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FACT SHEET

CONTROLLING TRACTOR WHEEL SLIP FOR EFFICIENT OPERATION

Elston K. Grubaugh and Thomas D. Valco*

We often say that anyone wasting time or not getting his work done is "spinning his wheels." If your tractor wheels slip more than 15 percent, you are wasting time, fuel and money.

Wheel slip is the percentage difference between drive wheel speed and ground speed. A tractor tire must grip the soil to develop a pulling force. As the tire gets a grip on the soil, some of the rotational speed of the tire is lost and not changed into ground speed. The proportion of speed lost is wheel slip, which is expressed as a percent. A wheel that is not slipping is not pulling; to develop pull, a drive wheel must slip. As it provides larger and larger pulling forces, wheel slip must increase.

Under most conditions, tractor drive wheel slippage should range between 10 and 15 percent. This is a compromise for various soil types because usually it is impractical to add or remove much weight when working different soil types. Most people barely notice wheel slip of 15 percent or less. If you notice tires spinning, you could easily have an extra 10 percent slippage. That means you spend 11 hours doing jobs you should have finished in 10. You will burn an extra gallon of fuel for every 10 gallons the work should have taken. Slippage also causes faster tread wear, and spinning tires are more prone to cuts from stones and stumps.

Drawbar horsepower is reduced by excessive slippage (at high wheel spin more power is consumed in the attempt to grip the soil, i.e., more power is consumed in soil deformation). But, reducing slippage to less than 10 percent results in excessive soil compaction and an increase in rolling resistance. Slippage below 10 percent indicates either too much tractor weight or too small a load. At low wheel slip, excessive tractor weight increases the tractor's rolling resistance on the soil surface — it takes more power to push the tractor around the field.

*Extension agricultural engineers–mechanization, The Texas A&M University System.

Check Slippage

You can check slippage by counting wheel revolutions with the tractor loaded and unloaded. Choose a typical area in the field and make a mark on one rear tractor tire. Bring the tractor up to speed with the implement working before you pass a predetermined mark such as a scratch or stake in the soil. Have someone mark the location on the ground where the tire completed 10 revolutions under load. Be sure to use the same gear and throttle setting used for normal operation.

Raise the implement and circle back to the starting point. This time, with the implement raised, drive the same distance in unworked soil next to your previous pass. Again count wheel revolutions to the nearest quarter-turn between the two marks on the soil. If you count 10 revolutions, you have no slippage and need to reduce weight.

Calculate wheel slip as follows:

$$\text{Percent slip} = 100 \times \frac{(\text{Loaded revolutions} - \text{No load revolutions})}{\text{Loaded revolutions}}$$

For example, if it took 8.5 revolutions to travel the distance covered in 10 loaded revolutions:

$$\text{Percent slip} = 100 \times \frac{10-8.5}{10} = 100 \times \frac{1.5}{10} = 15 \text{ percent.}$$

Factors Affecting Slippage

Weight is a major factor in controlling slippage. Before weighting a tractor, a few things must be taken into consideration. The more important ones are: (1) allowable or optimum drive wheel slip, (2) travel speed, (3) tire load rating, (4) avoidance of excessive soil compaction and (5) load rating of rollover protective structure (ROPS). If a tractor is weighted too heavily, a rollover may crush the safety structure.

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Ballast

Weight is added to tractors as ballast in three ways. Either dry powdered or liquid ballast can be pumped into tires, or cast iron weights can be attached to wheels or to the front frame. Because of installation problems and difficulties in checking pressure, some engineers discourage using dry ballast. Liquid ballast should be a calcium chloride solution to resist freezing and provide more weight than plain water. However, liquid and dry ballast tend to become permanent, where cast iron weights (except for extremely large ones) can be removed for lighter work. There is no difference in performance of equal amounts of the three types of weights.

Major tractor manufacturers suggest 130 pounds of total tractor weight per drawbar horsepower as a starting point. Two-wheel-drive tractors need 25 percent on the front wheels for pull-type implements, 30 percent in front for semi-mounted equipment and 35 percent for full-mounted equipment. Adjust weight for specific field conditions. You don't need much extra front weight with pull-type equipment. Take it off. Unnecessary front weight makes the tractor harder to steer. Front wheels roll uphill to climb out of their ruts and you waste fuel pushing unneeded weight.

