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DETERMINATION OF AXLE POWER OF DONGFENG POWER TILLER BY PRONY BRAKE DYNAMOMETER

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ABSTRACT

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The laboratory investigation was conducted at the work shop of the Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh during 2004 to measure the axle power of a Dongfeng power tiller, at varying engine speed and gear position. A prony brake dynamometer was used for measurement of axle power of power tiller. A Dongfeng 12-L diesel S195N, 12 hp (8.95 kW continuous output at 2000 rpm) was tested to determine the axle power. At the engine speed of 2000 rpm maximum axle power was found to be 11.39 hp (8.49 kW) for the belt sag 40 mm and axle rpm 76.53.

Key Words: Axle power, Dongfeng power tiller, prony brake dynamometer

INTRODUCTION

Power tillers were introduced as a source of farm power to prepare seedbeds with rotary tiller and for transportation. The use of power tiller is widespread throughout the country. The acceptance of power tiller to the farmers is increasing because of low prices compared to tractor, reduced drudgery and multi-purpose use such as land preparation, transportation, rice handling, pumps, small threshers, harvesters etc.

The first sizeable import of power tiller occurred in 1965. Nearly 300 Japanese power tillers of five different makes were imported by the then East Pakistan Agriculture Development Corporation for Experimental purpose but, subsequently disposed to the farmers. After 1972, the Bangladesh Planning Commission concluded that the experience gained up till now showed that scattered operation of tractor and power tillers was likely to prove unsuccessful since the past records of tractor and power tiller power tiller cultivation did not gave conclusive results in favour of introducing large scale mechanization programme in Bangladesh. According to Sarker (1997) under the tax relief provision private sector were recently importing over 25,000 power tillers annually and the number had exceeded 1,50,000 by 1996. Most of the power tillers being used in Bangladesh were of 7.5 to 9 kW power. Sarker (1997) showed that the present power availability of 0.388 kW/ha was just a little bit over to that minimum requirements. He also showed that total availability of farm power from all the sources (Animal, Human and Mechanical) standed at 5,948 MW. Hossain (1980) calculated an average total available power of 0.353 kW/ha in 1997. Another estimation of average farm power available for cultivation was 0.364 kW/ha (Sarker, 1997). Crossley (1971) indicated that the farm power needed for a minimum increase in productivity should not be less than 0.374 kW/ha. To increase the production by increasing cropping intensity mechanized cultivation is necessary. The power tillers are imported mainly from China and assembled in Bangladesh. Some accessories are fabricated here. Sometimes due to the power transmission system fault, power is not transmitted to the axle efficiently. Awal (1997) tested a Yanmar power tiller to determine axle power. He reported that at the engine speed of 2000 rpm maximum axle power was found to be 5.05 and 4.88 kW with 2 new and 2 old belts, respectively. But no attempt was taken to determine the axle power of Chinese Dongfeng power tiller. Therefore, this experiment was undertaken to measure the axle power of a Dongfeng power tiller, at varying engine speed and gear position.

MATERIALS AND METHODS

The laboratory investigation was conducted at the work shop of the Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh during 2004.

Power measuring device (dynamometer)

Many types of dynamometer are used for measuring the power available from a uniformly revolving shaft. In the experiment prony brake absorption dynamometer was used as a power measuring device.

Description of prony brake dynamometer

A simple type of the prony brake was consisted of two blocks of wood, each of which embraced rather less than one half of bolts of the pulley rim. The two blocks could be drawn together by means of bolts, cushioned by springs so as to increases the pressure on the pulley (Figure 1). One block carried an arm to the end of which a pull could be applied by means of a deadweight or spring balance. A second arm projected from the block in the opposite direction and carried a balance weight B, which balanced the brake when unloaded. The friction torque on the pulley might be increased by screwing up the bolts, until it balanced the torque due to the available power. For counterclockwise rotation of the drum, the arm L would float between the stops S with a weight W suspended from it. The torque on the drum was given by W1 and knowing the speed of rotation of the pulley, the power absorbed was calculated.

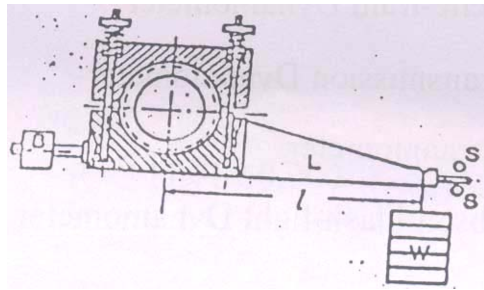

Figure 1. Prony brake

Description of power tiller

A Dongfeng 12-L diesel S195N power tiller 12 hp (8.95 kW) at 2000 rpm was used in this experiment. A detail specification about the power tiller is given in Appendix I. This power tiller had two hand steering clutches for ease of turning. The engine block was anchored on a flattened C-shaped support by means of three positioning bolts. The block could slide freely by loosening those bolts such that the center distance between the transmission pulley and engine pulley could be varied, if required. The clutch was used to disengage power from the wheel. The power transmission system used in the power tiller was a combination of V-belt and 8 gears with 6 forward speeds and two reverse speeds. The eight gear speeds were control by low and high speed gears. The engine power was transmitted through the middle shaft to the transmission gear box pulley by belt pulley. Power was further transmitted through gear trains to wheel axle.

