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Tractors I.—Mechanical Considerations

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Introduction

In recent years so great has been the increase in numbers and types of tractors available for farm purposes that a demand has arisen for a bulletin describing in general terms the main types of tractors that are available, together with some indication of the separate and special uses of each main type. Considerations of cost will be dealt with in Bulletin No. 116. Farm tractors may be classified according to such characteristics as horse power, engine type or fuel used, track, type of implements to be used or work to be done. It will first be necessary to define some of the terms used.

The Meaning of Horse Power

James Watt originated the unit of horse power to describe the capacity of the first steam engine. If a weight of 55lbs is lifted vertically through a height of 10 feet, or a weight of 110lbs. through 5ft., we say that 550 foot pounds of work are done. Simply the weight in pounds multiplied by the distance in feet (measured in the direction of the weight) is a measure of the work done, in foot pound units. If 550 foot pounds of work are done in a second the machine is working at the rate of 1 horse power. An average horse working throughout an eight-hour day will develop only about two-thirds of this power for Watt fixed a high standard so that his engines would compete favourably against horses in any trial.

Many tractors are described by two horse powers—such as 12-20. The first or smaller is the Drawbar Horse Power (D.B.H.P.) or power that is available for towing, apart from the power necessary to move the tractor itself. If, for example, a tractor must exert a force of 1500lbs. in order to draw a two-furrow plough through hard clay soil, and if the tractor travels at 3 miles per hour (4.4 feet per second) then in one second the tractor performs 1500 x 4.4 equals 6600ft pounds of work. Divide 6600 by 550 equals 12. That is, the tractor develops 12 Draw Bar Horse Power. Although a five-horse team may be able to do similar work this does not mean that a five-horse team is equivalent to a 12 h.p. tractor, because the horses may travel at 2 miles per hour (2.9 feet per second). At this speed it will be found that the plough penetrates the soil more easily so that the pull at the draw bar falls to 1100lbs. Then the horse power of the team is $\frac{1100 \times 2.9}{550}$ equals 5.8 h.p. The difference between the 12 h.p. and the 5.8 h.p. explains the saving in time that occurs with tractor work. A tractor should develop its greatest draw bar horse power when operating at a convenient working speed.

The second horse power mentioned in tractor specifications is that which is obtained when a brake test is applied to the belt pulley wheel. It is called Brake Horse Power (B.H.P.), is a measure of the power of the tractor for belt work such as threshing, sawmilling, etc., and is from one and a half times to twice that available at the drawbar because in belt work the tractor does not have to propel itself and also because losses occur in transmission gearing.

Power Required

To plough 1 acre per hour of light sandy soil to a depth of 5½ inches requires only about 12 D.B.H.P.; to plough heavy clay soil at the same depth and rate will need approximately 24 D.B.H.P. Generally in firm ground 5 D.B.H.P. is needed for each furrow ploughed. Thus 10 h.p. will pull 2 furrows, 15 h.p., 3 furrows and so on. As the horse power of the tractor is increased so the original purchase cost and fuel consumption per hour increases. While a tractor should not be overloaded it would be uneconomical, owing to higher overhead costs, to use a tractor of much greater horse power than that required. Nevertheless, it seems unfortunate that owing to the high initial cost of the very large Diesel tractors, farmers generally are unable to take advantage of the use of these tractors, which can plough at about half the per acre cost usual with the common low-powered tractors of 12-15 D.B.H.P.

Tractor Engines (classified according to fuel used)

(a) Kerosene (Paraffin) Burning. —These tractors operate well if the water in the radiator can be kept close to boiling point. Care must be taken to avoid idling on kerosene, and spark plugs need frequent attention. Even with these precautions wear tends to be somewhat higher than in petrol engines owing to dilution of the oil by unburnt kerosene, although various devices now reduce this wear considerably. As a rule the mixture of kerosene and air is ignited in the cylinders by a spark from a high tension magneto.

The following results of typical kerosene tractors will serve to explain the general method of fuel consumption calculations. The figures are taken from the 1936 Nebraska Tractor Tests.

Tractor	D.B.H.P. developed continuously throughout 10-hour day	Gallons of kerosene used per hour.
"A"	17.5	2.5
"B"	22.78	3.7
"C"	9.90	2.0

These may be compared by dividing the horse power by the number of gallons of fuel used in 1 hour; then in units of D.B.H.P. hours per gallons of kerosene, "A" gave 7.02, "B" 6.18, and "C" 5.00. If the tractors are loaded so as to develop their maximum horse power, A gives better fuel economy than tractor B or C.