Four-wheel-drive tractors usually should have 55 to 60 percent of their weight on the front wheels. When loaded, some of the weight shifts, equalizing weight on all wheels. However, in very soft or sandy soils, it may be more efficient to have less weight on front tires to cut rolling resistance, then the rear wheels pull in tracks firmed by front tires.

Speed

Another major factor in slippage is operating speed. The draft, or pull, on tillage equipment increases with speed, but you may be able to get more work done at a higher speed with less tractor weight. For instance, as a rule of thumb, acres covered in 10 hours equals speed in mph times implement width in feet. A 25-foot tandem disk pulled at 4 mph with excessive slippage probably would get the same amount of work done as an 18-foot disk running 5.5 mph. Higher fuel consumption for the increased draft is offset by reducing rolling resistance, less slippage and less soil compaction.

Most current tractors are designed to develop their maximum horsepower at four to six mph. If you must use a slower gear to get enough power and then have too much slippage, reduce implement size or working depth. Slow speeds (less than four mph)

Table 1. Agricultural drive wheel tractor tires used as singles (maximum speed = 20 mph). Figures in parentheses denote ply rating for which loads and inflations are maximum.

Tire Size	Ply Rating	Tire Load Limits at Various Cold Inflation Pressures, lb.									Torque Factor
		12 psi	14 psi	16 psi	18 psi	20 psi	22 psi	24 psi	26 psi		
8.3-24	4	970	1060	1150	1230	1310	1380(4)				0.94
9.5-16	4	970	1000	1080	1150	1230(4)					0.86
9.5-24	4	1210	1330	1430	1540	1630(4)					0.92
11.2-24	4	1470	1600	1740	1860(4)						0.90
11.2-28	4	1560	1710	1850	1980(4)						0.92
12.4-24	4, 6, 8	1760	1920	2080(4)	2230	2370	2510	2640(6)	2760	3120@32	0.89
12.4-28	4	1880	2050	2220(4)						(8)	0.91
13.6-24	4		2270(4)								0.87
13.6-28	4, 6		2420(4)	2620	2810	2980	3160(6)				0.89
13.6-38	4, 6		2810(4)	3040	3250	3460	3660(6)				0.94
13.9-36	6		2730	2960	3170	3370(6)					0.94
14.9-24	6		2700	2920	3130	3330(6)					0.86
14.9-26	6, 8		2790	3020	3230	3440(6)	3640	3830	4010(8)		0.87
14.9-28	6		2880	3120	3340	3550(6)					0.88
14.9-30	6		2980	3220	3450	3670(6)					0.89
15.5-38	6, 8		3160	3410	3660	3890(6)	4110	4330	4540(8)		0.94
16.9-24	6, 8			3540	3800(6)	4040	4270	4490(8)			0.84
16.9-26	6, 8			3660	3920(6)	4170	4410	4640(8)			0.86
16.9-28	6, 8			3780	4050(6)	4310	4560	4790(8)			0.87
16.9-30	6			3900	4180(6)						0.88
16.9-34	6			4140	4440(6)						0.90
16.9-38	6, 8			4380	4700(6)	5000	5280	5560(8)			0.91
18.4-16.1	6			2810(6)							0.79
18.4-26	6, 8, 10			4390(6)	4700	5000(8)	5290	5560	5830(10)		0.85
18.4-28	6			4530(6)							0.86
18.4-30	6, 8, 10			4680(6)	5010	5330(8)	5630	5930	6210(10)		0.87
18.4-34	6, 8, 10			4970(6)	5320	5660(8)	5980	6290	6600(10)		0.89
18.4-38	6,8,10,12			5250(6)	5630	5990(8)	6330	6660	6980(10)	7880@32	0.90
20.8-34	8			6010	6440(8)					(12)	0.87
20.8-38	8, 10			6360	6820(8)	7250	7670(10)				0.89
23.1-26	8, 10			6280(8)	6730	7160(10)					0.82
23.1-30	8			6700							0.84
23.1-34	8			7110(8)							0.86
24.5-32	10				8180	8700(10)					0.84
17.5L-24	6			3390(6)							0.86
28L-26	10				7800(10)						0.82

and excessive weight cause too much force on the power train, resulting in a shortened life and expensive repairs.

