning, drilling, milling and finishing operation. We implemented different optimization models used in bachelor course to study cost optimization in different sections of industry.

2.1 ASSIGNMENT MODEL:

Assignment model is a type of linear programming model where the objective is to minimize the assignment cost of completing the number of activities by the number of resources in a such way that only one resource is assigned to one activity. It is known as special case of transportation problem in which each source and destination will have unity capacity and requirement and also allocations are made on one to one basis.

2.2. Mathematical Formulation:

x_{ij} = 0 (when assigned)

x_{ij}= 1 (when not assigned)

Therefore, $$\sum_{i=1}^{n} x_{ij} = 1$$
$$\sum_{j=1}^{n} x_{ij} = 1$$

The total assignment cost will be given by

x_{ij} = Decision variable (allocation)

Cij = unit assignment cost

$$U = \sum_{j=1}^{n} \sum_{i=1}^{n} x_{ij} c_{ij}$$

The above definition can be developed into mathematical model as follows:

Determine $x_{ij} > 0$ (i, j = 1,2, 3…n) in order to

Minimize $$U = \sum_{j=1}^{n} \sum_{i=1}^{n} x_{ij} c_{ij}$$

Subjected to constraints

$$\sum_{i=1}^{n} x_{ij} = 1 \text{ when } j = 1, 2, 3.....n.$$
$$\sum_{j=1}^{n} x_{ij} = 1 \text{ when } i = 1, 2, 3.....n.$$

2.3 ASSIGNMENT PROBLEM HUNGARIAN METHOD EXAMPLE

The Hungarian method is based on the principle that if a constant is added to every element of a row or a column of cost matrix the optimal solution of the resulting assignment problem is the same as the original problem. Matrix is an approach of assignment method, which reduces original cost to a table opportunity cost. The opportunity costs are the costs associated with a sacrificed opportunity in order to make a particular decision.

3.1 SEQUNCING AND SCHEDULING MODEL

Sequencing is concerned with determining the best sequence in which a set of given jobs may be performed whereas scheduling deals with allocation of limited resources over time. The sequencing models are dealt with the situation where n jobs are to be processed on m machines. The optimal sequence in which it can minimize overall completion time of all jobs on al machines.

Terminology

1. Flow time: the time span between point at which a task is available for processing and processing time plus waiting time.
2. Due date: it represents completion date.

3.2 Priority dispatching rules

1. Shortest processing time rule

Sequencing the jobs in the increasing order of their processing time.

1. It minimizes the mean flow time as well as the number of tardy jobs
2. It minimizes the total inventory holding cost.
3. It also minimizes the mean tardiness if, all tasks have same due date

2. Early due date rule

Jobs are sequenced in the ascending order of their due costs i.e., jobs with earlier due date are processed. It minimizes the mean tardiness and the maximum lateness.

JOHNSON algorithm: it is used to find optimal job sequence, which can minimize make span in case of 5 jobs and 3 machine problem.

4.1 TRANSPORTATION MODEL

Transportation problem is a special type of linear programming problem. It indicates amount of consignment to be transported from various origins to different destinations so that total transportation cost is minimized without violating the availability constraints and requirement constraints.

MATHEMATICAL MODEL

Cij = transportation cost or unit from source I to destination j

Xij = number of units transferred from source I to destination j

Destination / Source	D1	D2	D3	SUPPLY
S1	X11 C11	X12 C12	X13 C13	a 1
S2	X21 C21	X22 C22	X23 C23	a 2
DEMAND	b 1	b 2	b 3	a1+a2 b1+b2+b3

OBJECTIVE: To minimize total cost

Z min = C11*X11 + C12*X12 + C13*X13 + C21*X21 + C22*X22 + C23* X23

Z min = ∑ Cij * Xij

Where m = number of sources,

n = number of destinations

subject to:

Supply restrictions:

X11 + X12 + X13 = a1

X21 + X22 + X23 = a2

∑ Xij = ai

j =1

Demand restrictions

X11 + X21 = b 1

X12 + X22 = b 2

X13 + X23 = b3

∑ Xij = bj

I= 1

4.2 STAGES IN SOLVING PROBLEM

Stage 1: Initial basic feasible solution by vogel approximation method. It generates the best initial basic feasible solution. This method is the best choice in order to get an optimal solution within Minimum number of iterations

Stage 2 : optimal solution by stepping stone method

5.1 OPTIMIZATION IN WAREHOUSE COST

Raw materials obtained in the form of castings are stored in ware houses. ABHI TECH industry have 5 types of warehouses and each can store only one type of component. Here we used Assignment model to allocate the components to warehouses in which HUNGERIAN METHOD is used so that cost for storage is minimum. A B C D E are raw material components and 1 to 5 are warehouses for storage of components.

Cost matrix for component and warehouses.

	A	B	C	D	E
1	100	135	215	265	315
2	120	150	230	255	320
3	140	145	200	270	305
4	130	135	225	250	325
5	125	115	235	260	300

5.2 Optimal solution

components	Warehouse type	Cost
A	1	100
B	5	115
C	3	200
D	4	250
E	2	320
	Total	985

Total cost required to store raw material is Rs. 985 per set of 5 components.

5.3 OBSERVATION

Previously the cost required to store one set i.e. components A,B,C,D,E was around Rs. 1200. Now it is reduced by 18 %.