(b) Petrol Burning.—Many of the new model tractors have high compression automobile type engines, that is, the cylinder heads are so shaped that a large volume of gas is compressed into a very small space before firing. The ratio of the volume in the cylinder above the piston when at the bottom of its stroke to the volume above the piston at the top of its stroke is called the compression ratio. While engines with a compression ratio of 4 to 1 usually employ kerosene as the fuel, the greatest power for a given fuel cost will be obtained in new engines with a compression ratio of 5.5 to 1 by using premium or super petrol. For example, a test was made on a 200 cubic inch engine operating at 1300 revolutions per minute and working 700 hours drawing a two-furrow plough. When working on kerosene with an engine compression ratio 4 to 1 it developed 24 h.p. A similar tractor but with compression ratio increased to 5.5 and operating on super (70 octane) petrol, developed 31 h.p. Petrol engines on test give about 7 D.B.H.P. hours per gallon used.

(c) Semi Diesel.—These engines employ a heated bulb or some other device to explode the mixture of crude oil and air at starting. Once started the heat generated by compressing the mixture to a very small space is sufficient to fire the charge. Cheap fuel is used. They work at about 10 h.p. hours per gallon.

(d) Full Diesels.— Some employ an auxiliary 10 horse power petrol engine or have a petrol engine cylinder connected to a Diesel cylinder for starting. Air and fuel are injected at high pressure and are fired by the heat of compression. Cheap Diesel fuel is used. They work at about 11.6 h.p. hours per gallon.

The rapid squeezing up of the air during the compression stroke increases its temperature to about 1000 degrees F., a heat sufficient to ignite the fuel spray. The fuel spray is so regulated that the combustion occurs at approximately constant pressure. In fact in normal running the pressure at the time of the explosion does not rise above the ordinary compression of 500 to 600lbs. per square inch, whereas in ordinary petrol engines the pressure due to the explosion rises sharply to a peak value greater than that of the compression stroke. Since in Diesel engines air alone is compressed, there is no need to use a low compression ratio in order to avoid detonating the working charge and compression ratios of 14 or 15 may be used. It can be shown mathematically and by experiment that a high compression ratio engine is efficient and economical in its conversion of fuel into work. When, in addition, the fuel is cheap to buy, operating costs become very low.

(e) Coal Gas Tractors and Electric Trailing Cable Tractors are both operating in Canterbury at running costs competitive with Diesel tractors.

Tracks.—Iron wheels with various types of grips, rubber wheels with rubber grips, chains or iron attachments and the caterpillar or crawler types are all available. Each has its own special advantages.

The iron wheels have a low initial cost and, it is claimed, a low upkeep, and enable work to be carried out when the soil is wet.

The rubber-tyred wheels permit greater speed in the field and on the road, greater riding comfort, smaller repair bill and about a 15 per cent reduction in fuel cost. The tendency to slip in very wet conditions is being countered by chains and by the use of special rubber treads on the tyres.

The crawler tractor is ideal for hilly conditions, for very soft, wet ground, for earthwork construction jobs, for cultivation where packing of the ground must be avoided, and where turning in a small space is required. The crawler tractors are slower on the road and attempts are being made to speed them up by using larger running wheels and rubber padded tracks. The ordinary crawler or track-laying tractor has a negligible slip, permits of the maximum draw bar horse power being utilised, gives considerable safety and a longer working period than is possible with other types. On the other hand, the initial cost is usually high and the maintenance of the tracks may be considerable when operated in a sandy, abrasive soil. Crawler tracks are particularly advisable for large horsepowers and heavy pulls.

Four-wheel drive tractors are available for very rough country such as stump land, where flexibility and stability are essential. There are also row crop tractors with small turning radius and with adjustable wheels which may be made to straddle the rows of plants in almost any crop. Two wheel market garden tractors of 5 to 30 h.p. are also available.

Method of Attachment

The type of implement which will be used most and the general class of work to be done must of course influence the purchaser of a tractor. The tractor should be provided with a device for quickly and rigidly attaching and releasing the implements used. Excellent results are obtained by the use of implements so directly attached as to be almost "built in," as for example with rotary hoes, pick-up balers, hay sweeps, header-harvesters and row cultivators. Mowers, reapers, and binders, potato diggers and orchard sprayers may be driven from the power take-off shaft. Several types of tractors are available which are worked in conjunction with special implement attachments designed to suit the tractor and the special work to be done.

Conclusion

As an approximate guide:—

For farms where 300 acres or over are cultivated, 25-40 h.p. tractor will do the work of three six-horse teams.

For farms where up to 200-300 acres are cultivated, 15-30 h.p. tractor will do the work of 6-12 horses.

For farms where 100 up to 200 acres are cultivated, 10-20 h.p. tractor will do the work of five to six horses.

Farm machinery ranges from a single cylinder engined garden hoe up to the mammoth gyrotiller with scores of types and models in between these extremes. The individual must consider the many factors involved and, having made sure that his farm will not be over-capitalised in machinery, select the tractor most likely to suit his particular needs; where co-operation enables the very large tractors to do the work, economy in cost of work done will result.

Copies of this bulletin may be obtained from the secretary, Canterbury Chamber of Commerce, P.O. Box 187, Christchurch.