Tires

Tires are another major factor in determining tractor performance. Always maintain recommended inflation in front and rear tires and increase inflation when maximum ballast is used. Use an air-water gauge if you have liquid ballast and place the valve at the bottom when checking pressure. Then wash the gauge.

When you add ballast, avoid exceeding the load rating of each tire. The ratings are based on tire size and inflation pressure, and are for static tractor weight. Allowance is made for weight transfer from implements.

Reducing tire pressure is not a good way to reduce slippage. At lower pressure, sidewall buckling increases and tires are more likely to slip on the rims. Table 1 lists tire load limits and inflation pressures for modern tractor tire sizes.

Duals

The use of dual tires is another method of slippage control. Dual tires provide more flotation, and the weight of extra tires and wheels increases traction. Dual tires have several advantages and limitations.

Advantages of dual tires include:

- Dual tires, with added ballast, give more ground contact. This reduces slippage, increases ground speed, improves work rates, and possibly reduces fuel consumption.
- Tractor stability is improved by the greater contact and tread width.
- Operator fatigue is lessened because the ride is smoother.
- The use of duals to replace single tires of the same size increases flotation.
- Tractors converted to duals have a higher potential for all season use. Duals can be used to meet the high horsepower requirements for land preparation, but the tractor can be used with single tires for row crop cultivation.
- Duals often permit the use of the tractor under adverse weather and soil conditions when using single rear wheels would make field work impractical.

Disadvantages of dual rear tires include:

- Some tractor axles, bearings and power trains may be overstressed by dual wheels with resulting serious damage to the tractor.
- If the drawbar load is relatively light, there is no real advantage in dual tires over single tires of the same size, other than reducing soil compaction.
- Dual tires may make the tractor more difficult to turn. If short turns are made, the extreme stress on the tread lugs may cause the lugs to tear.
- In situations requiring duals only a small part of the year, the added cost may not be recovered in benefits.

Remember, there are no universal guidelines for using or not using dual tires. Each situation must be examined separately. Your tractor dealer should be consulted prior to installing duals to make sure that power train components can withstand the additional stress of dual tires.

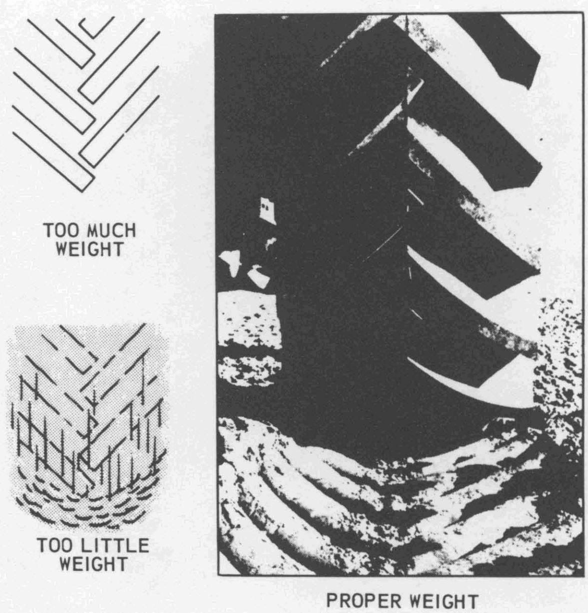

Figure 1. When too much weight is used, tire tracks will be sharp and distinct in the soil and there will be no evidence of slippage. When the tires have too little weight, tread marks are completely wiped out and forward progress is slowed. A small amount of slippage occurs when the tires have proper weight. Soil between the cleats in the tire pattern is shifted, but the tread pattern is still visible.

Cooperative Extension Work in Agriculture and Home Economics, The Texas A&M University System and the United States Department of Agriculture cooperating. Distributed in furtherance of the Acts of Congress of May 8, 1914, as amended, and June 30, 1914.
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