Productivity Optimization of Earthwork equipment by Fleet Management

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Abstract-*Construction sector particularly infrastructure projects like roads and dams etc. employees various type of construction equipment in large numbers. In India Excavators, dumpers, dozers, Motor graders, soil compactors etc are most commonly used earth work equipments on road project. These equipments work in synchronization with each other. Construction equipment are the major resource in infrastructure projects. Construction equipments occupy major portion of project finance. But improper utilization of such resource leads to loss of productivity, ultimately affecting profit. This paper tries to shows how productivity and profit optimization of these equipments can be achieved. To perform these optimization production capacity and cost of equipments, idle period is taken into consideration. To validate the results, case study of NH50 is taken and it is found that there is increase in profit.*

Keywords-Fleet, Construction equipments, production potential, Idle period , cost optimization.

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 equipments. This group of equipments 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 equipments 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 equipments. 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 equipments 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 equipments, maintaining a maintenance schedule, etc

1.1 Equipment fleet.

A fleet can be homogenous fleet of similar equipments or heterogeneous fleet of group of different equipments When these equipments work together it develop a complex situation as number of variables increases. This complexity give raise the use of EMS.

1.2 Equipment management system (EMS)

EMS solves the following problems accompanied with fleets of various equipments.

1.2.1 Equipment selection and optimization:

Equipment selection means which type of equipment to be assigned for this particular type of work. As we discussed there are large variety of equipment are available to do project, it is very important to choose proper equipment which will be feasible financially and functionally.

Equipment optimization means assigning optimum number of equipment so as to reduce the idle period of these equipment.

1.2.2 Productivity analysis and monitoring:

This is another important element regarding the production calculation of the equipments. It do the study of cycle times, loading capacity, performances of loading. Basically this component works to find out and optimize the production potential of equipments.

This EMS make easy to monitor the production potential in real time using latest data communication technologies.

1.2.3. Position and material monitoring:

When these equipment work they work simultaneously. This develops congestion on hauling route. Also it equipment are not positioned where they should be then it hamper the activity. This component helps to monitor of these equipments so as to reduce congestion on hauling roads at loading sites.

But this is not limited up to position monitoring only. This also helps to monitor which type of material and in which quantity the equipment is shifting. This is very important from safety point of view of both equipments and operators. This also analyzes performance of the overall fleet which gives managers exact idea about the productivity of the fleet.

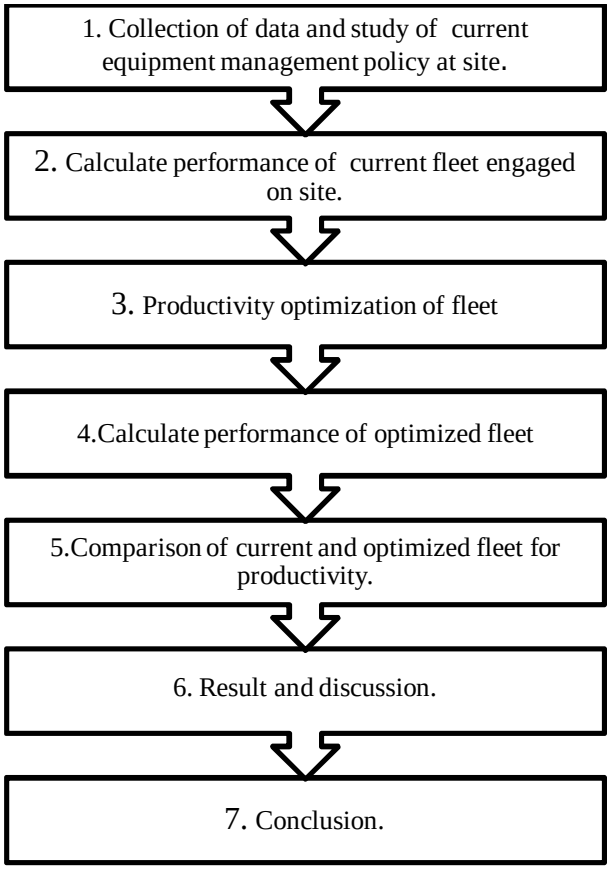
1.3 Research motivation:

The construction industry has undergone automation and still is. Contractors are employing more and more equipments to get job done. And they are being successful. Top managements are trying to provide best working environment to its working executives. But equipments are still used and managed on the basis of the experience. These methods are resulting in production losses, delays which ultimately lead to loss in profit of company.

1.4 Aim of paper:

This paper aims towards optimizing the productivity of fleet at site using productivity analysis.

1. Methodology



II. PRODUCTION ANALYSIS

For fleet management production capacity is very important parameter. Fleet is group of number of various equipments. The production capacity of each and every equipment in fleet is important as it will give the idea about the capacity of fleet as whole..

The productivity is governed by various parameters like distance, time, speed, capacity, cycles etc. Universally used unit for productivity is m3 per/hr.

