13. SETTING UP THE TRACTOR

CHAPTER OBJECTIVES:

- ***To introduce the reader to the meaning and importance of tractor wheel slip;***
- ***To describe the need for tractor ballasting;***
- ***To explain the methods of weight transfer between the front and rear of the tractor.***

The correct weight and balance between the front and the rear are critical for maximizing operational efficiency and obtaining reasonably trouble free tractor life. In the past, the philosophy was that the heavier the tractor, the wider the implement that can be pulled, therefore, the more efficient the operation.

This approach is not necessarily the most economical one in modern days. Tractors are now designed quite differently from their predecessors and they are expected:

- To be more powerful;
- To operate at higher speeds;
- Pull smaller drawbar loads.

A modern tractor must be set up correctly in terms of ballast and weight transfer to achieve the required wheel slip. This will enable the tractor to operate efficiently and to use the fuel economically.

13.1. WHEELSLIP

Although it seems hard to be true, wheel slip is necessary for efficient tractor operation. Excessive wheel slip wastes power, but low wheel slip on the other hand can be just as wasteful.

When a tractor pulls a load, there must be a certain amount of wheel slip because the tires stretch and the soil moves in response to the applied drawbar pull. Even the smallest drawbar pull causes some tire stretching and soil movement. Therefore, wheel slip is always present when the tractor is working.

There are three main factors that influence wheel slip:

- **The pull the tractor exerts.** Increased drawbar pull results in greater tire stretching and more soil movement. This means that for any given tractor weight, increasing the drawbar pull will increase wheel slip;

- **The weight on the tire.** In most situations, increasing the weight on the tire reduces wheel slip. The reason for this is that the extra weight compresses the soil, making it stronger and allowing the soil to develop the required strength with less movement;

- **The soil type and conditions.** Soil types vary in strength and in the amount they deform under load so that the tractor wheel slip will vary with soil type. Wheel slip will therefore increase on weaker soils and decrease on stronger soils.

13.1.1. WHY WHEELSLIP?

When a tractor is performing draught work like plowing, cultivating or ripping, wheel slip is a good indicator of efficient tractor operation. If wheel slip is too low, it is an indication of either:

- The tractor is not using a high percentage of its available power. Fuel economy will be poor and a smaller, less expensive tractor could also do the job; or

- The tractor is over-ballasted and power is being wasted moving the tractor around. Fuel economy will be poor and there is increased risk of drive-train failure.

If wheel slip is too high, this indicates either:

- The tractor is overloaded and it is being used for a job that it is not designed for; or
- The tractor is not ballasted correctly to do the job efficiently.

13.1.2. OPTIMUM WHEELSLIP

The amount of wheel slip required for maximum efficiency depends on the tractor type and the soil conditions it is operating in. On firm soils, maximum efficiency occurs at lower wheel slip than on loose or soft soils. Four-wheel-drive tractors achieve maximum traction efficiency at lower slips than two-wheel-drive tractors because the rear wheels are working on soil, which has been strengthened by the passage of the front wheels.

Acceptable levels of wheel slip are described in Table 13.1.

TABLE 13.1: ACCEPTABLE LEVELS OF WHEELSLIP

Tractor type	Percentage wheel slip	
	Firm soil	Cultivated soil
2-wheel-drive	7-11%	10-15%
4-wheel-drive	6-10%	8-12%

If a tractor engine is well loaded and the wheel slip is close to the acceptable values described in Table 13.1, the tractor should be operating at high power efficiency. This will result in good fuel economy.

13.1.3. MEASURING WHEELSLIP

Wheel slip cannot be visually estimated accurately. One of the best ways to measure wheel slip without expensive instruments is to do it with a tape measure and two people helping, the one driving the tractor and the other one counting the wheel revolutions. To measure wheel slip:

- Make a reference mark with chalk or adhesive tape on the sidewall of one of the tractor's driving tires;
- Measure the distance required for the tractor to travel ten drive-wheel revolutions on a hard surface. This is the *no load distance*;
- Proceed to the area where the wheel slip is to be measured. Select a spot in the area that is very typical of the paddock. Allow time for the tractor and implement to stabilize to a normal working pattern before taking any measurements. Do not start measurements from a resting position;
- Walk parallel with the tractor while the tractor and implement is traveling at normal working speed. Mark the spot where the mark on the tire comes down to the ground;
- Continue walking alongside the tractor and count ten revolutions. Mark the spot on the ground that corresponds to the end of the tenth revolution;
- Measure the distance between the two marks. This will be the *loaded distance*;
- The percentage wheel slip can now be calculated as

$$\frac{\textit{(No load distance – loaded distance)} \times \textit{100}}{\textit{No load distance}}$$

13.1.4. ADJUSTING WHEELSLIP

If wheel slip is too low:

- The tractor may be too big for the implement and the efficiency can be improved by:
  - Reducing tractor ballast; or
  - Increasing the implement draught with extra tines or discs.

- The tractor may be incorrectly ballasted. The efficiency can be improved by:
  - Reducing ballast; or
  - Reducing the weight transferred from the front to the rear of the tractor by lowering the height of the drawbar.

If wheel slip is too high:

- The implement may be too big for the tractor, or the tractor was not designed for heavy pulling at low speeds. To improve efficiency:
  - Reduce the implement width by reducing tines or discs; or
  - If practical, reduce the working depth of the implement.

- The tractor may be too light. To improve efficiency:
  - Add ballast without exceeding the manufacturer's maximum recommended weight; or
  - Increase the drawbar height to transfer more weight from the front to the rear of the tractor.