Experimental set up and Instrumentation

Two wooden blocks of 30 x 6.5 x 3.75 inch (L x H x B) wide were used in brake shoe. Shoe was set in the semicircular hole in the wooden block in such a way that the wooden blocks could properly set between the lower and upper portion of the fly wheel. The brake arm of 54 feet (1520 mm) and 6 x 5 x 3.5 inch wide were used on the brake shoe wooden block. Two bolts were used in the front and the rear side of the fly wheel for loosening and tightening of the brake shoe of fly wheel. Brake was setup on wooden block in such a way that it was horizontal. After removing the right side wheel, the axle of the power tiller was directly coupled with a fly wheel. This extra flywheel was used as brake drum. The power tiller was fixed on two supporting frames (front and rear frame) with bolts. All frames were fixed on angle bar in the concrete floor with the help of foundation bolts and mild steel angle bars. Two supporting frames were fabricated with 3 inch (76.2 mm), 2.5 inch (63.5 mm), 2 inch (50.8 mm), mild steel angle bars and bolted with foundation bolt. The base frame made by Habib Ullah (1994) was modified to attach with the Dongfeng power tiller. The right side supporting frame and the base frame were extended 6 inch (152.4 mm) and 8 inch (203.2 mm).

A wooden sprit level (24 x 1 x 2 inch) was used to cheek the alignment of the brake arm. Two anchor bolts were set up in the head of the brake arm and overhead wooden block. A pull type dynamometer was used for the measurement of tension of brake arm. Then dynamometer was connected between two anchor bolts with S-type mild steel rod. The capacity of dynamometer was 0 to 500 kg.

Power Measurement

Experiment was conducted with 4^{th} and 5^{th} gear. The no-load engine speed was measured by tachometer. The load was increased by tightening pressing bolts on the brake arm step by step. Axle wheel rotation was counted for a certain recorded time. At the same time, engine speed was measured by tachometer and load in dynamometer was recorded. The same process was continued until and unless the engine was stopped completely. Power was calculated by following formula: Axle power (hp) = 2 ΠNF r/75, Where, N = speed of axle wheel, rpm, F = load, kg and r = arm length, m.

RESULTS AND DISCUSSION

Effect of axle speed on axle power

For gear no. 5 at no load engine speed of 2000, 1800 and 1600 rpm maximum axle power was found to 8.49, 7.52 and 7.25 kW (Table 1). At loaded engine speed of 1945, 1660 and 1440 rpm and corresponding axle rpm of 76.5, 64.4 and 56.4 rpm (Table 2) respectively. At the maximum axle power, the belt slip was 17.8, 29 and 34% for the engine speed of 2000, 1800 and 1600 rpm, respectively. The Table 1 and 2 also showed that maximum axle power did not develop at maximum axle speed. With the increase of load on the brake arm the axle speed decreased but axle power increased. But after attaining certain limit with the increase of load on the brake arm both the axle speed and axle power decreased. With further increase of load on the brake arm engine suddenly stopped.

Table 1. Different axle hp with different engine rpm (Gear no. 5)

Different engine speed	Time (sec)	Engine speed (rpm)	Axle (rpm)	Load (kg)	Axle (hp)	Axle power (kw)
2000 rpm	7.25	1980	82.75	30	3.88	2.89
	7.5	1970	80	60	6.26	4.66
	7.74	1960	77.52	70	8.5	6.34
	7.84	1945	76.53	95	11.39	8.49
	8.34	1800	43.16	150	10.14	7.56
	7.32	1990	81.96	40	5.13	3.82
	7.5	1970	80	70	8.77	6.54
	7.87	1940	76.23	80	9.55	7.12
	8	1800	75	95	11.16	8.32
	5.22	1710	34.78	150	8.1	6.04
1800 rpm	8.4	1790	71.42	35	3.91	2.91
	8.5	1760	70.58	50	5.52	4.11
	8.87	1740	67.64	80	8.47	6.31
	9.31	1660	64.44	100	10.09	7.52
	4.44	1500	40.55	140	8.89	6.63
	8.37	1790	71.68	30	3.36	2.5
	8.5	1740	70.58	50	5.529	4.11
	8.91	1710	67.34	90	9.49	7.07
	9.72	1680	61.72	105	10.15	7.57
	6.22	1560	38.58	140	8.46	6.31
1600 rpm	9.54	1570	62.89	30	2.95	2.2
	9.75	1540	61.53	50	4.82	3.59
	9.9	1490	60.6	100	9.49	7.07
	10.84	1440	55.35	110	9.53	7.1
	5.3	1380	33.96	150	7.98	5.95
	9.5	1580	63.15	20	1.97	1.46
	9.69	1530	61.91	50	4.85	3.61
	9.85	1500	60.91	80	7.63	5.69
	10.63	1440	56.44	110	9.72	7.25
	5.63	1360	31.97	150	7.51	5.6

