International Journal of Advanced Academic Research | Sciences, Technology and Engineering | ISSN: 2488-9849
Vol. 5, Issue 12 (December 2019)

MODELING TRANSPORTATION ALGORITHM USING MATERIALS HANDLING SYSTEM IN FOUNDRY WORKS

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ABSTRACT

The growth of any organization depends on optimum utilization of resources and the arrangement of elements and facilities aimed at reducing congestion, thereby enhancing the productivity. The aim of this study was to achieve this by adopting a quantitative technique (Transportation model) which is a statistical modeling that is capable of handling cost minimization of material flow through the facilities such as store, heat treatment section, scrap yard, administrative office and more. A model was formulated to predict that a total of 7390 elements were moved through the available facilities yet at a minimum cost by comparing Least Cost Method (LCM), North West Corner Method (NWC) and Vogel's Approximation Method (VAM) of the transportation model which revealed that total cost of ₦123,500 through a software package called TORA could be spent in a quarter rather than ₦750,253 in the same period. This method could save the organization from excessive spending while maximizing the productivity and efficiency.

Keywords: Transportation Algorithm, Minimization, Network, Programming, Modeling.

INTRODUCTION

In any enterprise, productivity is best served by an efficient flow of the elements that move through the facility. An efficient enterprise will provide element flows that will facilitate the efficient movement of the elements through the activities. A well-designed smooth out material flows will automatically trim down production costs in a plant whereby receiving, assembling, shipping, and storage areas link together by materials handling devices of one kind or another (Apple, 2017). Globally, any system that will enhance productivity by cost minimization is always desirable.

In essence, a plant can only be productive if there are simplified handling activities, better equipment utilization, less idle time, minimal backtracking and smooth production flow. In order to achieve the target, a model which deals with the situation in which a commodity or element is shipped from sources to destinations within a plant is employed.

This is Least Cost method of transportation model. The transportation model deals with problems concerning as to what happens to the effectiveness function when we associate each of a number of origins (sources) with each of a possibly different number of destinations (Gupta and Hira, 2002).

Transportation problem can be solved using Object-Oriented Model (OOM) (Taghrid, *et al.* 2019). They proved that OOM and C++ programming language are identical having compared the effectiveness of both approaches and recommended that the decision maker may choose the optimal result of the running of the five program (minimum) and determine the number of units transported from source *i* to destination *j*.

The continuing cry of a businessman is for ways of minimizing costs to offset the ever-increasing prices they must pay for labour and material. Re-designing of facilities is one of the prime sources of cost improvement opportunities in which the materials flow within a factory or workshop could be easier. Behind the scaling up and modernization of industrial plant and the changes in technology and organization that go with it, there is one prime motivation to produce more goods and services with less labour and cost. Development of an affluent society brings with it a structure of costs that almost automatically forces management to economize on labour. Therefore, there is a need to explore the opportunities of reducing overheads and thereby maximizing profits. This, in a way will tend to cause business expansion and employment opportunities.

It is obvious and essential if we are to achieve great stability of unit costs and price productivity. If we are to improve the ‘quality of life’, the alternative to taxes or a reduction of both demands is higher productivity and higher output. If we are going to continue to have a high and rising standard of living, productivity is the *sine qua non* (Stewart, 1968).

The growth of a plant must be matched by the optimum utilization of resources *vis-a-vis* the man-power, machines and natural resources. This growth is measured in changes observed in consumption materials, components and assemblies, excessive handling by skilled operator, amounts of work in process, long transportation, line long production cycle and delay in delivery. These in turn alter gradually, the basic pattern of flows in the factory, if they are not controlled by cost minimization to achieve the optimum. The industrial facility involves the determination of facility layout and Material Handling System (MHS). These are inter-related issues. It is estimated that MHS account up to 55% of the cost production. This illustrates the importance of reducing MHS cost to achieve competitive edge. MHS and MHC are direct functions of move and machine (Deb and Bharcchartyya, 2015). The objective of the present study was to formulate a transportation model for material handling in a foundry. The optimal feasible solution that will minimize the transportation cost while satisfying the supply and demand limits of company was also investigated.

