UNIT 3 OUTPUT OF CONSTRUCTION EQUIPMENT

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3.1 INTRODUCTION

In Unit 2 you learnt about operating schedules of construction equipment and breakdowns that may occur. In this unit you will learn about the output of construction equipment and how they are computed for different working periods.

Objectives

By the end of this unit you will be conversant with

- theoretical considerations in determining the output of a machine,
- manufacturer's ratings as regards production of an equipment,
- output of an equipment in the field,
- target output of machines,
- output of matching equipment when they work together,
- output of an equipment during night shifts,
- output of machines during inclement weather,
- monitoring actual output of an equipment, and
- evaluation and corrective action.

3.2 THEORETICAL CONSIDERATIONS

The output of excavating equipment such as power shovels and draglines depends on several factors. The principal ones include : type of soil excavated ; size of power shovel; depth of cut; angle of swing; job and management conditions; size and capacity of haul units; condition of the equipment, efficiency of the operating staff; size and type of bucket and length of boom (for dragline only) and method of disposal.

The ideal output of power shovels and draglines from theoretical considerations can be calculated by first finding the machine cycle time and number of cycles made in an hour, and then multiplying the dipper or bucket size with this number of cycles. Alternatively, time and motion studies of the working of equipment may be made to determine the probable output. These studies are conducted at several different times during the day and repeated for several days to obtain realistic values. The figures for ideal output of excavators

under defined conditions are also available in literature. By applying suitable corrections to these ideal production figures it is possible to determine probably expected output under the conditions of a project. The ideal output is given for optimum depth of cut, 90 degrees angle of swing and 60 min-hour.

SAQ 1

i) What factors affect the theoretical output of power shovels and draglines?

ii) How will you determine the ideal output of a power shovel or a dragline?

3.3 MANUFACTURER'S RATINGS (RATED OUTPUT)

Most equipment selection is based upon production rates which are taken from textbooks, manufacturer's handbooks, or contractor's records. Manufacturers and their dealers also perform equipment selection studies for contractors or owners. These studies are made on large projects where contractors have a greater opportunity to recover a large percentage of the cost of new equipment. The production figures are computed from machine payload, machine weights, rimpull curves, rotating mass constants, average fixed times, rolling resistances, grade resistances, length of haul segments, and tyre loading in tonnes per tyre. Other algorithms include engine specifications, converter specifications, final drive ratio, engine brake horse power and rpm, and other data for computing performance. Production may be based on either 50- or 60-minute hour, but no allowance is made for downtime; operator efficiency; haul road conditions other than length, grade, and rolling resistance; and other job efficiency factors. Sophisticated computer simulation techniques are being used by large contractors as well as equipment manufacturers.

SAQ 2

How are the manufacturer's production ratings worked out?

3.4 OUTPUT IN THE FIELD

Regardless of the method of estimating production rates for a particular project, the contractor depends upon his previous experience to verify his answers. For this reason, most estimators have bench-mark production rates for equipment which provide a cross-check on the job under consideration. These bench-mark production rates have been derived from prior time studies or other measurements of production and are generally applicable to well defined job conditions. Often a new project can be classified as harder than one of the bench-mark jobs but easier than another. Since obsolescence is shortening the economic life of much of the heavy equipment, it is important that good bench-mark production rates be obtained as early as possible in the life of an equipment.

SAQ 3

What are the bench-mark production rates of an equipment?

3.5 TARGET OUTPUT

Since the equipment planning is done on peak requirements, it is worthwhile that construction scheduling is done in such a manner that peak requirement is not substantially higher than that of average production. The new equipment acquired on a project should be utilised at least to the extent of 75% of its life. Production targets of equipment output should be drawn as required by the job and evaluation should be restricted only to production oriented machines. Proper development should be ensured through the year to

keep up the production targets. Deployment schedule and the production targets should be reviewed where equipment have recurring breakdowns and suffer from lack of spare parts.

The target output or production rate for which equipment is planned should be such that the peak requirement of equipment is not more than 10 to 20 % compared to that of the average requirement.

SAQ 4

How is the target output used to determine the peak requirement of an equipment?

3.6 OUTPUT OF MATCHING EQUIPMENT

When a number of equipment work together as a team, for example, shovel loading earth into dump trucks, the output of the combination is to be considered. The shovel being the heavier machine, it works continuously, once it has been started. The dump truck on the other hand can be readily started and stopped. For maintaining the shovel to excavate at its full capacity, adequate number of dump trucks should be provided. The production of the dump truck depends on the cycle time which includes the loading time, hauling time, unloading time, empty return time, and time for spotting, accelerating and decelerating and shifting gears. The production of the shovel should be balanced by the production of the truck or trucks. If the trucks are excessive in number, the cost of the waiting truck may become high. If the trucks are less in number, the shovel remains idle. However, the shovel is not stopped but it takes up its new position for further work, and levels the ground for the trucks to park themselves.

SAQ 5

When two machines work as a team, how is the output of matching equipment computed?

