

Capacity and Throughput Testing

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Capacity

- The term capacity is used to evaluate the productivity of a machine.
- In agriculture, two types of capacity are commonly used, field capacity and throughput capacity.
- Field capacity is used to evaluate the productivity of machines used to work the soil, such as plows, cultivators, and other machines such as drills, sprayers, and harvesting machines.
- Throughput capacity is a measure of the volume of material that passes through a machine, machines such as grain augers, balers, forage harvesters, and combines.

Capacity

- If a tillage machine operates at 100% efficiency, it is operating at 100% capacity.
- This is called the theoretical field capacity.
- Theoretical field capacity is determined using the width of the machine and the speed of travel. It can be calculated using unit cancellation, but an equation is also available.

$$C_T = \frac{S \times w}{8.25}$$

- where C_T = theoretical field capacity, ac/hr; S = speed of travel, mi/hr; w = width of the machine.

Capacity

Problem: Determine the theoretical capacity for a machine that travels at 5.0 mph and has an operating width of 20.0 ft.

Solution:

$$C_T = \frac{S \times w}{8.25} = \frac{5.0 \text{ mph} \times 20.0 \text{ ft}}{8.25} = 12.12 \dots \text{or} \dots 12 \frac{\text{ac}}{\text{hr}}$$

If this machine travels at a constant speed and uses a constant width, it has a theoretical capacity of 12 ac/h.

- The difference between theoretical capacity and effective capacity is lost capacity.
- Lost capacity is an important concern for the machine operator and/or manager because it represents lost revenues or resources.

Capacity

There are two primary causes of lost capacity, lost time, time not operating, and operating the machine with less than the maximum working width. Common causes of lost time include:

1. Mechanical breakdowns
2. Taking time to adjust the machine
3. Stopping to fill seed hoppers, spray tanks, etc.
4. Slowing down to turn at the end of the row or crossing waterways, etc.
5. Operator rest stops

The common equation for effective field capacity is:
$$C_E = \frac{S \times w \times E_f}{8.25}$$

Throughput

- Throughput incorporates time, but because throughput usually refers to the flow of material through a machine, the units may be different from those used for capacity.
- For example, the performance of a hay baler could be evaluated using units of bales per hour or tons per hour. Or the Solar Food Dryer for Amla Candy Drying developed at IIT Kanpur has a throughput of 25Kg/16Hours.
- The throughput of a baler also can be evaluated in units of bales per hour (bales/hr).
- To use these units, additional information is required, including the weight of the hay (lb/bale) and two unit conversion values.

Throughput

Problem: What is the throughput capacity of a baler that baled 150.0 tons in 1 week while operating an average of 6.0 hr per day?

Solution: The units of the throughput capacity are not identified. They could be tons/week, tons/day, or bales/day. For this example, assume that the manufacturer advertises that the baler has a capacity of 6 tons/hr and the owner wants to compare the actual performance to the advertised performance. This means the effective throughput capacity needs to be calculated in units of ton/hr.

$$\frac{ton}{hr} = \frac{150ton}{1week} \times \frac{1week}{5days} \times \frac{1day}{6hr} = \frac{150}{30} = 5.0 \frac{ton}{hr}$$

Throughput

Knowing the actual throughput for the baler, the throughput efficiency can be determined. The throughput efficiency is:

$$E = \frac{\textit{output}}{\textit{input}} \times 100 = \frac{5 \frac{\textit{ton}}{\textit{hr}}}{6 \frac{\textit{ton}}{\textit{hr}}} \times 100 = 83.3\dots 83\%$$

Assuming the advertised throughput of the baler is a reasonable value, this operation is only 83% efficient in baling hay.

Thank You