MATERIALS AND METHODS

A survey was conducted using Just-In-Time (J1T) to collect data from the Foundry unit of Department of Works and Estate Workshop of the Federal College of Forestry, Ibadan, Oyo state, Nigeria. This was obtained during the performance evaluation of the newly installed Furnace at the foundry unit of the workshop. The quantity of items moved from the store, raw-material yard, administrative office, Physics and Chemistry laboratory, maintenance and machine workshop (as sources) was equal to the quantity demanded at the destinations.

These were measured in grammes. They were moved by using simple handling equipment, amongst which are wheel barrow, skid, pallets, file-tray, crane and so on. The movement of the items ranged from the transportation of the furnace into the workshop, to obtaining a cast product while the cast profile was obtained through the process of sand casting which involved a series of Materials Handling System (MHS). Each item moved was considered not to be carried more than once in order to prevent back-tracking and hence determined the optimum cost required enhancing the marketability of the cast.

However, in order to effectively minimize cost, quantitative technique was adopted. This approach is concerned primarily with the optimum location of equipment, materials, and products. Some of the procedures are based on classical mathematics and statistics; others have been developed from the field of Operations Research (OR). In this case, a transportation model was used, but by comparing different approaches, that is, Least Cost Method (LCM), North West Corner Method (NWCM) and Vogel's Approximation Methods (VAM).

DATA ANALYSIS

The transportation model is a special class of the programming problem (Taha, 2007). It deals with the situation in which a commodity or facility is shipped from sources to destinations within the factory or from factory to warehouses, for example, transporting one equipment from the gate to installation site.

Assumptions

(i) There are six sources and four destinations
(ii) No equipment item will be carried more than once
(iii) The shipping or transporting cost on a given route is directly proportional to the number of units shipped or transported on that route

(iv) There are *i* sources and *j* destinations, each represented by a node. The arcs linking the sources and destinations represent the routes between the sources and the destinations.

Notations

i: Source

j: Destinations

C_j: Transportation/shipping cost

X_{ij}: Amount transported (Kg)

A_i: Amount of supply at source

B_j: Amount of demand at destination

Formulation

$$\min \sum_{i=1}^{m} C_{ij} \sum_{j=1}^{n} C_{ij} \; X_{ij} \left[\sum_{j=1}^{n} \sum_{i=1}^{m} C_{ij} X_{ij} \right]$$

For a balanced system $\sum_{ai} = \sum_{bj}$

i = 1 j = 1

$$\begin{aligned} \min \; = \; & X_{11} + X_{12} + X_{13} + X_{14} = 450 \\ & X_{21} + X_{22} + X_{23} + X_{24} = 1200 \\ & X_{31} + X_{32} + X_{33} + X_{34} = 1500 \\ & X_{41} + X_{42} + X_{43} + X_{44} = 950 \\ & X_{51} + X_{52} + X_{53} + X_{54} = 2450 \\ & X_{61} + X_{62} + X_{63} + X_{64} = 840 \end{aligned}$$

s.t $\sum X_{ij} = b_j \qquad j = 1, 2, 3, \ldots.. n$

$$\begin{aligned} & X_{11} + X_{21} + X_{31} + X_{41} + X_{51} + X_{61} = 1620 \\ & X_{21} + X_{22} + X_{32} + X_{42} + X_{52} + X_{62} = 1500 \\ & X_{13} + X_{23} + X_{33} + X_{43} + X_{53} + X_{63} = 770 \\ & X_{14} + X_{24} + X_{34} + X_{44} + X_{54} + X_{64} = 770 \qquad \ldots. \; (1) \end{aligned}$$

$$X_{ij} > 0, \qquad (i = 1, 2, 3, 4)$$

This could be translated to:

$$Min.\, Z = 20X_{11} + 300X_{12} + 10X_{13} + 100X_{14} + 30X_{21} + 100X_{22} + 50X_{23} + 70X_{24}$$

$$+ 90X_{31} + 70X_{32} + 100X_{33} + 20X_{34} + 80X_{41} + 70X_{42} + 200X_{43} + 150X_{44} +$$

$$60X_{51} + 25X_{52} + 35X_{53} + 45X_{54} + 80X_{61} + 75X_{62} + 82X_{63} + 78X_{64} \quad ...(2)$$

St $\quad \sum_{i=1}^{m} C_{ij}\ X_{ij} = a_i \qquad i = 1,\ 2,\ 3\ ....\ m$

The solution was obtained using TORA software (Table 2)

RESULTS AND DISCUSSIONS

The results were shown in Tables 1 and 2. Table 1 showed the amount of items shipped from sources *i* to Destination *j,* while Table 2 is a model formulation that showed the cheapest routes in optimality.