It is not possible to have the tractor working at the correct level of wheel slip in all situations. Implement draught variation, different slopes and different implements will all put different loads on the tractor. A practical approach is to adjust ballast so that wheel slip is the optimum for the most common cultivation operation in typical soil conditions. If the ballast is in a form which can be conveniently added or removed, it may be practical to adjust it for certain operations, or at some times of the year.

13.2. BALLASTING AND WEIGHT TRANSFER

If a tractor is not ballasted correctly, it will not work efficiently and there is also a risk of premature drive-train failure. Too much weight means power is wasted in moving the tractor around and drive-train components may fail prematurely.

If the tractor is too light, excessive wheel slip will waste power and cause rapid tire wear.

13.2.1. CORRECT WEIGHT LEVELS

Correct tractor weight depends on the pull it exerts. When working at high power and low speed, the tractor will develop a high pull and will need heavy ballasting. When working at high power and high speed, the tractor will require less ballasting.

Table 13.2 gives an estimate of the correct working weight for tractors.

TABLE 13.2: APPROXIMATE WEIGHT REQUIRED BY TRACTORS

Working speed (km/h)	Weight required per PTO kW (kg)	
	2-wheel-drive	4-wheel-drive
4	150	125
5	120	100
6	100	83
7	86	71
8	75	63
10	60	50
12	50	42

** The weight required is for tractors working on firm or cultivated soil, using 80% of its available power.*

Optimum weight for a given speed can be calculated by multiplying the figure opposite that speed by the tractor's maximum PTO power in kW. These weights are only guidelines. The measuring of the actual wheel slip can be used to adjust the ballast.

13.2.2. WEIGHT TRANSFER

Pull on the tractor drawbar causes weight to be transferred from the front axle onto the rear axle. Tractor ballasting must allow for this effect to achieve the correct weight distribution when the tractor is working.

The exact amount of weight transferred will depend on the tractor wheelbase, the drawbar height and the drawbar pull. Increasing the drawbar height or the drawbar pull will increase the amount of weight transferred. Typically, a well loaded tractor pulling an implement which imposes little or no downward force on the drawbar like plows, discs, and some tined cultivators, will have about 10% of its weight transferred from front to rear. To allow for this, tractors should be ballasted as shown in Table 13.3.

TABLE 13.3: APPROXIMATE STATIC WEIGHT DISTRIBUTION

Tractor Type	Weight distribution at rest (%)	
	Front	Rear
Two-wheel-drive	25	75
Front-wheel-assist	40	60
Four-wheel-drive	60	40

** The weight distribution is for tractors pulling implements, which impose little or no downward force on tractor drawbar.*

According to Table 13.3, a four-wheel-drive tractor, ballasted with 60% front and 40% rear weight would actually be working at 50% front and 50% rear because of the 10% weight transfer.

13.2.3. WEIGHT ADDITION

Some three-point-linkage implements and some trailed chisel plows and rippers can impose heavy downward forces on the tractor drawbar. This causes additional weight to be added to the rear of the tractor and increases the weight transfer.

As a rough guideline, tractors working with implements, which impose heavy downward loads, should be ballasted with 10% less total weight than specified in Table 13.2. and the portion of weight on the front wheels should be increased by about 10%, as shown in Table 13.4.

TABLE 13.4: ADJUSTED STATIC WEIGHT DISTRIBUTION

Tractor Type	Weight distribution at rest (%)	
	Front	Rear
Two-wheel-drive	30	70
Front-wheel-assist	45	55
Four-wheel-drive	65	35

** The weight distribution is for tractors pulling implements, which impose heavy downward force on tractor drawbar.*

Table 13.4 applies only to tillage implements. Other implements like carry drag scrapers have the potential to impose very high downward loads on the tractor and can cause extreme overloading of the tractor's rear axle.

13.2.4. ADJUSTING BALLAST

Cast iron wheel weights or water in the tires are equally effective means of adding weight. Cast iron has the advantage of being easier to remove when the tractor is being used for light draught work. One man can usually install weights up to about 50kg, provided there are ledges or pins to support the weight whilst the attaching bolts and nuts are fitted. If the weights have to be held in the exact position while the bolts are inserted and the nuts started, the job becomes very difficult for one man and can be dangerous.

Ballasting tires with water is the cheapest way of adding weight to the tractor. Tires can be filled up to 90% full with water, although 75% full is more usual. Adding too much water leaves insufficient air space for a cushioning effect. When adding water ballast, care must be taken not to add more than what is necessary.

If the height of the tractor drawbar can be adjusted, it provides the simplest way of making changes to the tractor's weight distribution when working. As explained previously in this chapter, raising the drawbar increases the load on the rear wheels and reduces the load on the front wheels.

On two-wheel-drive tractors, the only reason for adding ballast in the front is to stabilize the steering control. Excess front weight wastes power and fuel.

13.3. CONCLUSION

Wheel slip is important for effective tractor operation because of tire stretching and soil movement. The amount of wheel slip required for maximum efficiency will depend on the tractor type and on soil conditions. Wheel slip can be controlled by ballasting and weight transfer.

The correct amount of weight is essential for efficient tractor performance. The weight required depends on the tractor power and the working speed. Tractors should be ballasted correctly and the weight evenly transferred. Too much weight will lead to power waste and excessive fuel use. Too little weight will increase wheel slip to insufficient levels and will also increase fuel usage. If not set up correctly, the tractor will not function in the most economical way.

13.4. REFERENCES

Agfact E6.4. 1983: *Tractor ballasting and weight transfer.* New South Wales Agriculture and Fisheries, Australia.

Agfact E6.2. 1983: *Tractor wheel slip.* New South Wales Agriculture and Fisheries, Australia.