EQUIPMENT

Selecting Energy-Efficient Tractors no. 5.007

by H.W. Downs and R.W. Hansen[1]

Quick Facts...

Energy costs have become a significant part of total farm expenditures.

The Nebraska Tractor Tests are a nationally accepted standard of comparison for farm tractors.

Use information on specific tractors to determine proper operating conditions, such as correct ballasting and operating speeds, as well as operating costs.

The test reports are available for a small fee from the University of Nebraska Department of Biological Systems Engineering, Lincoln, NE 68583.

Energy costs have become a significant part of total farm expenditures. Proper selection and management of tractors is necessary to keep production costs at an acceptable level. The Nebraska Tractor Tests, discussed in this fact sheet, offer useful performance information on tractors.

The Nebraska Tests

The Nebraska Tractor Tests are conducted by the University of Nebraska, according to the Agricultural Tractor Test Code approved by the American Society of Agricultural Engineers (ASAE) and subcommittee of the SAE Tractor Technical Committee. A test advisory group is made up of farmers, implement dealers and extension agents in Nebraska. Although the original goal of the tests was to test all tractors marketed in Nebraska, virtually all tractors produced and marketed within the United States are tested, resulting in a nationally accepted standard of comparison for farm tractors.

Copies of the test results for any tractor tested may be obtained for a nominal fee by writing to the Department of Biological Systems Engineering at the University of Nebraska in Lincoln, NE 68583. A subscription service for yearly reporting is available. The test results also are published by the Implement and Tractor Redbook and Doane's Agricultural Service in summary form.

Test Procedures

All tractors tested are stock production units selected by the manufacturer. Each tractor is allowed a 12-hour break-in period during which adjustments may be made by a manufacturer's representative. After break-in, the tractor is subjected to extensive testing, involving both power takeoff (PTO) and drawbar performance.

Interpreting the Test Data

Model and General Information

This section gives specific information about the unit tested, including engine displacement, bore and stroke, oil and air filtering system, use of turbochargers, rated rpm, tire size and weight. These data are useful when comparing tractor engines.

The location of the center of gravity is important if the tractor is operated on hilly or sloping ground. The tractor turning radius gives an indication of its maneuverability. Optional equipment included on the tractor is listed, along with transmission type, PTO speeds, brake type, etc.

Colorado State University Cooperative Extension

Putting Knowledge to Work

Maximum Power and Fuel Consumption and Efficiency (PTO-Performance)

Maximum PTO horsepower (hp) and fuel consumption at both the rated engine speed and at the rated PTO speed is given. Note that these performance figures are obtained on a dynamometer and allow no margin for power required to drive the tractor or for pulling implements. Therefore, they must be reduced somewhat for a field operation, such as forage harvesting (see fact sheet 5.009, *Matching Tractor and Implement Sizes*.) Fuel consumption figures can be used for comparison between tractors. Fuel efficiency is expressed in terms of horsepower hours per gallon (hp-hrs/gal).

Varying Power and Fuel Consumption (PTO-Performance)

The tractor is run at several PTO loadings in this test to provide fuel consumptions and efficiencies. This data is particularly good for comparing fuel use at partial loading. For PTO testing, the engine speed is kept constant regardless of the loading, so the best fuel efficiency will be obtained at 100 percent load. At reduced loading, the fuel efficiency will drop because the engine must remain at PTO speed despite the reduced power required. At a PTO loading of 25 percent, the fuel efficiency may be only half that at full power.

The average power and fuel efficiencies for the various loading levels are also given. They may be used to determine the average yearly consumption for the tractor. For example, a 100-PTO hp tractor is to be used 700 hours yearly. If the average fuel consumption reported is 4.72 gal/hr, the yearly consumption will be 700 x 4.72, or 3,304 gallons of fuel per year.

Varying Drawbar Power and Fuel Consumption (Drawbar Performance)

For these drawbar tests, the manufacturer selects a gear ratio, and the drawbar performance and fuel consumption of the tractor is evaluated at various drawbar loads. Two tests are made at 50 percent of maximum available power, one with the tractor at rated engine speed and the other with the tractor in a higher gear ratio and throttled back to the same ground speed. This comparison shows that for partial load operations, the tractor can be operated more efficiently at reduced throttle settings. For example, using Test No. 1255, the tractor has a fuel efficiency of 10.02 hp-hrs/gal at 50 percent load and rated engine speed. At reduced throttle, the tractor has an efficiency of 13.39 hp-hrs/gal at the same load and ground speed.