Table 1: Amount (g) of items moved from one source to one destination

	D1	**D2**	**D3**	**D4**	**D5 (Dummy)**	
S1	20	300	10	100	0	**450**
S2	30	100	50	70	0	**1200**
S3	90	70	100	20	0	**1500**
S4	80	70	200	150	0	**950**
S5	60	25	35	45	0	**2450**
S6	80	75	82	78	0	**840**
	1620	**1500**	**770**	**770**	**2730**	**7390**

Table 2: Optimal Variation for Transportation Model Methods

Iteration	***New Corner***	***LCM***	***VAM***
1	357,700	223,810	162550
2	354,400	213,950	142400
3	299,800	186950	123500
4	277,754	170450	-
5	224,954	128450	-
6	224,950	123950	-
7	171,050	123500	-
8	138,200	-	-
9	123,500	-	-

Z = 420(20) + 30(10) + 1200 (3) + 770(20) + 730 (0) + 950(0) + 1500(25) + 740(35) + 2100(0) + 840(0) = **₦123, 500**

MODIFIED ARCS

The network in Fig. 1 represents the general problem. There are *m* number sources and *n* number of destinations, each represented by a node. The arcs represent the routes linking the sources and the destinations. Arc $_{(i,j)}$ joining source to destination, *j* carries two pieces of information: the transportation cost per unit, c_{ij}, and the amount shipped, x_{ij}. The amount of supply at source *i* is a_i, and the amount of demand at destination $_j$ is b_j. The objective of the model is to determine the unknown x_{ij} that will minimize the total transportation cost while satisfying all the supply and demand restrictions (Taha, 2007).

