Construction Equipment Fleet Management

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Abstract— Large number of construction equipment is required on construction sites across the world. The effort of contractor are to constantly push machine capabilities forward. As the array of useful equipment expand, the importance of careful planning and execution of construction equipment's increases. The objective of the project is to predict the fleet production rate and to optimize the number and size of equipment's in the fleet to match the equipment to project situations. Equipment economics is taken into consideration for the optimization. Observation is done on the actual ongoing highway construction project Fleet performance of practiced fleet is compared with optimized fleet with respect to cost, equipment idle period per cycle and productivity. The project concludes that the performance of fleet is enhanced through optimization of equipment in the fleet.

Key words: Fleet Management, Construction Equipment, Practiced fleet, Optimized fleet, Productivity

I. Introduction

Large contractors have been steadily increasing their investment in construction equipment to satisfy their needs in response to increased construction volume in recent years. The technical advancement of earthmoving equipment during the 20th century includes many improvements in key parts of machines making the machine mechanically more efficient. Hence major large construction operations and mega projects uses a large number of various construction equipment's. This group of equipment's collectively forms a Fleet. The fleet operations have become complex due to a large number of manufacturers, various capacity and sizes of equipment available which makes the equipment selection a crucial task. After equipment selection the complexity further increases to optimize the size and number construction equipment's in the fleet. Moreover large and highly competitive markets for infrastructure projects especially BOT type of contract, enforces the contractors to complete the project as early as possible to start regaining the investments. This demands a continued improvement in the performance of construction equipment's. Hence there is a need of application of management techniques and systems in managing the fleet to complete projects on budget, on schedule, safely, and according to plans and specifications. Construction Equipment fleet management at its basic level addresses the problem of managing fleets of various construction equipment's stationary as well as mobile such as dumpers, excavators, shovels, scrapers, belt conveying systems, graders, pavers, rollers, cranes, HMA plant, RMC plant, transit mixers, etc. Use of Equipment fleet management increases the productivity of overall site and increases the profitability through a proper equipment selection & optimization, production monitoring, tracking of equipment's, maintaining a maintenance schedule, etc. Use of various sophisticated tools & techniques can be used for the same such as the telematics, GPS navigation, information transmission systems & various software's.

II. Objective

The main goal of the research was equipment optimization and benefit analysis at the site through equipment production analysis. The specific goals of the research included the following:

- Study the highway construction site for current practices of equipment management.
- Perform equipment productivity analysis to optimize the current composition of the earth/material moving fleet.
- Recommend changes to the company to assure the optimum level.
- Perform benefit analysis by comparing the current composition and the recommended theoretical fleet and recommended available fleet.

III. Research Goals

There is lack of effective management of construction equipment's even though large capital investments are made in procurement and operation of the equipment. The cost of construction equipment involved in a project may sometime exceed the cost of the project. Ineffective management of equipment leads to loss in production, delayed production and hence leads to reduced overall profitability of the firm.

IV. Equipment Productivity Analysis

Production of each equipment involved in the fleet is manipulated as actual and theoretical using the performance charts and other parameters such as distance, speed, number of trips, capacity, cycle time etc. using various mathematical formulae. The unit of measure for the production is always quantity of material excavated or moved on hourly basis i.e. m^3 /hr. various mathematical standard formulas are used for the direct production calculations for the respective equipment as follows:

Excavator output=(3600 X Q X F X E X V.C.) / T

Where,

Q = capacity of bucket in m^3 loose

F = fill factor

E = operator efficiency

V.C. = soil conversion factors

T = excavator cycle time (sec)

2. Tipper output = (V X 60) / T

Where,

v = tipper body volume (m^3)

T = tipper cycle time (min)

V. Parameters

A. Efficiency

Efficiency factor is the job efficiency of the operator. It is calculated as number of operating minutes per hour divided by 60 min. Job efficiency for each type of machine operator is calculated by taking mean of the daily machine working time divided by actual working time.

