Monitoring wheel slip to achieve fuel efficiency

Wheel slip is a key indicator of efficient tractor set-up and operation. The level of wheel slip serves as a proxy to indicate whether the right combination of tyre pressures, tractor weight (ballast) and tractor operating speed are resulting in the correct traction required to perform efficiently and save fuel. Many operators are misinformed as to the appropriate levels of slip.

Mastering wheel slip
Understanding wheel slip and learning how to measure it is an essential skill in tractor operation.

Wheel slip is one of the most important variables in assessing the efficiency of traction and correct operation of the machine.

The level of wheel slip serves as a proxy indicator of whether the right combination of tyre pressures, tractor weight (ballast) and operating speed is resulting in correct traction for efficient performance and fuel savings.

Further, wheel slip can determine the wear and expected lifetime of a tractor’s drive train and tyres. A wheel slip that is too low may be a sign that the drive train is being strained and excessive weight is being hauled. Conversely, a very high wheel slip suggests that the tyres are wearing excessively and wasted rotations are likely wasting fuel.

Refer to supplementary papers, Tractor Ballasting and Tyre Pressure.

What is appropriate wheel slip?
Many operators may mistakenly believe that zero percent wheel slip is optimal but this is rarely the case for most field operations. Only in certain situations, such as when transporting a tractor on hard surfaces (e.g. roads), is zero percent wheel slip desired.

Although there are some differences in opinion regarding the most appropriate wheel slip, several sources suggest that the most optimal wheel slip range is between eight and 15 percent.

- For 2WD tractors using tyres, the recommended range is between 10 and 15 percent.
- For 4WD or front wheel assist (FWA) tractors with tyres, the recommended range is between 8 and 12 percent.

These wheel-slip ranges are considered optimal for balancing fuel efficiency and longevity of the drive train and tyres.

Quick tips
Review your tractor set-up. Ensure that the weight/tyre pressures are correct for the task.

Install a performance monitor. If not already fitted, consult your dealer in regard to the fitting of a groundspeed radar/slip monitor (many tractors are fitted with such equipment or can be retrofitted in the field).

Calibrate existing equipment. For tractors already equipped with radar, ensure that any required calibration is carried out prior to usage.

Provide training. Ensure that operators are aware of any fitted performance monitors and know how to use them.

Inspect field conditions. Review field performance by conducting regular in-field inspections regarding tractor operation and soil conditions. Tread marks may not provide an accurate estimate for wheel slip but should allow a farmer to spot overballasting or underballasting.

Measuring wheel slip
Wheel slip cannot be measured directly as it is the result of comparing two variables:

- the actual forward travel speed of the vehicle, and
- the tyre or track surface speed.

Wheel slip is expressed as a percentage (i.e. how much travel distance has been reduced due to slippages); it can be calculated using the equation below:

\[
\text{Slip} (%) = \left( \frac{\text{tyre or track surface speed} - \text{true vehicle forward speed}}{\text{tyre or track surface speed}} \right) \times 100
\]

Equation 1: Wheel slip calculation using forward travel and tyre speed

Option 1: Use a performance monitor
The preferred method of determining wheel slip is to track it continuously via the tractor’s performance monitor.
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These systems typically require radar to provide accurate readings of slip and field performance. This radar is used in conjunction with the speed input from the tractor’s engine/transmission to determine the wheel slip and performance data displayed to the operator. GPS positioning can also be used to reference the tractor’s true ground speed; however, GPS systems may require clear weather to work and can be inaccurate at low speeds (Zhixiong, et al., 2013).

Most new tractor manufacturers offer monitors that can measure wheel slip (along with other parameters) as an optional add-on. If you did not select this feature at purchase, it is likely that the dealer can retrofit it.

Option 2: Measure tyre rotations over a set distance

Alternatively, wheel slip can be calculated from tyre rotations. To do this, you must first measure the number of tyre rotations that occur when the tractor travels over a set distance, at working speed and under no load. Then you must repeat the measurement while the tractor is under load. The following equation can then be used to calculate slip:

\[
\text{Slip}(\%) = \left( \frac{\text{no. of rotations with load} - \text{no. of rotations with load}}{\text{no. of rotations with load}} \right) \times 100
\]

An implementation of this way of measuring wheel slip is known as the ‘10-turn method’ (Wyoming Energy Conservation Office, 1983). For a comprehensive list of steps required to measure wheel slip this way, see (Government of Alberta, 2012).

Be aware that this method of measurement will provide you with the wheel slip only for the specific working conditions tested and therefore, the measurement will have to be repeated if any of the following parameters change:

- tractor weight or ballast,
- type of implement or working depth,
- tire pressures,
- working speed, and/or
- soil conditions (soil type, moisture, hardness, etc.).

The awkwardness of such a process makes clear why an integrated performance monitor is the preferred option.

Option 3: Installation of a ‘bolt-on’ system

‘Bolt-on’ wheel-slip monitors could be of use if you are using very old tractors which may not have the appropriate components or controls to enable the use of a typical performance monitor.

These types of systems are no longer available in the Australian market, however, as their manufacture has been phased out with the advent of integrated systems.

Farmers may be able to source specialists in Doppler radars and electronics who can help them to set up similar systems; however, the complexities of custom-made bolt-on systems are not trivial (see Further information).

Visual inspection of the tyre footprint

Another important way of determining whether your tractor’s wheel slip is appropriate is by inspecting the tread marks it leaves behind.

With excessive slip (common with underballasted tractors), the tractor’s tread mark will show little or no distinct tyre pattern as the soil will have been shifted throughout.

Conversely, a heavily overballasted tractor will leave distinct tyre tread marks in the soil and will show very little shifted soil between the cleats in the tyre pattern. This is an indication that wheel slip is too low.

A tread mark showing a distinct tyre pattern with shifted soil in between the cleats is a sign that the tractor is performing with an appropriate amount of wheel slip.

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1. Please note: Many systems require some input regarding the calibration of both the tractor’s drive wheel size and the radar input. Consult the tractor manufacturer’s appointed dealer for further information regarding these points.
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Other considerations

Visual estimations
Some operators determine the level of wheel slip by visually ‘eyeing’ the tyres when the tractor is in operation. The literature suggests, however, that wheel slip will become apparent to an observer through this method only when it is at least 15 percent (which is already too high). So the rule of thumb is:

“If an operator can see the tractor is slipping, it is already slipping too much.” (Reed J. Turner, 1993)

Tractors with tracks
The appropriate amount of wheel slip for tractors using tracks is different from the ranges suggested in this information paper, which relate to tractors using tyres. Generally, acceptable track slippage is considered to be between three and six percent, although it can be as high as 10 percent with no detrimental effects.

Further information

Ballasting, tyre pressures, wheel slip and their relation to tractor performance

Slip measurement using dual radar guns
Provides information on how a potential bolt-on system can be developed and implemented using radar technology.
www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/eng8286

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References


