Power Requirements for the tractor

Coefficients of Rolling Friction	
0.001 - 0.002	railroad steel wheels on steel rails
0.001	bicycle tire on wooden track
0.002	bicycle tire on concrete
0.004	bicycle tire on asphalt road
0.008	bicycle tire on rough paved road
0.006 - 0.01	truck tire on asphalt
0.01 - 0.015	car tires on concrete, new asphalt, cobbles small new
0.02	car tires on tar or asphalt
0.02	car tires on gravel - rolled new
0.03	car tires on cobbles - large worn
0.04 - 0.08	car tires on solid sand, gravel loose worn, soil medium hard
0.2 - 0.4	car tires on loose sand

The tractor has various modes of drawing power:

i) Driving mode
ii) Working mode

Let the top speed of the tractor during ploughing be 11km/h (3.056m/s).

A design consideration is made such that the tractor accelerates from rest to top speed in 8s. Therefore, acceleration is:

$$a = \frac{3.056 - 0}{8} = 0.3820 m/s^2$$

The tractor's acceleration can be used to define the tractor's differential equation as:

$$\frac{d^2 s}{dt^2} = 0.3820$$

To obtain the displacement function for the tractor, we can integrate the acceleration function to obtain the velocity function and integrate the velocity function to obtain the displacement function

$$\frac{d^2s}{dt^2} = a$$

The velocity function is:

$$\frac{ds}{dt} = at + u$$

Since the tractor is at rest before it starts moving, its initial velocity is 0.

$$\frac{ds}{dt} = 0.3820t$$

Where u is a constant of integration and represents the initial velocity of the tractor.

The displacement function is:

$$S = \frac{1}{2}at^2 + ut$$

Power requirements for driving mode

Design considerations

- In driving mode, the tractor top speed is 30km/h (8.3333m/s).
- The rolling coefficient (μ) of tractor tires on asphalt is taken as 0.01.
- The gravitational acceleration is taken as 9.81m/s^2

i) Power required to accelerate the tractor from rest to top speed in driving mode

Accelerating force:

$$F = ma$$
$$F = 650 \times 0.3820 = 248.2638889N$$

Traction force:

$$H = \mu W$$

$$H = 0.01\ x\ 650\ x\ 9.81$$

$$H = 63.765N$$

The total force is therefore:

$$F_{Total} = 248.2638889 + 63.765 = 312.0288889N$$

$$P = Fv = F\frac{ds}{dt}$$

$$P = F\ x\ 0.3820t$$

To determine the time required to accelerate from rest to top speed:

$$t = \frac{v - u}{a}$$

$$t = \frac{8.3333}{0 \cdot 382} = 21.81818182s$$

$$P = 312.0288889 \; x \; 0.3820 \; x \; 21.81818182 = 2600.240741W$$

ii) Power required to maintain the tractor at top speed in driving mode

$$H = \mu W$$

$$W = mg$$

$$W = 650 \; x \; 9.81 = 6376.5N$$

$$H = 0.01 \; x \; 6376.5 = 63.765N$$

$$P = Fv$$

$$P = 63.765 \; x \; 8.3333m/s$$

$$P = 531.375 \; W$$

Power requirements for working mode

Design considerations

- In working mode, the tractor top speed is 11km/h (3.056m/s).
- The rolling coefficient (μ) of tractor tires on farm soil is taken as 0.09.
- The gravitational acceleration is taken as 9.81m/s^2
- The width of the implement is 50cm and its depth is 10cm
- Specific force of a chisel plough is on clay soil is 280N/unit width/cm depth.

i) Power required for accelerating the tractor from rest to top speed in working mode

$$P = Fv = F\frac{ds}{dt}$$

Draught force:

$$F = 280 \times 0 \cdot 5 \times 10 = 1400N$$

Acceleration force

$$F = ma$$
$$F = 650 \times 0.382 = 248.2638889N$$

Traction force

$$H = \mu W$$

$$W = mg$$

$$W = 650 \ x \ 9.81 = 6376.5N$$

$$H = 0.09 \ x \ 6376.5 = 573.885N$$

Total force = $1400N + 248.2638889N + 573.885N = 2222.148889N$

$$P = F \ x \ 0.3820t$$

To determine the time required to accelerate from rest to top speed:

$$t = \frac{v - u}{a}$$

$$t = \frac{3.056}{0 \cdot 382} = 8s$$

$$P = 2222.148889 \ x \ 0.3820 \ x \ 8 = 6790.887004W$$

ii) Power required to maintain the tractor at top speed in working mode

Traction force:

$$H = \mu W$$

$$W = mg$$

$$W = 650 \ x \ 9.81 = 6376.5N$$

$$H = 0.09 \ x \ 6376.5 = 573.885N$$

Draught force:

$$F = 280 \times 0 \cdot 5 \times 10 = 1400N$$

Total force = $1400N + 573.885N$

$$P = Fv$$

$$P = 1973.885 \ x \ 3.056m/s$$

$$P = 6032.19256W$$

Taking traction efficiency as 80 percent yields the expected load as

Expected load = $\frac{Maximum\ load\ power}{Traction\ efficiency}$

Expected load = $\frac{6791}{0.8} = 8488.608755W$

Expected load taking into account the traction efficiency is 8.5KW