Parameters of productivity for various equipments:

3.1.1 Capacity:

It is the volume capacity of equipment with which it operates. Capacity of bucket of excavator, capacity of body of tippers these are the examples of capacity of equipment

3.1.2 Efficiency:

It is the ability of equipment operator to do the work. It shows how much actually the operator works in one working day. The operational efficiency of construction equipment,

which refers to the ratio of the productive work time of equipment to its total operating time (Nichols and Day 2005)

3.1.3 Fill factor:

It is also refer as bucket efficiency factor. Bucket handles wide range of materials form black cotton soil to murrum, rocks to boulders. Different material fill differently in bucket loose material will have less voids so volume will be more whereas rock etc will fill at less volume that is the efficiency will be less. This fill factor will give how specific material will fill.

3.1.4 Swell factor

The volume of material in its natural state will be different than in case of loose state and volume of material in processed state like after compaction will be different than any of these two cases. Thus when the material is changed from one state to another it is to multiply by some conversion factor. That factor is swell factor or volume correction.

A) Productivity of Excavator:

Output = (3600 XQ x F x E x $V.C.$)/T
Q = Capacity of bucket in m3 (loose state).
F = Fill factor.
E = efficiency
T = Cycle time of excavator.
V.C. = Volume correction factor.

B) Productivity of Tipper:

Output = (V*60)/T
V = Volume of tipper m3
T = Tipper cycle time (min)

C) Productivity of Dozer:

Output = ((60 x)/T) x f x E
T = push cycle time (min)
f = material type correction factor
E = efficiency
L = blade load (m3)

D) Productivity of Roller

Output = (W x S x L x E x 0.9)/n
W = compacted width
S = avg. roller speed
L = compacted lift thickness
E = Efficiency.
n = no. of roller passes.

Table 1: Optimized numbers and production potential of current fleet

CASE	***Current fleet***			
	Equipment	***Nos.***	***Individual Productivity m3/hr***	***Overall production m3/hr***
A	Volvo EC 210B	1	33.41	33.40
	Tata HAIWA 2518	2	37.84	
B	Volvo EC 210B	1	46.92	38.05
	Tata HAIWA 2518	5	38.05	
C	LnT Komatsu PC200	1	57.68	32.74
	Tata HAIWA 2518	2	32.74	
D	Volvo EC 210B	1	75.69	75.69
	Tata HAIWA 2518	5	94.25	
E	LnT Komatsu PC200	1	49.56	49.56
	Tata HAIWA 2518	6	101.16	

3.2 Fleet optimization:

Fleet optimization means engaging exact quantum of Tipper at work so that near optimum productivity can be achieved. This can be done by calculating optimum number of units by using following formula
Optimum no. of tipper **(n) =** tipper cycle time / tipper loading time

Table 2: Optimized numbers and production potential of optimizes fleet

CASE	*Optimized fleet*			
	Equipment	*Nos.*	*Individual Productivity m3/hr*	*Overall production m3/hr*
A	Volvo EC 210B	1	33.41	33.41
	Tata HAIWA 2518	4	56.76	
B	Volvo EC 210B	1	46.92	46.92
	Tata HAIWA 2518	8	68.49	
C	LnT Komatsu PC200	1	57.68	57.68
	Tata HAIWA 2518	6	65.48	
D	Volvo EC 210B	1	75.69	75.69
	Tata HAIWA 2518	9	94.25	
E	LnT Komatsu PC200	1	49.56	49.56
	Tata HAIWA 2518	5	84.3	

IV. RESULT AND DISCUSSION

4.1 Fleet size:

In this study the Tipper ware under consideration were TATA Hyva 14.95m3 The table gives the difference of number of hauling units between both fleets.

Table 3: Hauling units comparison of fleets

CASE	*CURRENT FLEET*	*OPTIMIZED FLEET*
A	2 Nos.	3 Nos.
B	5 Nos.	9 Nos
C	2 Nos.	5 Nos.
D	5 Nos.	5 Nos.
E	6 Nos.	5 Nos.

4.2 Production potential:

After calculating the productivities of both cases it can be seen that productivity in optimized fleet has increased following table shows the difference in production potential of the both fleets i.e. current and optimized.

Table 4: Productivity comparison of fleets.

Case	Current Fleet		Optimize fleet		% increase in productivity
	Productivity m^3	*Type*	*Productivity m^3*	*Type*	
A	33.40	Excavator control	33.41	Excavator control	**17.13 %**
B	38.05	Tipper control	46.92	**Excavator control**	-
C	32.74	Tipper control	57.68	**Excavator control**	**12.18%**
D	75.69	Excavator control	75.69	Excavator control	-
E	49.56	Excavator control	49.56	Excavator control	-

V. CONCLUSION

The above discussed results concluded that:

The optimized fleet gives more productivity than current fleet employed at site. *Also it can be explained that the after tipper control fleet are converted into excavator control the productivity increases.*

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