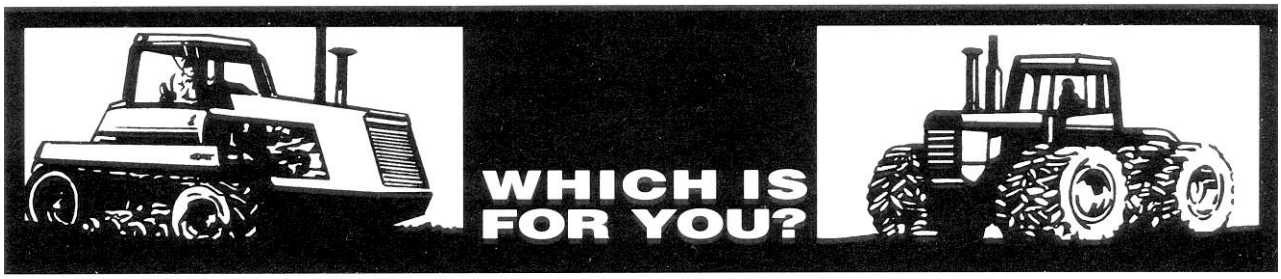
TRACKS VERSUS WHEELS



By Reed J. Turner

Introduction

With the production of the Challenger series of rubber belt farm tractors, Caterpillar Tractor introduced a new set of variables to farm machinery management. What those variables are and how they affect conventional thinking about farm tractor usage has been the focus of a series of tests at the Agricultural Technology Centre (Agtech).

Engineers at the Centre evaluated the various Challenger models and compared the tractive performance of the rubber belts to different conventional four wheel drive (4WD) tractors. Comparisons were made to tractors equipped with single, dual and triple tires. All the tractors were instrumented to measure engine power, drawbar power, speed, slip and ride quality. The measurement of power delivery efficiency, the ability of the traction system to deliver available engine power to the ground as useful working power, was the main emphasis of the test. Tests were conducted in various soil conditions throughout Alberta and Montana during 1991 and 1992.

Results show definite differences between rubber belt tracks and rubber tires. On the *plus* side for the tracks were pull and the ease of optimizing the traction system performance. The tracks also showed a slight plus in power delivery efficiency. On the plus side for tires were steering control and overall cost. A neutral issue for both systems was ride quality. The issue of soil compaction was not resolved by the tests.

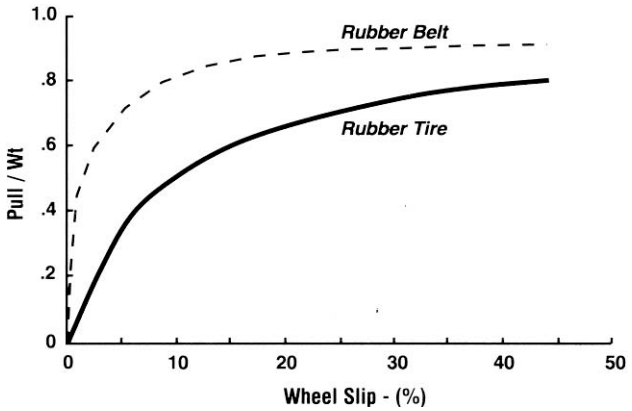
Pull

A Plus for Tracks

In straight pulling, the rubber belts can develop substantially more force than rubber tires for the same tractor weight.

Pull/weight ratio is the ratio of the pull a tractor produces, divided by the tractor weight. Normally, heavier tractors produce more pull, whatever their power delivery system. Slip is the ratio of a vehicle's actual forward speed to the track or tire speed. Normally, slip increases as pull increases. Figure 1 shows pull/weight ratio for various slips for a 270 hp Challenger 65 and a 270 hp 4WD tractor equipped with eight radial tires. Both tractors weigh 32,000 lb. The rubber belt curve rises steeply at low slip levels while the rubber tire curve increases gradually over a larger slip range. The rubber tire curve does not reach as high a pull/weight value.

Figure 1. Pull to weight ratio versus per cent slip



While a rubber belt can develop more pull than a rubber tire, this is only part of the story for a farm tractor. In most farm operations, drawbar horsepower, the product of pull times speed, is what counts. Agtech engineers found both rubber track and rubber tire systems have ample pull and traction to deliver 200 drawbar horsepower at field speeds of five miles per hour and higher. While the additional pull capability of the rubber belt track can deliver 200 drawbar horsepower at speeds as low as three miles per hour, this may not be a big advantage since most farm operations are done at higher speeds.

