ROTHAMSTED RESEARCH

The Use of Electricity in Agriculture

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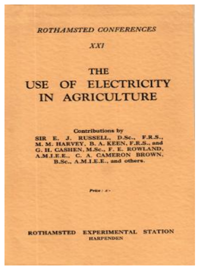

Rothamsted Measurements Comparing Fuel and Electricity As a Source of Power

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ROTHAMSTED MEASUREMENTS COMPARING FUEL AND ELECTRICITY AS A SOURCE OF POWER

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Introduction

THERE are few farms that do not use to-day some form of power—either tractors or stationary oil engines or both—for the various operations in and around the farm buildings. The extension of rural electrification is providing more and more farmers with the opportunity of using electric motors instead of internal combustion engines for this work. While electricity has a number of very definite advantages, particularly for lighting, cleanliness, and simplicity and convenience in operation, to which the farmer can assign some money value, his main concern is to know the relative costs of electric and mechanical power on his own farm for his average yearly requirements in grinding, pulping and other farm operations. For this purpose he must first ascertain the relative power consumption of electricity and fuel for the same job of work; e.g., the number of units of electricity and the number of gallons of fuel required to grind a ton of barley to a given fineness. There is already information available from which he could ascertain these comparative figures. The manufacturers of barn machinery can say what horse-power the machine requires for efficient and economical running; and, in their turn, the electric motor and internal combustion engine makers can give the electricity or fuel consumption of a power unit delivering the required horse power.

Probably most farmers would have a natural suspicion that such figures erred on the side of optimism, and that under normal farm conditions a lower efficiency would be achieved. Whether this be so or not, it is clear that direct comparative measurements under farm conditions of the quantity of electricity and of fuel consumed for the same operations will be a useful guide to farmers. This is the purpose of the Rothamsted measurements; to show for typical operations how many units of electricity are equivalent to one gallon of paraffin or petrol or heavy oil. With this figure, and knowing also the quantity and cost of the oil fuel he already uses, the farmer who contemplates changing to electricity could compute what the equivalent quantity of electrical power would cost him. This is, of course, putting the matter in its simplest form; the final comparison must include such comparisons as the cost of equipment, depreciation and repair and, in the case of electricity, any charge for bringing the supply to the farm; the money value the farmer puts

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on the undoubted conveniences of electric power, already mentioned above, must also be taken into account.

The Rothamsted measurements are made under the normal conditions of farm work, except that accurate and detailed records of fuel and electricity consumptions are taken, together with numerous subsidiary records required in the final calculations. In order to reduce the effect of irregularities due to variations in the quality of the farm produce (e.g., as between the top and bottom of a stack in threshing experiments) the usual procedure is to use the electric motor and the internal combustion engine alternately in short periods, treating each period as a separate experiment.

The experiments to date have been on threshing wheat, oats and barley, and on the grinding of barley for meal.

Threshing Experiments

Stacks of oats, wheat and barley built close to the farm buildings were threshed. Three sources of power were used :

(1) A General Electric Company Witton 20 h.p. portable motor ;

(2) A new International Harvester Company 10-20 h.p. tractor, that had done about 100 hours' farm work before these experiments ;

(3) An old International Harvester Company tractor in use at Rothamsted since April 1928 and still in fair condition after 7,000 hours' work.

Sixteen two-hour runs were made, of which seven were with the motor, six with the new tractor and three with the old. Special arrangements were made to obtain accurate measurements of the electricity, and the fuel and lubricating oil used in each experiment, and in addition records of the following were taken :

(1) the weight of produce as first and second-grade grain, offal, chaff, cavings and straw ;

(2) time and labour required to line-up motor or tractor with the threshing machine ;

(3) the cause and duration of any stoppage ;

(4) revolution speed of driving pulley and thresher drum ;

(5) petrol required for starting and warming up the tractor before turning over to paraffin.

The Marshall threshing machine used has a drum width of 48 in. and the optimum speed of the drum is given as 1,240 r.p.m. In our experiments the speeds were somewhat lower. Experiments were done at various speeds ranging from 1,064 to 1,206 r.p.m. This variation was obtained by suitable combinations of the pulleys on the thresher and the driving machine.

A summary of the results is given in Tables 1, 2 and 3, in which any differential effect due to the kind of crop used is ignored. The threshing rate was about 2 tons of grain per hour. Although there were certain small differences in the power consumptions for barley, oats and wheat, these differences were not in the same order for each form of power, and it is not possible to disentangle them from changes in the other variables, such as drum speed.

