# A Dynamometer for Determination of the Power Requirements of a Sugar Beet Thinner

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When designing any type of machine, a knowledge of the power requirements and the stresses imposed upon the various elements of the machine is necessary if a balanced, economical design is desired.

The device herein described measures the torque applied to the drive-shaft of an experimental tractor-mounted power takeoff-driven sugar beet thinner. Since the power input is a function of the torque and the angular velocity of the shaft, the power input may be calculated when the torque and r.p.m. of the drive shaft are known. Experience with sugar beet thinners has demonstrated that any small farm tractor has more than ample power to operate a 4-row or a 6-row sugar beet thinner. The need for designing the machine to fit the power source is not a problem. Data are needed concerning the power input required and the loads imposed on the gears, shafts, chains, or belts so that the correct selection of these component parts can be made.

## Apparatus

The dynamometer herein described was designed specifically for use with the experimental counter-rotating beet thinner (1)[2] (Figure 1). In the tests conducted, only the rear head on each of the two rows was used. Figures 2 and 3 show the drive mechanism and the dynamometer attached thereto. A mathematical analysis of this dynamometer is shown in Figure 4.

**Figure 1. — Experimental tractor-mounted 2-row sugar beet thinner used for dynamometer tests.**

## Test Procedure

This dynamometer was built in 1953 and only limited exploratory tests have been made. These tests demonstrated that the dynamometer functioned as intended and provided information on the torque imposed on the thinner head shafts by three types of commercial thinner heads. The heads tested were: 1. 14-tine weeder head; 2. 14-spoke 7/8-inch cut thinner head, and 3. 10-spoke 2-inch cut thinner head. All of these heads are 19 inches in diameter.

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[2] Numbers in parentheses refer to literature cited.

**Figure 2.—Variable speed power transmission mechanism with dynamometer installed. The hydraulic cylinder "A" is connected to the pressure gauge mounted on the tractor to the left of the operator. A second hydraulic hose from the cylinder is connected to the pump used for filling the system with oil. The pressure indicated on the gauge is a linear function of the torque applied to shaft "B," which turns at the same velocity as the thinner heads.**

These exploratory tests also indicated that speed and spacing of cut did not markedly affect the torque on the thinner drive shaft. As would be expected, an increase in the depth of penetration in the soil did increase the torque. All of the tests reported *in* Table 1 were run at $2\text{-}^{3/4}$ m.p.h. Th variables introduced were spacing of cuts across the row and depths of peneration (Table 1) . The area on which these tests were made was settled by a 1-inch rain following working with a disk harrow and a spike tooth harrow. The soil, a Conover Loam, as moderately compact but not as hard as soil sometimes found in sugar beet fields at the time of thinning. Each test run was 39 feet long and replicated 10 times. Maximum and minimum readings over the course of each test were recorded.

## Discussion of Results

The torque measurements obtained are based on a series of tests conducted on a single area. They provide an indication of the magnitude of the torque imposed by different types of thinner heads. Additional tests are contemplated.

**Figure 3.—Arrangement of component parts of hydraulic dynamometer. Tension in the drive chain exerts force in the idler sprocket shaft which through the idler lever arm, exerts torque on shaft C. The torque in shaft "C" is resisted by hydraulic cylinder A which is connected to the pressure gauge shown in Figure 2.**