Optimization

A Plus for Tracks

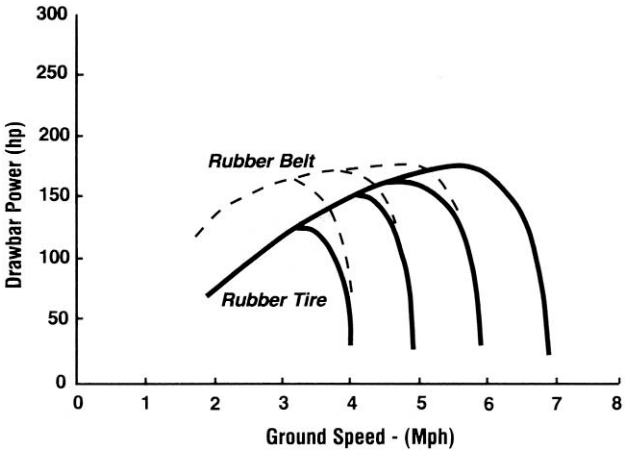
Optimization is the selection of the proper tractor weight and tire set-up for a particular speed, pull and ground condition. Using a tractor at its optimum gives the highest performance and the lowest operating cost.

Optimizing a rubber tire tractor for a given speed, pull and ground condition can require changes in ballast and tire inflation pressure. Since this takes planning, measurement and the slinging around of heavy weights, it is often only done once for a tractor. Because of this, a rubber tire tractor may not always be at an optimum set-up for its current working condition.

With rubber belt tracks, there are no pressures or weights to change, yet the tracks usually perform at their optimum. Figure 2 shows the rubber belts develop maximum drawbar power over a wider range of speeds than rubber tires. In day-to-day usage, the tracks should average out to deliver more power to the ground because they remain at about the same efficiency regardless of changes in the operating conditions. This can be a significant advantage.

Rubber tires can have another problem that rubber tracks do not. In some conditions rubber tire tractors have the tendency to "power hop" under load. Power hop is a bouncing or "porpoising" of a tractor in a fore/aft up/down motion while it is pulling. Adjusting a tractor to reduce this problem may move it away from its optimum setup.

Figure 2. Drawbar power versus ground speed

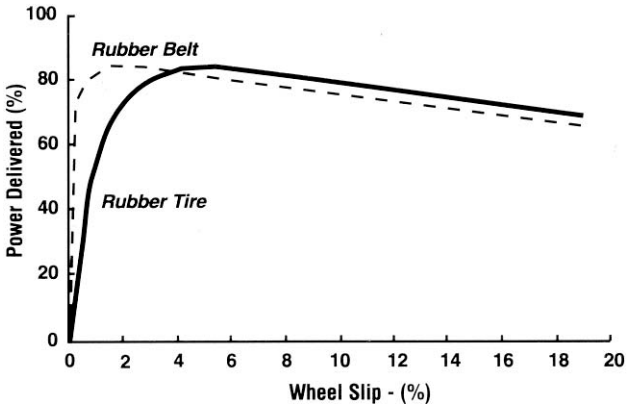


Power Delivery Efficiency

A Slight Plus for Tracks

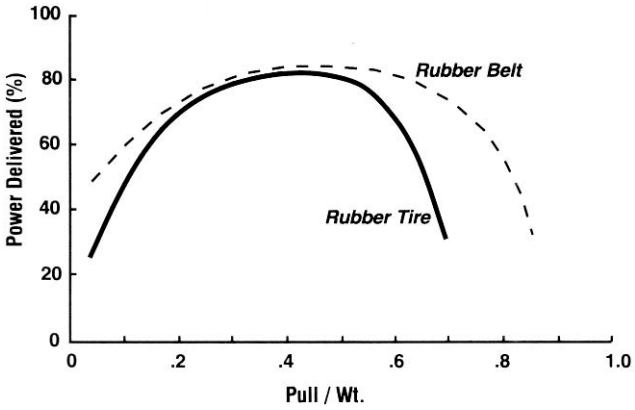
Power delivery efficiency is a measure of the ability of a traction system to deliver available engine power into useful work on the ground. Tests showed little difference between rubber belt tracks and *correctly set-up* rubber tires. Figure 3 shows power delivery efficiency at various levels of slip for a rubber belt and a rubber tire system. Although the two curves are different in shape, both power delivery systems reach similar maximum efficiencies, about 80 per cent. In some tests rubber belt tracks showed a slight (1 to 3%) increase in efficiency over rubber tires.

