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Operations Research Applications in Steel Industry

Akash Jha[1], Vaibhav Rustagi[2], Srishti Kalra[3], Muskaan Nagpal[4]
[1,2,3,4]*Student, School of Commerce, NMIMS Bengaluru, India*

***Abstract*—The aim of this research paper is to discuss the problems faced by the steel industry during the production process and how the usage of operation research with mathematical models help the companies to solve such problems. Operations Research has a long history of providing solutions in terms of cost reduction, selecting the most relevant solution for the given problems and finally executing it. Using real life examples, we will know about the problems and their solutions to solve the given problem.**

***Index Terms*—operations research optimization, replacement theory, transportation.**

I. Introduction

Operations Research terminology was actually used to describe the work civilian scientists were doing for the radar system which was used at the time as an early warning system in World War 2. The United Kingdom was using radar technology as an early warning system for incoming threats against Luftwaffe (German Air Force) helped them to properly make attacking and defense strategy against the Germans. Later they came to realize that much more important things to be researched besides the radar technology. They took every potential threat as a problem and then created solutions based on that like when to attack, when to defend and what would be the attack and defense position for the fighter pilots. This research proved fruitful because UK was able to thwart the plans of an invasion by Germany. After the end of the war, it was found out that operations research is not limited to military planning and executions only but also it encompasses a wide range of industries and other fields where there is a particular problems which is needed to be solved. Today, operations research is used in every possible field one can think of. From industries involve in any production process to making certain decisions. Operation Research has become the need for such fields to get an optimal solution of such problems. Fields that use Operation Research are: Manufacturing, Research, Transport, Information Technology and Companies etc.

II. Applications of Operation Research in Steel Industry

A. Transportation problem

Transportation Problem is one of the fundamental problems which is usually use to minimize the transportation cost for industries with number of sources and number of destination while satisfying the supply limit and demand requirement. Business and Industries are practically faced with both economic optimizations such as cost minimization of non-economic items which are vital to the existence of firms. The transportation models or problems are primarily concerned with the optimal best possible way in which raw materials can be supply at different factories or plants from the source of raw materials can be transported to a number of sides of raw materials according to the plant demand called demand destinations. The objective in a transportation problem is to minimum the transportations cost.

B. Overview of Preparation of Data Sheet for Transportation Model

Steel industry needs different raw materials according to their requirement for proper work to the plant. The materials are Iron ore, manganese, coal and dust may not be available in a single place so it needs to supply to the different source to destination by the help of the transport modes like train, trucks, ships etc. The study of the transportation problem for a steel plant which is located to the Mandir Hasaud and taken the materials from three sources are Mandhar Railway Station, Mandir Hasaud Railway Station and Urkura Railway station. The materials comes to the source by the help of the railway then it's distributed to the plant according to the demand by the help of the truck by road. In transportation of material to the plant needs high fund to minimize the transportation cost by applying the method of transportation problem solver. The routes of road from source to the destination. The routes to be decided or optimized for the transport the materials from the sources to destination at minimum time to choosing best route to compare the shorter distance, less of traffic signals and the condition of the road by the helps of the Google Maps according to the distance cover to transport the raw materials to the destination of the steel plant.

Vehicle condition and Optimized manpower Vehicle condition is to be good as the average of the truck is more so the consumption of the fuel diesel is low here to use the truck so the average of the truck is 3Kmpl. In the plant the some trucks are old so its average capacity is less as it is not used for the transportation of long distances because the fuel consumption is more. The truck drivers and conductors wages

are fixed per day wise. So the transport of the raw material is more than more in a day to be transported to save some amount. Other different parameters are included in the transportation cost per trip is loading of material in the truck, royalty cost which is permitted by the govt. to heavy loaded vehicle to run on the road, Toll cost and all these parameter where money is involved are included into the cost of per trip of raw material which is transported from the sources to the destination. Data sheet for transportation cost per trip and demand of raw materials for 30 days in month of Jan-Feb 2017.

TABLE I
OPTIMIZED ROUTE DISTANCE

Sources	Actual Distance in KM	Optimized Route Distance in KM
Mandhar Railway Station	19.3	17.5
Urkura Railway Station	21.8	20.0
Mandir Hasaud Railway Station	1.9	1.9

TABLE II
TRANSPORTATION COST PER TRIP WITH DEMANDS

		iron	coal	Mn
Mandhar Railway Station	Total Cost per trip	3187.18	2687.18	2487.18
	Demand in trips	10	7	3
Urkura Railway Station	Total Cost per trip	3230.2	2730.2	2530.2
	Demand in trips	8	5	2
Mandir Hasaud Railway Station	Total Cost per trip	2586.04	2086.04	1886.04
	Demand in trips	120	140	70

Solving for the optimized value of the minimum transportation cost is through Vogel's method and the optimized Transportation Cost = ₹831917.7

1. The transportation model is solved manually by calculating the actual transportation cost for the supply of raw materials from the sources to the destination.
2. Total transportation cost= (2586.04*120)+(2086.04*140)+(1886.04*70)+(3187.18*11)+(2687.18*7)+(2487.18*3)+ (3230.2*9)+(2730.2*5)+(2530.2*2)is
3. ₹843507.18 .Solving manually for transportation cost minimization.
4. Objective Function, Minimization

