NSW GOVERNMENT Department of Primary Industries

primefact

Monitoring wheel slip for fuel efficiency

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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. The most optimal wheel slip range is between 8 and 15 percent.

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.

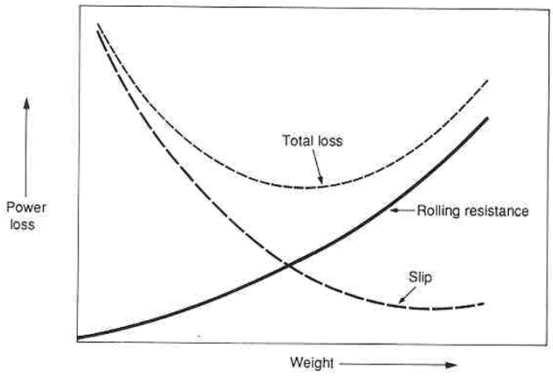
Quick tips

- **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 provide a useful guide of wheel slip and should allow a farmer to spot overballasting or underballasting if

more accurate methods are not available.

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. Wheel slip is necessary to develop pulling force in the field.



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 8 and 15 percent.

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

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:

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

$$Slip(\%) = \left(\frac{tyre\ surface\ speed - true\ vehicle\ forward\ speed}{tyre\ surface\ speed}\right) \times 100$$

Option 1: Use a performance monitor

The preferred method of determining wheel slip is to track it continuously via the tractor's performance monitor.

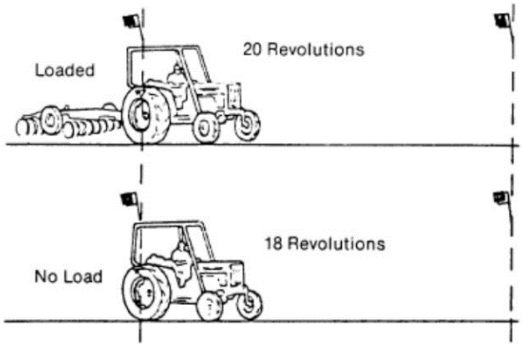
Modern farm machinery is often equipped with advanced telemetry, such as tractor management systems (TMS), which enables the farmer to assess the actual fuel efficiency of farm machinery, including engine speed, forward speed, and wheel slip etc.

These systems typically require radar to provide accurate readings of slip and field performance. The 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.

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:

Equation 2: Wheel slip calculation using tyre rotations over a set distance

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

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 ballasts
- type of implement or working depth
- tyre pressures
- working speed and/or
- soil conditions (soil type, moisture, hardness, etc.).

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

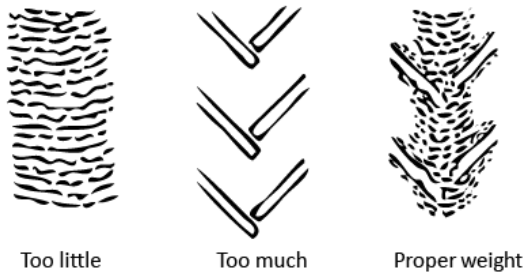
Option 3: Installation of a 'bolt-on' system

'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.

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.

Figure 1: Tread marks depicting excessive wheel slip (underballasted), insufficient slip (over ballasted) and optimal slip[1]



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

[1] Adapted from Svejkovsky, C., 2007. *Conserving Fuel on the Farm.*

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.

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).

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 or lower, although it can be as high as 10 percent with no detrimental effects.

Case study

At a mixed farming operation just outside Moree NSW, the Greer family implemented a range of energy efficiency measures. These measures included changing the tractor ballast set up when switching from sowing to spraying to optimise wheel slip. This, in combination with adopting adaptive driving techniques, is estimated to reduce diesel use by five percent per year.[2]

Acknowledgements

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Please see this factsheet for more detailed information about this topic.

Reference number DOC21/80927

[2] https://www.aginnovators.org.au/initiatives/energy/case-studies/energy-savings-watercourse