Figure 3. Power delivery efficiency versus per cent slip



Rubber belt tracks maintain their efficiency over a wide range of pull and ground conditions. Figure 4 shows power delivery efficiency versus pull/weight for the two tractors. The rubber belt tracks have a wider range of effective operating area.

Figure 4. Power delivery efficiency versus pull to weight ratio



A given engine power level will produce the same drawbar power on a *correctly set-up* rubber tire tractor as it will on a rubber belt tractor. On an *average* rubber tire tractor, it will probably produce less drawbar horsepower than it will on a rubber belt tractor. The amount of difference will vary depending on the operating conditions and on how close to optimum the wheel tractor is operating, but the average day-to-day power delivery efficiency should be higher for the rubber belt tracks. Improved average power delivery efficency can mean either more field work done in a day or less fuel usage for the same amount of field work.

Some promotional information suggests rubber belts are better because they operate at a lower slip than rubber tires. They do operate at lower slip, but this is not necessarily an advantage. Slip is simply a factor of operation of the track or the tire in delivering power. As Figure 3 shows, the differences in slip had little effect on the overall power delivery performance of the systems.

Ride

Equal for Either System

There was little difference in average ride quality between the rubber belt tracks and the rubber tires. The long flat area of track smoothed out closely spaced ground contour variations such as cultivator sweep spaced ridges. The short wheelbase of the track amplified more widely spaced variations such as implement width spaced ridges. Thus, in some ground conditions the rubber belt tracks rode better than rubber tires and in others they did not ride as well. Average ride vibration levels were similar for both systems.

Steering

A Plus for Tires

Rubber tire tractors generally steered better than the rubber belt tractors. When a rubber tire tractor is steered, the tires turn and point in the direction of the turn. When a rubber belt tractor is steered, the track on the outside of the turn speeds up and the track on the inside of the turn slows down. Under moderate to heavy draft loads, a rubber tire tractor may slide sideways as it turns, but it still turns. Under similar draft loads, a rubber belt tractor may not turn at all. This is a nuisance and can present a serious problem if an operator doesn't expect it. With rubber belt tracks the draft load must be reduced before significant steering can occur.

As a rubber belt tractor turns, the tracks slip sideways, pushing soil and producing ridges and depressions. A tire rolls through a turn and produces little soil disturbance.

Steering a rubber belt system requires more power than steering a rubber tire. The extra power is needed to overcome the sideways slipping and to speed up the outside track. This can cause overload or stalling problems when the tractor is steered while operating near full engine load.

Costs

A Plus for Tires

Caterpillar rubber belt tractors cost about 15 per cent more than equivalent drawbar horsepower rubber tire tractors if comparing dealer retail prices in Alberta in the fall of 1992. If comparing actual prices paid by farmers in Alberta during the same time, the difference was even greater, with rubber belt tractors being about 30 per cent more than equivalent rubber tire tractors.

Tractor costs are situation and location dependent, and can change quickly. The dealer retail prices used for comparison were the December 1992 retail prices in Alberta, in Canadian dollars. They included freight, ballast and delivery to a farm in Alberta. Taxes were not included. The actual prices paid by customers were determined from interviews with customers who dealt on tractors in Alberta during the November to December 1992 period, in Canadian dollars, again including freight and ballast, but not taxes.

Soil Compaction

Unresolved

Rubber belt tracks may reduce soil compaction, although this was not determinable in the Agtech tests. Rubber tracks have a low average ground pressure and good flotation, and showed less tendency to dig down and get stuck than any of the rubber tire set-ups. For a rubber tire tractor to have similar average ground pressures required triple tires. Triples are expensive and can be a nuisance because of their width. Agtech tests also showed triples to have a power delivery performance penalty ranging from 4 to 7 per cent compared to duals or singles.

Conclusion

Rubber belt tracks are an option in farm machinery selection. So are four wheel drive tractors with single, dual or triple tires. Each system has strengths and weaknesses and provides certain features and performance characteristics. Potential owner/operators need to balance these pluses and minuses against their operating needs to decide what will work best for them.

To receive more detailed information about these tests, contact Reed Turner, research and development engineer, at the Agricultural Technology Centre, 3000 College Drive South, Lethbridge, Alberta, TIK 1L6, phone 403-329-1212.