B. Fill Factor

According to the type of material being handled, fill factor corrections are applied. Fill factors account for the void spaces between individual material particles of particular type of material when it is loaded into an excavator bucket. Materials such as sand, gravel, or loose earth should easily fill the bucket to capacity with a minimum void space. At the other extreme are the bulky-shaped rock particles. If all the particles are of the same general size, void spaces can be significant especially with large size pieces.

C. Cycle Time

The sum of time required to complete one production cycle is the cycle time for equipment. The cycle time consist of different elements for different equipment's. Typical cycle time elements for different equipment are as follows:

D. Excavator:

1) Excavate/load bucket
2) Swing with load
3) Dump load
4) Return swing

E. Hauler:

1) Load
2) Haul
3) Dump
4) Return

The cycle time for the equipment's involved in the operation are taken by the mean value of the actual observations taken.

F. Equipment Economics

The economics of any equipment in a company is associated with equipment ownership and operation. Ownership expense is the cumulative result of those cash flows the company experiences whether or not the machine is productively employed on a project. Operating cost is the sum of those expenses an owner experiences by working a machine on a project.

G. Ownership Cost

The cash outflow the firm experiences in acquiring ownership of a machine is the purchase expense. It is the equivalent cost of the machine for the current year considering time and a specific rate of interest and taxes and the insurance premium. It is a cost related to finance and accounting exclusively, and does not include the wrenches and consumables necessary to keep the machine operating. Annualized purchase expense is the required equivalent cost for the amount paid whiles the purchase of equipment.

H. Optimization of Haul Units

The ultimate goal of optimizing a hauling system is to maximize productivity while minimizing total cost. Therefore, it is conceivable that an optimum equipment mix which is based on physical factors alone may not minimize the cost in every location. Thus, cost factors must be considered equally important to engineering fundamentals.

A virtual fleet is designed to find out the actual benefits been incurred using optimization of the equipment. The optimum no. of haul units required in each case is designed considering four categories as: Fleet 1: Optimum No. of 18.52 m3 MAN tipper (Rounding Up)

- Fleet 2: (Fleet 2 - 1) + 9.3 m3 TATA Tipper
- Fleet 3: (Fleet 2 - 1) + 14.95 m3TATATipper

VI. Result

The total time to complete an earth- moving project is merely the total quantity of earth to be hauled divided by the production rate of the hauling system. Once the total hourly project costs are known, they can be multiplied by the TT to find the total cost to complete the project. That figure can then be divided by the total quantity of material to be moved (M) to arrive at a unit cost for a given size and number of haul units.

The result of % saving in cost are compared between practiced fleet and cost effective optimized fleet as follows:

Case	Practiced Fleet Unit Cost (Rs.m^3)	Cost Effective Optimum Fleet Unit Cost (Rs/m^3)	% Saving In Cost	Avg % saving in cost
1	31.59	22.62	28.39506	9.51%
2a	22.62	22.34	1.237843	
2b	27.69	26.585	3.99061	
3	33.53	16.94	49.47808	
4a	19.35	19.35	0	
4b	10.55	10.55	0	
5	35.54	32.19	9.425999	
6	11.85	11.85	0	

The results of % reduction in Idle period per cycle are compared between practiced fleet and cost effective optimized fleet as follows:

Case	Practiced Fleet idle Period (min)	Cost Effective Optimum Fleet idle period (min)	% Reduction In Idle Period	Avg % Reduction in Idle Period
1	36.565	0.67	98.16764666	34.72%
2a	25.15	9.555	62.00795229	
2b	34.39	0.73	97.87728991	
3	10.08	0.22	97.81746032	
4a	6.4	6.4	0	
4b	1.755	1.755	0	
5	14	11.195	20.03571429	
6	3.985	3.985	0	

VII. Conclusion

- About 9.51% of cost saving can be achieved through equipment optimization

- Optimization of equipment reduces the idle period of equipment and achieves higher productivity and thus higher profits to the firm
- About 34.72% reduction of idle period of equipment per cycle can be achieved
- About 20.89% increase in productivity rate can be achieved
- Efficient usage of available resources can be achieved through correct equipment assignment through equipment productivity analysis

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