Table 1

Electric Motor:

Expt.	*Thresher Drum r.p.m.*	*kW.*
3	1,066	7.5
4	1,068	7.7
12	1,078	7.15
8	1,080	7.95
9	1,204	8.45
16	1,204	7.85
13	1,206	9.17

Output : 2 tons of grain per hour.

Table 2

New Tractor:

Expt.	*Thresher Drum r.p.m.*	*Paraffin Consumption gallons per hour*	
7	1,067	1.30	1.35
1	1,074	1.41	
11	1,151	1.45	1.34
15	1,154	1.23	
2	1,206	1.52	1.48
6	1,203	1.43	

Output : 2 tons of grain per hour.

Table 3

Old Tractor:

Expt.	*Thresher Drum r.p.m.*	*Paraffin Consumption gallons per hour*	
5	1,064	1.18	1.31
10	1,128	1.39	
14	1,134	1.37	

Output : 2 tons of grain per hour.

Table 1 shows that for the four experiments at the lower drum speed (1,068-1,080 r.p.m.) the mean consumption was 7.6 kW. and 8.5 kW. for the higher drum speed (1,204-1,206 r.p.m.). The general mean for the seven experiments was 8.0 kW.

Table 2 shows that for the new tractor the average paraffin consumption was greatest for the highest drum speed. The mean value for the six experiments was 1.39 gallons per hour, a figure slightly in excess of the consumption with the old tractor, 1.31 gallons per hour (Table 3). It is probable that the carburettor

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adjustment made at the factory gave an unnecessarily rich mixture, for it will be noted that experiment 15 (table 2), in which the setting was altered to give a weaker mixture, gives a lower value for paraffin consumption than in any of the other five experiments. However, it may be assumed that most farmers would not alter the carburettor adjustment made at the factory, so for our present purpose we can take the weighted mean of the nine experiments made with the tractors as a fair value for the paraffin consumption under the normal farm conditions at Rothamsted ; this value is 1.36 gallons per hour. Hence 8 kW. hours are equivalent to 1.36 gallons of paraffin in these conditions, or 10 kW. hours are equivalent to 1.7 gallons of paraffin. In using this relationship for working out comparative costs, account must also be taken of the petrol required to warm up the tractor, about 1¼ pints, and the consumption of lubricating oil which, if the tractor manufacturer's directions are followed, amounts to just under one pint of oil each two hours.

The careful measurements of the different grades of threshed produce and a close examination of their condition gave no support for the statement, sometimes advanced, that the smoother torque of the electric motor produces a better sample of threshed grain. The percentage of second grade grain and offal was slightly higher with the motor, and although a constant feeding rate to the thresher was aimed at, the rate was some 4 per cent. lower with the motor due, it may be suggested, to the psychological effect of the quieter running. But these differences are not significant and may well be due to variations in factors such as stack height, sheaf weight, and the fact that any one crop provided only sufficient material for four to five experiments.

No stoppages during the experiments occurred to the motor or tractor ; the most frequent trouble was the breaking of the string in the straw trusser.

It is important to realise that in these experiments the output of both the motor and tractors was only about 10 h.p. so that they were working at only 50 per cent of their full load. The efficiency of a motor falls less rapidly with reduced loads than that of an internal combustion engine. Hence, if smaller power units had been used, say 10-12 h.p., which would have worked under full load, it is very probable that a lower figure than 1.7 gallons for the paraffin equivalent of 10 kW hours would have been given.

This raises, however, a very important point in farm practice. Even on the most efficiently run farms, the tractor spends only a small fraction of the year in cultivating, harvesting and haulage work. While it may be inefficient—in the engineering sense of the term—to employ it for driving barn machinery that requires only a fraction of its available horse-power from the viewpoint of farm practice the matter appears in a different light. The farmer is "wasting" only the difference between the fuel consumption of the tractor and a smaller engine, but against this he saves the capital cost of the smaller machine. It would be interesting to know how far similar considerations apply to electric motors.

In the World Tractor Trials held at Oxford in 1930, the average consumption at half-load was 1.6 gallons of paraffin per hour. The International tractor working at half-load used approximately 2 gallons of paraffin per hour, as compared with our figure of 1.36 gallons. The two values may not be strictly comparable, but part of the difference is undoubtedly attributable to the improvements in tractor design since 1930.