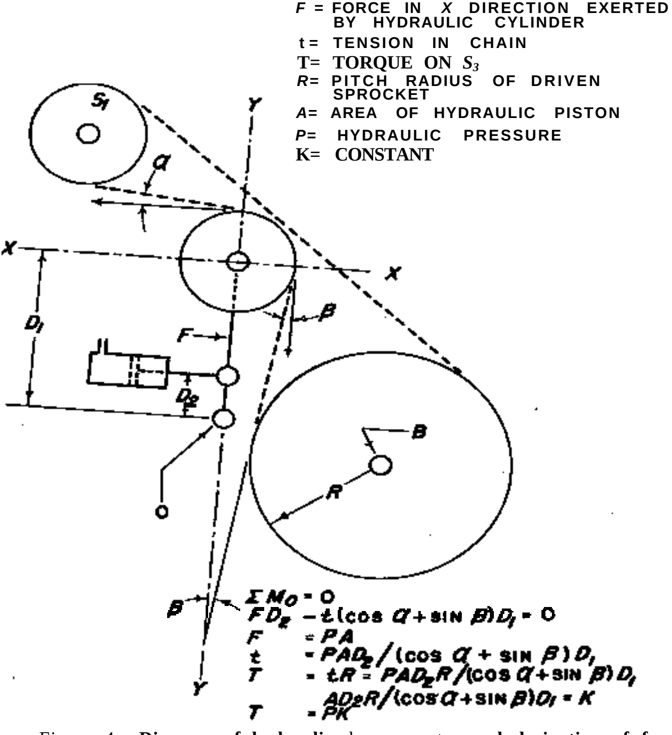


Figure 4.—**Diagram of hydraulic** dynamometer **and derivation of formula for computing torque applied** to **driven shaft,** $S_3$.

Total torque in Table 1 indicates the torque on the drive shaft to the thinner required to drive two heads. The figures shown for gauge reading in the fourth column are the maximum pressures observed in any of the ten replications of each test. The fifth column is the average of the maximum readings observed in ten replications.

The thinner used in these tests is a mid-mounted power takeoff-driven machine. The application of this data for design purposes is not necessarily limited to this type of machine. It may be used when heads similar to the ones tested are operated with any type of sugar beet thinner.

In comparing the effects of spacing of cuts upon torque imposed upon the thinner head shafts, it is seen from Table 1 that the torque is increased with an increase in spacing with thinner heads $H_1$ and $H_3$. The maximum increase occurs with thinner head $H_1$ when the spacing of cuts is increased from 2.4 inches to 4.0 inches. The increase is 26 percent. A reverse tendency is indicated with thinner head $H_2$ as the torque decreases when the spacing is changed from 1.7 inches to 2.8 inches.

Table 1.—Torque Measurements Obtained in a Series of Tests with Three Types of Sugar Beet Thinner Heads 19 Inches in Diameter.

| Thinner Head | Cut Spacing (inches) | Depth (inches) | Max. Gauge Reading (p.s.i.) | Aver. Max. Gauge Reading (p.s.i.) | Aver. Total Torque (lb.-in.) |
|---|---|---|---|---|---|
| $H_1$ | 4 | 1 3/8 | 1,100 | 919 | 357 |
| $H_1$ | 2.4 | 1 3/8 | 900 | 729 | 284 |
| $H_1$ | 4 | 3/4 | 850 | 698 | 266 |
| $H_1$ | 2.4 | 3/4 | 625 | 566 | 220 |
| $H_2$ | 2.8 | 1 3/8 | 1,250 | 1,075 | 417 |
| $H_2$ | 1.7 | 1 3/8 | 1,400 | 1,300 | 545 |
| $H_2$ | 2.8 | 3/4 | 700 | 568 | 220 |
| $H_2$ | 1.7 | 3/4 | 825 | 647 | 251 |
| $H_3$ | 2.8 | 1 3/8 | 1,050 | 921 | 359 |
| $H_3$ | 1.7 | 1 3/8 | 1,000 | 858 | 323 |
| $H_3$ | 2.8 | 3/4 | 325 | 325[1] | 94 |

H1 = 10-spoke thinner head, 2-inch cut.
H2 = 14-spoke thinner head, Ms-inch cut.
H3 = 14-tine springtine head.

[1] This particular test was only replicated three times and the maximum gauge reading observed in each case was 325 p.s.i.

The most important variations in torque result from changes in depth of soil penetration. The highest torque reading was obtained with thinner head $H_2$ at 1 3/8 inch depth. When the depth was decreased to 3/4 inch, a 50 percent reduction in torque occurred.

The actual power input is quite small in comparison to the capacity of a one-plow tractor. The maximum power input was recorded with thinner head $H_2$ with a 1.7-inch spacing of cuts and a soil penetration of 1 3/8 inches. The thinner heads rotated at the rate of 123 r.p.m. The average maximum torque was 545 lb.-in. and the calculated power input was 1.06 horsepower. This figure for power input involves only the power required to rotate the thinner heads. Obviously, a certain amount of power is required to overcome resistance to forward movement along the row. Tests could be revised to measure this component of the total power input but it appears that such information is not particularly essential for design purposes.

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