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Construction Equipment Fleet Management

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ABSTRACT: *Fleet management can be defined by three basic components: Equipment assignment and optimization, Production monitoring, and Position and material monitoring. Equipment assignment and optimization is the primary reason many construction companies choose to implement fleet management systems in the first place. By enabling the scheduling and assignment of all types of equipment from multiple manufacturers as well as shift change management from a central office location. The second critical element, production monitoring, is the ability to review information on machine cycle time, payload, loading performance and other key operational parameters. Fleet management provides visibility in real time to this kind of data which can be tracked by individual machine or operator, groups of machines, specific sites or an entire fleet enabling miners to make timely changes to improve loading performance and increase payload predictability. Position and material monitoring is the third key component. At its most basic level, fleet management is about monitoring equipment location for an entire fleet but beyond that, it also helps to ensure that machines are in the right location and that the amount and type of material they are moving is accurate. The study revealed to analyze performance factors such as dump movement and haul road congestion to boost overall site productivity*.
Keywords – *Fleet management, Equipment assignment, Production monitoring, Material monitoring, Productivity.*

I. Introduction

Flipping through a mining journal or attending any mining industry conference there is a likely possibility to come across some discussion of fleet management. It's a hot topic these days. But beyond the obvious definition—managing a fleet of equipment—what exactly does it entail? And what benefits should it deliver for a construction operation? The simplest way to define fleet management is to look more closely at its three basic components: Equipment assignment and optimization, Production monitoring, and position and Material monitoring.

1.1. Equipment assignment and optimization:

Equipment assignment and optimization is the primary reason many construction companies choose to implement fleet management systems in the first place. By enabling the scheduling and assignment of all types of equipment from multiple manufacturers—as well as shift change management—from a central office location, fleet management helps minimize unproductive machine wait time and optimize equipment usage on site.

1.2. Production monitoring:

The second critical element, production monitoring, is the ability to review information on machine cycle time, payload, loading performance and other key operational parameters. Fleet management provides visibility in real time to this kind of data which can be tracked by individual machine or operator, groups of machines, specific sites or an entire fleet enabling fleet managers to make timely changes to improve loading performance and increase payload predictability.

1.3. Position and material monitoring:

Position and material monitoring is the third key component. At its most basic level, fleet management is about monitoring equipment location for an entire fleet—but beyond that, it also helps to ensure that machines are in the right location and that the amount and type of material they're moving is accurate. This type of data can be used to alert operators to misroutes before mistakes or safety hazards occur, as well as to analyse performance factors such as dump movement and haul road congestion to boost overall site productivity.

II. Fleet Problem And Action Plan:

The construction of dams, levees, highways, airports, commercial buildings and industrial plants utilize some type of earth-moving operations. Earth-moving is must on every construction site. Moreover all the mining operations include excavation and haulage. Earth-moving operations include excavating, hauling, placing, and compacting.

Consider a virtual problem of moving of Aggregate stockpiled at a certain location A to certain location B which is 2 Km away. The total stockpile volume is 10,000 m^3

Solution:

2.1 Equipment Selection:

First step the fleet manager has to take is the decision regarding equipment selection. In general the type's equipment's that can be chosen for earth-moving operations include dozers, scrapers, loaders, excavators, dragline, clamshell, haulers, graders and compacters. For each type of equipment selected, there are unique qualities that must be considered (e.g. horsepower, size, productivity, etc.) Many contractors depend on their years of experience for selecting the right pieces of equipment for a job. The preparation for selecting a fleet of equipment and estimates for earth-moving operations depend heavily on skilled judgment and taking into account all likely variables (e.g., job specifications, soil conditions, etc.). Much of the information needed is available to assist the selector; it usually exists in the form of historical data, manufacturers' performance specifications, and guidelines on methods of calculating production output, labour resources, and equipment requirements.

The various factors governing equipment selection in earthmoving operations can be summarized as follows:

2.1.1 Budget & schedule.
2.1.2. Range of total size of work. (i.e. total of amount material to be moved)
2.1.3. Material condition. (i.e. if soil weather wet or dry)
2.1.4. Distance of soil movement.
2.1.5. Hauling road condition (i.e. off highway road or a public road)
2.1.6. Digging Depth.
2.1.7. Working space available.

In this problem the equipment's selected are:

JCB 426, Bucket capacity: 1.14 m^3

ASHOK LEYLAND 1631, capacity: 6.84 m^3

2 .2 Equipment Optimization

A front loader with a 1.14 m^3 bucket has the following cycle elements:

Move to stockpile 0.05 min
Fill bucket 0.10 min
Move to truck and man oeuvre to load0.15 min
Dump loaded bucket 0.10 min

Total cycle time $_{(loader)}$ 0.4 min

Loader productivity = $\frac{\text{capacity} \times \text{cycle time}}{60}$

$= \frac{1.14 \times 0.4}{60}$

$= 171\ m^3/hr$

The tipper has to move 2 Km to and 2 Km fro i.e. 4 Km. considering the average speed 40 Kmph the travel time is:

$$\text{Travel Time} = \frac{\text{Distance}}{\text{Speed}}$$

$= \frac{4}{40}$ = 0.1 hr = 6.5 min

$$\text{Loading time} = \frac{\text{tipper capacity} \times \text{loader cycle time}}{\text{loader capacity}}$$

$= \frac{6.84 \times 0.4}{1.14}$ = 2.4 min

Thus Total Cycle time $_{(tipper)}$ = 6.5 + 2.4 = 8.9 min Number of Tippers required satisfying the operation:

N = $\frac{\text{Tipper cycle time}}{\text{Loader cycle time}} = \frac{8.9}{2.4}$ = 3.71 tippers Now the selection of optimum numbers is a crucial task. Rounding off the number of tippers will depend on two factors p, productivity and Profit Differential.