3.7 OUTPUT DURING NIGHT SHIFTS

The output during the night shift is not the same as during the day shift, and is usually less. If the lighting is inadequate, the output reduces further. However, when certain operations are to be carried out during the night to take advantage of the cool working hours as in concrete placement during hot weather, the output of the equipment will be higher.

SAQ 6

Why is the output during night shifts less than during the day?

3.8 OUTPUT DURING INCLEMENT WEATHER

Equipment produce less than the rates quoted by the manufacturers when the weather is rainy, windy, very hot or very cold. The rated horsepower of the equipment reduces with changes in temperature and atmospheric pressure.

The engine manufacturers rate engine performance at a temperature of 60°F and average sea level barometric pressure of 29.9 inches of mercury. If the engine performance is to be estimated at other than standard conditions a correction for temperature in addition to altitude correction should be applied to the manufacturers' ratings since a change in temperature also affects the output of internal combustion engines. The following relationship incorporating effects of both altitude and temperature correction is suggested :

$$H_c = H_s \times \left(\frac{P_o}{P_s}\right) \times \sqrt{\left(\frac{T_s}{T_o}\right)} \qquad (3.1)$$

where,

H_c = corrected horsepower,

H_s = horsepower under standard conditions, specified in the manufacturer's ratings,

P_s = standard barometric pressure, 29.92 inches of Hg,

P_o = observed barometric pressure, in inches of Hg,

T_o = observed absolute temperature, R,

= 460 + observed temperature, °F, and

T_s = absolute temperature for standard conditions, R

= 460 + 60 = 520 R.

SAQ 7

i) How does the weather affect output of an equipment?

ii) How does temperature and atmospheric pressure affect the rated output of a machine?

3.9 MONITORING ACTUAL OUTPUT

The loss of working efficiency on a project is attributable to many factors inherent in the job and resulting from managerial limitations. These factors are called job and management factors. By actual monitoring output of a machine these factors may be considered in actual planning of works. An alternative method of accounting for the loss of efficiency is by use of suitable factors depending upon the job and management conditions of the project.

Job factors pertain to the physical conditions of the job, apart from the type of material to be handled, that affect the output of an equipment. These have been broadly classified into following three types:

1) Site topography and work dimensions including working space and factors such as depth of cut and extent of material movement.

2) Surface and climate conditions, such as drainage of surface and ground water and climate of the area.

3) Specifications of the work including the methods to be used and sequence of operations.

The management factors pertain to suitability of organisational set up and efficiency of operation of staff and workmen. These factors include :

1) Personnel who operate the equipment including their professional skill and devotion to duties. Incentive necessary to get optimum output, and here managerial effectiveness is involved.

2) Equipment selection and utilisation with a view to reduce downtime to a bare minimum.

3) Job planning, supervising and management including proper coordination of the activities of different units.

Frank A. Nikirk after a close study of these factors grouped them into a matrix as shown in Table 3.1.

Table 3.1 : Job and Management Factors

Sl. No	Job Factors	Management Factors			
		Excellent	Good	Fair	Poor
1	Excellent	0.84	0.81	0.76	0.70
2	Good	0.78	0.75	0.71	0.65
3	Fair	0.72	0.69	0.65	0.60
4	Poor	0.63	0.61	0.57	0.52

It should be appreciated that the job factors are inherent in the job itself, and little can be done to alter them. For all practical purposes these factors are beyond human control. However, these are worthy of assessment, and the job under consideration can be classified under one of the four groups shown in the table. The management factors are somewhat intangible, and depending on the judgement of the engineer, the proper group should be selected after a dispassionate consideration.

The ideal ouput of an equipment is multiplied by the job and management factor to get the average output of the machine.

SAQ 8

i) What are job and management factors?

ii) How are job and management factors considered in obtaining the average output of an equipment?

3.10 EVALUATION AND CORRECTIVE ACTION

The output of the construction equipment is observed over a period of time to see whether the production is within reasonable limits prescribed by the manufacturer and after accounting for the job and management factors. The comparison may be required to be done over different times of the day and during different working periods. Some slight variation of the output may be attributed to the operator's skill, and condition of the equipment. If the variation is large then corrective action will be required on the part of the management. By improving the management factors some improvement in the output of the equipment can be expected. Timely and effective maintenance of the machine will also be a contributing factor towards better equipment performance.

SAQ 9

How is the ouput of an equipment evaluated and correction made in case of large variation in the average and actual values of production?

3.11 SUMMARY

In this unit you have learnt as to how the production of an equipment is evaluated when it works independently and when it works with another machine as a team. How the weather conditions affect the manufacturer's rating is also clear to you. Output of the equipment in the field, during night shifts and inclement weather will be different from the manufacturer's ratings, and how these are to be evaluated is explained in this unit. Remedies or corrective action for shortfalls in production have been suggested.

3.12 ANSWERS TO SAQs

Check answers of all SAQs with respective preceding text.