Another interesting comparison can be made using the maximum available drawbar hp at 100 percent load and the maximum PTO hp. A ratio of the drawbar hp to the maximum PTO hp is an indicator of the efficiency of the drive train of the tractor. Consider Test Nos. 1255 and 1257 for an IH 986 diesel with 16-speed transmission and IH hydrostatic diesel 186. These tractors have identical engines, producing approximately 105 PTO hp. However, the standard transmission 986 produces 90 drawbar hp, while the hydrodrive produces 80 drawbar hp.

The comparison of drive train efficiencies is as follows. IH 986: 90/105 = 86 percent; IH 186 hydro: 80/105 = 76 percent. The tractor with the standard transmission has less loss in the drive train and is able to transmit more power to the drawbar. The overall fuel efficiency with the standard transmission is obviously better. In this case, the potential buyer would have to decide whether the advantages of the hydrostatic transmission were worth the increase in fuel consumption and efficiency.

Maximum Power With and Without Ballast (Drawbar Performance)

This section shows maximum drawbar performance for up to six different forward gear ratios selected by the manufacturer. One speed above 8 mph may be selected, with an upper safety speed limit of 15 mph. The slip in all gear ratios

Summary

The Nebraska Tractor Tests can be used to compare tractors on the basis of energy and power performance. Information on any specific tractor can be used to determine proper operating conditions, such as correct ballasting and operating speeds. The fuel efficiency information in the tests can be used to estimate average operating costs.

Individual tractor test reports are available for a small fee or as an annual subscription. Subscribers to the Nebraska Tractor Test Reports receive individual tests, as they are printed and also the Nebraska Tractor Test Data summary booklet. To order the test reports, send money or a check made payable to University of Nebraska, c/o Department of Biological Systems Engineering, Lincoln, NE 68583.

is limited to 15 percent. The maximum drawbar hp usually is somewhat less for slower ground speeds. In order to produce maximum hp at slow speeds, the drawbar pull must be large, resulting in a higher percent of slip and more power loss.

It usually is most fuel efficient to operate in a middle range of speeds that result in neither excessive power losses due to slip or increased power requirements caused by high-speed operation. The maximum drawbar performance without ballast gives an indication of how an unweighted tractor might perform and also how important ballasting is. A tractor usually is ballasted so that approximately two-thirds of its total weight is placed on the rear wheels.

Varying Drawbar Pull and Travel Speed With Ballast (Drawbar Performance)

Testing starts in a certain gear ratio with the tractor operating at full load. The load gradually is increased until engine speed is reduced and drawbar pull increased to some limiting factor, such as percent slip. These data show the lugging characteristics of the tractor.

It is important to note how much the total drawbar pull is increased and the engine rpm at which maximum pull is reached. Downshifting should occur at this speed since peak torque has been reached, and the amount of drawbar pull then decreases as the engine speed continues to drop.

Information from this section can be used to compare tractors' lugging ability if a specific percent reduction in engine speed is used. For example, it will show how much increase in drawbar pull is obtained for a 20 percent reduction in rated engine speed for the tractors being compared.

Tractor Sound Level

Operator comfort is affected by how much noise the tractor produces during continuous operation. Consider 90 decibels (db) a limit for continuous operation without ear protection. An increase of 10 db roughly doubles the noise level sensed by the ear.

Usually, tractors equipped with cabs have acceptable noise levels. However, the same tractor purchased without a cab might create unacceptable noise levels. Tractors with hydrostatic transmissions usually are somewhat noisier than those with standard transmissions.

Tires, Ballast and Weight

Details on tires, ballast and weight are given in the test reports. The potential buyer can see how much additional ballast must be added to obtain optimum performance. The original weight of the tractor is an indication of how heavy the chassis is. The front and back axle weights indicate how weight is distributed to obtain best performance.

For operation with fully mounted implements, it may be necessary to add more front-end ballast to counterbalance the additional rear implement weight. Information on the tire size, ply and pressure on the tractor also is shown.

[1] H.W. Downs, former Colorado State University research associate, chemical and bioresource engineering; and R.W. Hansen, former Colorado State University Cooperative Extension specialist and associate professor. Reviewed by D. Oatman, Cooperative Extension agriculture agent, Las Animas County.