2.2.1 Rounding Based On Productivity: The decision of rounding off the optimum number of haul units up or down can have a marked effect on the system's productivity. Rounding the number up, maximizes the loading facility productivity. Rounding the number down, maximizes haul unit productivity. Therefore, it is logical to check both and select the higher of the two. Rounding down will maximize haul unit productivity. In other words, the haul units will not have to wait to be loaded, but the loader will be idle during a portion of each cycle.

Therefore productivity of 3 hauls units:

$= \frac{3 \times 6.84 \times 60}{8.9} = 138\ m^3/hr < 171\ m^3/hr$ (loader production)

Rounding up will maximize loader productivity, with the haul units having to wait for a portion of each cycle. This assumes that there will always be a truck waiting to be loaded as the loader finishes loading the previous truck.

Here the cycle time changes as the each tipper has to wait for each cycle.

Waiting time = (no. Of tipper × loading time) – (original cycle time)

= (4 × 2.4) – (8.9) = 0.7 min

New cycle time = 8.9 + 0.7 = 9.6 min

Therefore productivity of 4 hauls units:

$= \frac{4 \times 6.84 \times 60}{9.6} = 171\ m^3/hr = 171\ m^3/hr$ (loader production)

Thus in this case it is better to round up as a greater productivity is realized.

2.2.2. Rounding based upon Profit Differential: Another philosophy on rounding off the optimum number of haul units involves analyzing both cases to determine which would yield the greatest amount of profit. The aim is to find the best trade-off between the added cost of an extra vehicle and the benefit of having or not having that vehicle. The means of measuring the productivity of earth work is done by cost per ton and the lower that number, the greater is their profitability. As the largest contributor to those costs, loading and haulage are key areas of focus for sites looking to improve their operations. Even small changes can add up to big benefits.

Considering the hourly cost of operating loader with operator is 150 $^{Rs}/_{hr}$ and 50 $^{Rs}/_{hr}$ for the tipper with a driver.
The total cost (TC) to complete the project can be described by the following

TC = $\frac{(M)(C)(Hn \times N + Hl)}{N(Sh)(60)}$

Here M= Total Project quantity (m^3)

C = Cycle Time (min)

Hn= Hourly cost of tipper ($^{Rs}/_{hr}$)

Hl= Hourly cost of loader ($^{Rs}/_{hr}$)

N= No. Of tippers

Sh= Tipper size (m^3)

If N is rounded down to 3 units, the total cost is

$$TC = \frac{10000 \times 8.9 \times ((50 \times 3) + 150)}{3 \times 6.84 \times 60} = Rs1231.2$$

If N is rounded up to 4 units, the total cost is

$$TC = \frac{10000 \times 9.6 \times ((50 \times 4) + 150)}{4 \times 6.84 \times 60} = Rs1641.6$$

The total revenue = Rs5000 /-
Profit with 3 tippers = Rs3768.8
Profit with 4 tippers=Rs3358.4
Thus in this case it is better to round down as a greater profit is realized.

III. Theoretical Content

3.1 Swell factor:

$$\text{Swell Factor} = \frac{\text{Loose dry unit weight}}{\text{Bank dry unit weight}}$$

Material	Swell factor
Clay, dry	0.74
Clay, wet	0.74
Earth, dry	0.80
Earth, wet	0.80
Earth & gravel	0.83
Gravel, dry	0.89
Gravel, wet	0.88
Limestone	0.63
Rock, well blasted	0.63
Sand, dry	0.87
Sand, wet	0.87
Shale	0.71

3.2. Fill factor:

Material	Fill Factor (%)
Moist Loam/sandy clay	100-110
Sand and Gravel	95-110
Rock-poorly blasted	40-50
Rock-well blasted	60-75
Hard, tough clay	80-90

IV. Conclusion

Project engineers and estimators may accept less than optimum selections of equipment under the pressure of instantaneous decision making and lack of time to perform the tedious repetitive calculations necessary to determine the most economical selection.This paper gives a idea for the selection of equipment, finally it's the decision of contractor or engineer to go with productivity or cost. The automated procedure permits the user to perform what-if scenarios to compare the production and cost of different equipment spreads. The procedure could easily be extended to allow the user to enter limitations on the time allowed for the excavation and request the system to provide the total number of equipment required to complete the work within the time allotted.

Thus with using fleet management overall site productivity increases by increasing efficiency of the group of machine.

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