Z=9003.42X1+7503.42X2+6903.42X3……..
2586.04X1+3187.18X2+3230.20X3≥138…..….. (1)
2086.04X1+2687.18X2+2730.20X3≥152…..….. (2)
1886.04X1+2487.18X2+2530.20X3≥75……. (3)

5. X1, X2 & X3 ≥ 0 Where, X1= Number of coal in trips X2= Number of Iron in trips X3= Number of Manganese in trips
6. Solving the above equation (1), (2) and (3) we get the values of the X1, X2, and X3 X1= 48.97999 X2= 42.42099 X3= 10.52055.
7. Then, Put the value of X1,X2 and X3 in equation
8. objective function Minimization (Z) = 9003.42*(48.97999) + 7503.42*(42.42099) + 6903.42*(10.52055)
9. Minimization transportation cost (Z) = ₹831917.7

III. CALCULATIONS

1. Transportation model solved by the North West Corner method Minimum Transportation Cost= (2586.04*138) + (2086.04*152) + (1886.04*38) + (2487.180 *20) + (2530.2*15) Rs. 833317.720.
2. Transportation model solved by the Least Cost method Minimum Transportation Cost= (2586.04*102) + (2086.04*151) + (1886.04*75) + (3187.18 *20) + (3230.2*15) is Rs. 832417.72.
3. Transportation model solved by the Vogel's method Minimum Transportation Cost= (2586.04*136) + (2086.04*152) + (1886.04*40) + (2487.18 *20) + (2530.20*15) is Rs. 831917.7

Solving for the optimized value of the minimum transportation cost is through Vogel's method and the optimized Transportation Cost = Rs. 831917.7

A. Replacement Theory

Example: A steel company purchased a motor vehicle for ₹80000/-. Resale value of the vehicle decreases from ₹70000/- in the first year to ₹5000/- in the eighth year and the running cost in maintaining the vehicle keeps on increasing with ₹3000/- in the first year till it goes to ₹20000/- in the eighth year as shown in the below table. Find out the optimum replacement policy?

TABLE III
SCRAP VALUE AND RUNNING COSTS

Year	1	2	3	4	5	6	7	8
Scrap Value	70000	61000	55000	49000	32000	20000	10000	5000
Running Cost	3000	3600	4800	5000	8000	11200	15000	20000

TABLE IV
SOLUTION WITH REPLACEMENT THEORY

Year	C	S	Rn	Σ Rn	(C-S)	TC [Σ Rn+ (C-S)]	ATC (TC/Year)
1	80000	70000	3000	3000	10000	13000	13000
2	80000	61000	3600	6600	19000	25600	12800
3	80000	55000	4800	11400	25000	36400	12133.33
4	80000	49000	5000	16400	31000	47400	11850
5	80000	32000	8000	24400	48000	72400	14480
6	80000	20000	11200	35600	60000	95600	15933.33
7	80000	10000	15000	50600	70000	120600	17228.57
8	80000	5000	20000	70600	75000	145600	18200

The answer can be seen in the last column. The average total cost (ATC) at first dips from ₹13000/- till it reaches ₹11850/- .Later it increases again. This cost at which the ATC is lowest in a year (after which the value of ATC will increase again) will give us the optimum replacement period (year) and the cost of the vehicle.

B. Solution

1. The vehicle should be replaced after four years of its purchase when the cost of maintaining that vehicle would be lowest at an average cost of ₹11850/- per year.
2. Two considerations here. First, the running cost (Rn) is increasing every year at the same time when the value of the vehicle is depreciated. This depreciation is "(C-S)" in first year of its purchase where the scrap value of the vehicle is ₹70000/- which was originally purchased for ₹80000/- . So, the vehicle is depreciated by ₹10000/- in the first year and depreciated further in the coming years. (See column F).
3. The total cost in keeping the vehicle is this depreciation and maintenance. The maintenance is made cumulative when we add previous years running cost into every successive year.
4. The depreciation is ₹10000/- in the first year of its purchase, ₹19000/- in the second year, ₹25000/- in the third year and so on. Remember that the vehicle is depreciated by ₹25000/- "by" the third year and not "in" the third year.
5. As, the depreciation in itself is a cumulative function in this case, we make the running cost cumulative as well. That means the cost of maintaining the vehicle "by" the particular years. So, the cost of maintaining the vehicle "by" the third year is ₹11400/- (3000+3600+4800).
6. The total cost incurred by the third year would be ₹25000 + ₹11400 = ₹36400. Finally, the "average cost" of keeping this vehicle for three years would be ₹36400 divided by 3 years i.e. ₹12133.33 and so on.

C. Noticed Used

1. C – Capital/Cost of Equipment
2. S – Scrap/Resale Value
3. Rn – Running/Maintenance Cost
4. E Rn – Cumulative Running Cost
5. (C-S) – Depreciation
6. TC – Total Cost
7. ATC – Average Total Cost

IV. Conclusion

We have learnt what actually operations research is all about, its history and which fields use operation research in order to solve their problems. We have seen that what transportation problem is and when steel industry companies face any transportation problem, how that problem was solved with the help of proper techniques to get the minimum cost for transporting raw materials. We also come to know about replacement theory and how it is used by a steel company in order to replace a truck used for transporting raw materials. These applications of operation research in steel industry helps us understand its importance in the daily lives of the company and to achieve its aim with respect to it i.e. minimizing costs, replacing machines etc.

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