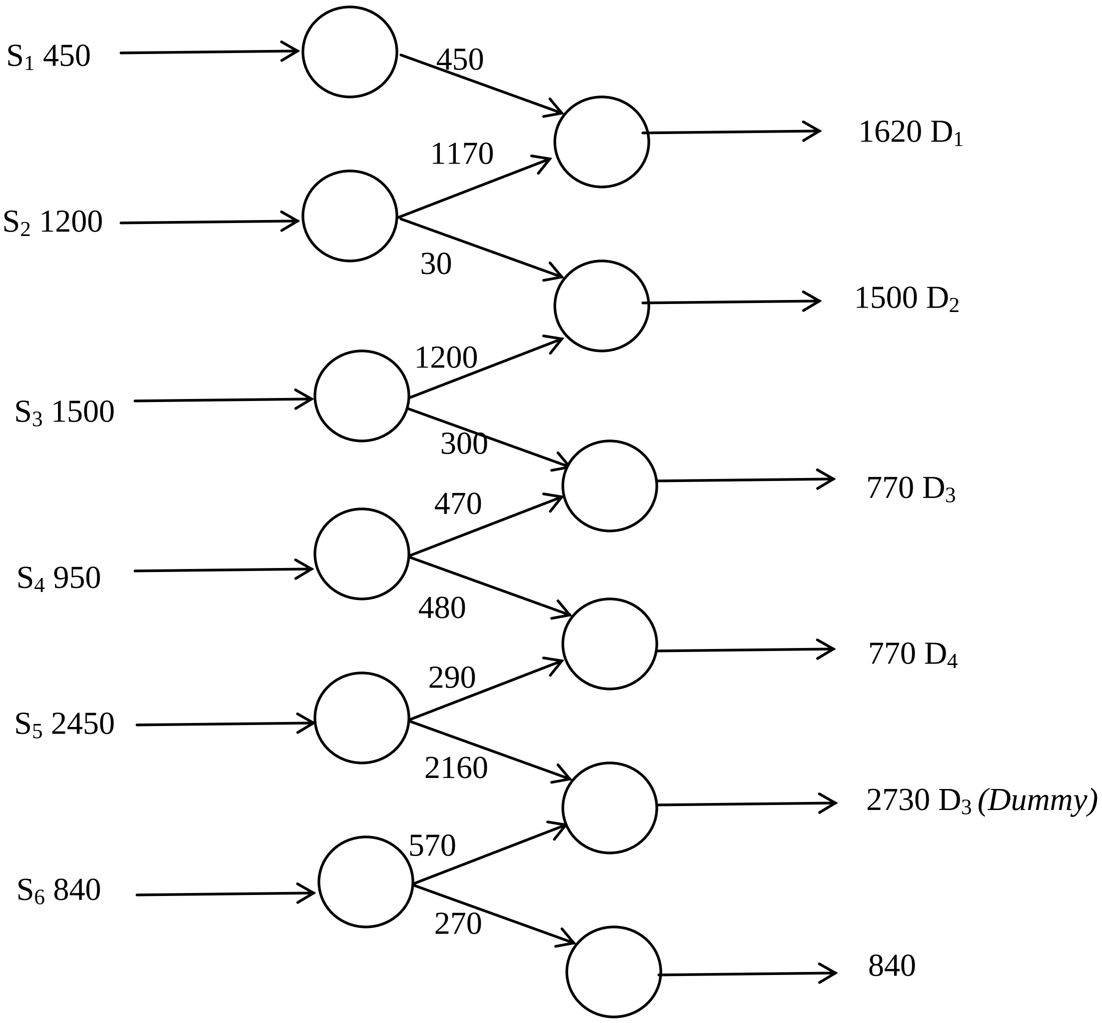

Fig 1: Modified Arcs

Organization's objective is to maximize profit while minimizing the overhead cost (Sasieni *et al.*, 1959). This overhead cost includes inter-alia transportation cost, salaries and wages, cost of raw materials and other costs that may be associated with the production processes. This was the subject of investigation in this study. Most organizations fail, not because they fail to state their goals in the feasibility study, but because they pay little or no attention to some salient processes that are capable of shutting down the establishment.

From the model formulation, and the resulting feasible solution, it could be observed that a model capable of handling the processes of cost minimization was adopted. A solution of the mode is feasible if it satisfies all the constraints (Equation 2). It is optimal if in addition to being feasible it yields the best (maximum or minimum) value of the objective function stated in (Equation 2). Though, Operation Research models are designed to optimize a specific objective criterion subject to a set of constraints, the quality of the resulting solution depends on the completeness of the model in representing a real system. This underscores the validity of the model to be used for optimizing the cost shipping from one source (store, raw-materials section, foreman's office, Quality Control, Maintenance, and Machine workshop) to another point called destination (Scrap yard, Heat treatment section, Furnace for melting. and the pattern making workshop).

In ascertaining the optimal solution a method called Least Cost Method was adopted above its peers due to its simplicity in determining the quantity of items moved from one point to the other. In addition, it concentrates on the cheapest routes. It assigns as much as possible to the cell with the smallest unit cost which ties are broken arbitrarily.

Figure 1 shows that 450g of items were shipped from the store to the scrap yard and the furnace sections. The associated cost was determined to be ₦8700.00 whereas, from raw materials and Administration, a total of l, 970g of items were moved to the scrap (D_1) and pattern making shop (D_4) with the associated cost of ₦51,400.

In a nutshell, similar observations were made for other activities within the workshop to give:

Z = 420(20) ÷ 30(10) + 1200(30) + 770(20) ÷ 730(0) ÷ 950(0) ÷ 1500(25) + 740(35) ÷ 210(0) ÷ 840(0) = **₦123,500**

This is the optimal solution (minimum cost) of transportation when compared with the killer-cost of ₦750,253 obtained from the existing conventional techniques.

CONCLUSION AND RECOMMENDATION

The transportation model is a special class of the linear programming (LP). It deals with the situation in which an item is shipped from one source within the workshop to another point called destination.

This work had studied the quantity of items from one place to the other in a foundry workshop (Figure 1) with their associated cost.

The model assumes that the shipping cost on a given route is directly proportional to the number of units (g) shipped on that route. The proposed approach is simple but more realistic than the existing conventional techniques. It can easily be implemented for heavy as well as medium processing industries and also can be applied in other related areas of production management (Deb and Bharcchartyya, 2015)

For optimum performance in engineering workshop, manufacturing processes, cost minimization is desirable. It is a fulcrum on which the development growth of a manufacturing industry is founded.

This method could save the organization from excessive spending while maximizing the productivity and efficiency.

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