6.1 SEQUENCING JOBS FOR TIME OPTIMIZATION FOR MINIMUM FLOW TIME

First Raw material is Turned then drilling or milling and finally undergoes finishing process. To decide sequence of jobs so that flow time is minimum, Johnson algorithm is used. It is based on shortest process time method. 5 components are required to assemble a single product. Therefore, machining all 5 components is done to produce a single product.

SEQUENCING AND SCHEDULING

Job	TURNING (min)	DRILLING / MILLING (min)	FINISHING (min)
A	15.2	5..3	10.1
B	18.3	7.4	12.7
C	24.5	6.5	14.5
D	20.2	8.4	18.2
E	22.4	9.2	20.3

According to Johanson's algorithm, the optimal sequence for which components should be machined first so that flow time is minimum is as below. Johnsons algorithm based on S.P.T. (Shortest process time) rule

E	D	C	B	A

Total time calculated as per optimal sequence

Job	*M*1 In time	*M*1 Out time	*M*2 In time	*M*2 Out time	*M*3 In time	*M*3 Out time
5	0	0 + 22.4 = 22.4	22.4	22.4 + 9.2 = 31.6	31.6	31.6 + 20.3 = 51.9
4	22.4	22.4 + 20.2 = 42.6	42.6	42.6 + 8.4 = 51	51.9	51.9 + 18.2 = 70.1
3	42.6	42.6 + 24.5 = 67.1	67.1	67.1 + 6.5 = 73.6	73.6	73.6 + 14.5 = 88.1
2	67.1	67.1 + 18.3 = 85.4	85.4	85.4 + 7.4 = 92.8	92.8	92.8 + 12.7 = 105.5
1	85.4	85.4 + 15.2 = 100.6	100.6	100.6 + 5.3 = 105.9	105.9	105.9 + 10.1 = 116

6.2 OBSERVATION

The total minimum elapsed time = 116 min is the minimum time required to complete machining of all 5 components once. We can use this sequence so that flow time is minimum. Previously the total time was 134 minutes because improper sequence of jobs on machines. Here time is reduced by 18 minutes

7.1 TRANSPORTATION OF FINISHED GOODS

Now after completion of machining process next step is to transport the components. Here Transportation model used to calculate optimum solution. First vogal approximation method is used find out initial basic feasible solution and its optimality is checked using stepping stone method.

ABHI TECH industry have 3 assemblies in pune, Kolhapur and Solapur. Demand is from firms located in cities in nagar, latur and indapur. Total demand and supply from industry in each city is given in table.

Solution using Vogel's Approximation method, also find optimal solution using stepping stone method

	NAGAR	LATUR	INDAPUR	Supply
PUNE	123	325	142	1500
KOLHAPUR	314	352	207	3200
SOLAPUR	231	122	111	2800
Demand	2000	3000	2500	7500

Initial basic feasible solution by Vogal's approximation method

<table>
<tr><th></th><th>D1</th><th>D2</th><th>D3</th><th>Supply</th><th>Row Penalty</th></tr>
<tr><td>S1</td><td>123(1500)</td><td>325</td><td>142</td><td>1500</td><td>19 | 19 | -- | -- | -- |</td></tr>
<tr><td>S2</td><td>314(500)</td><td>352(200)</td><td>207(2500)</td><td>3200</td><td>107 | 107 | 107 | 107 | 207 |</td></tr>
<tr><td>S3</td><td>231</td><td>122(2800)</td><td>111</td><td>2800</td><td>11 | -- | -- | -- | -- |</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Demand</td><td>2000</td><td>3000</td><td>2500</td><td></td><td></td></tr>
<tr><td>Column Penalty</td><td>108
191
314
314
--</td><td>2
0
3
2
7
3
5
2
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--</td><td>31
65
207
207
207</td><td></td><td></td></tr>
</table>

7.2 final optimal solution is arrived.

	NAGAR	**LATUR**	**INDAPUR**	**Supply**
PUNE	**123 (1500)**	**325**	**142**	**1500**
KOLHAPUR	**314 (500)**	**352 (200)**	**207 (2500)**	**3200**
SOLAPUR	**231**	**122 (2800)**	**111**	**2800**
Demand	**2000**	**3000**	**2500**	

FOR MINIMMUM COST MINIMUM DISTANCE SHOULD BR TRAVELLED

Total transportation cost with heavy vehicles is RS. 35 per km in Maharashtra

1. For nagar to fulfill the demand of 2000 finished components it should get 1500 units from pune and 500 units from Kolhapur so total transportation cost is Rs. 35 per km in Maharashtra

Total distance travelled to nagar 123+ 314= 437 km

cost = 437* 35 = 15295

2. For latur to fulfil the demand of 3000 components it should choose 200 finished components from Kolhapur and 2800 finished components from Solapur

Total distance travelled to latur 474 km

Cost 474*35 = 16590

3. For indapur to get total requirement it should be planned to get all finish goods from Kolhapur from mimimum overall cost

Cost 207*35= 7245

Total cost is 7245 + 16590 + 15295= 39130

Considering different additional cost will be 39130 + 5000 = 44130

7.3 OBSERATION:

Total cost before applying transportation model was around Rs. 50,000. Cost is reduced by 12%.

8. CONCLUSION INDUSTRY GOT BENEFITS AS FLLOWS

1. Cost required to store the raw material is reduced
2. Due to effective scheduling of jobs on the machine mean flow time i.e., average time of component on shaft floor is as minimum as possible. Further inventory holding cost of finished goods is also reduced by this method.
3. Transportation cost required to from suppliers to demand is minimized due transportation model.

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