Table 2. Belt slip in different engine speed (Gear no. 5)

Different engine speed	Engine speed (rpm)	Axle (rpm)	Ratio	Slip (%)
2000 rpm	2000	90.15	22.18	0
	1980	82.75	23.92	7.4
	1970	80	24.62	12.68
	1960	77.52	25.82	16.29
	1945	76.53	25.41	17.79
	1800	48.16	37.37	87.18
1800 rpm	1800	83.12	21.65	0
	1790	71.42	25.06	16.38
	1760	70	25.14	18.74
	1740	67.64	25.72	22.88
	1660	64.44	25.76	28.98
	1500	40.55	36.99	91.22
1600 rpm	1600	74.22	21.55	0
	1570	62.89	24.96	18
	1540	61.53	25.02	20.62
	1490	58.6	25.42	26.65
	1440	55.35	26	34.09
	1380	33.96	40.63	96.12

For gear no. 4 at no load engine speed of 2000, 1800 and 1600 rpm maximum axle power was found to 8.44, 7.5 and 7.19 kW (Table 3) at loaded engine speed of 1930, 1670 and 1420 rpm and corresponding axle rpm of 42.49, 37.75 and 30.76 rpm (Table 4) respectively. At the maximum axle power, the belt slip was 12.36, 17.86 and 26.5% for the engine speed of 2000, 1800 and 1600 rpm respectively. Power transmission efficiency was found to be high (95%) which was similar to Roy (1994). All tests were carried for the belt sag of 40 mm.

Table 3. Different axle hp with different engine rpm (Gear no. 4)

Different engine speed	Time (sec)	Engine speed (rpm)	Axle (rpm)	Load (kg)	Axle (hp)	Axle power (kw)
2000 rpm	12.93	1980	46.4	50	3.63	2.71
	12.97	1970	46.26	70	5.07	3.78
	13.31	1960	45.07	80	5.65	4.21
	13.43	1940	44.67	120	8.39	6.26
	14.12	1930	42.49	170	11.31	8.44
	10.3	1880	29.12	220	10.03	7.48
	12.97	1980	46.26	50	3.62	2.7
	13.04	1970	46.01	70	5.04	3.76
	13.44	1960	44.64	120	8.39	6.26
	13.68	1940	43.85	150	10.3	7.68
	14.38	1800	42.72	170	11.11	8.29
	11.38	1710	26.36	230	9.49	7.04
1800 rpm	14.38	1780	41.72	40	2.61	1.95
	14.69	1770	4084	50	3.2	2.39
	15.18	1760	39.52	70	4.33	3.23
	15.29	1745	39.24	110	6.76	5.04
	16.01	1710	37.46	130	7.63	5.69
	7.75	1640	23.15	200	7.25	5.41
	14.54	1790	41.26	35	2.26	1.69
	14.84	1780	40.34	50	3.16	2.36
	15.28	1750	39.26	100	6.15	4.59
	15.41	1700	38.93	140	8.53	6.36
	15.84	1670	37.75	170	10.05	7.5
	7.87	1605	22.87	180	6.45	4.81
1600 rpm	16.68	1590	35.97	30	1.69	1.26
	17.38	1520	34.52	70	3.78	2.82
	17.94	1500	33.44	160	8.38	6.25
	18.41	1480	32.59	180	9.19	6.86
	19.5	1420	30.76	210	9.84	7.19
	10.22	1380	18.49	230	6.66	4.96
	16.44	1590	36.49	20	1.44	0.85
	16.79	1560	35.72	60	3.35	2.5
	17.85	1500	34.12	120	6.41	4.78
	17.9	1490	33.52	130	6.82	5.09
	18.28	1440	32.82	170	8.74	6.52
	8.78	1350	20.49	250	8.02	5.98

Table 4. Belt slip in different engine speed (Gear no. 4)

Different engine speed	Engine speed (rpm)	Axle (rpm)	Ratio	Slip (%)
2000 rpm	2000	48	41.6	0
	1980	46.26	42.8	3.74
	1970	46.01	42.81	4.32
	1960	44.64	43.9	7.52
	1940	43.85	44.24	9.46
	1800	42.72	44.47	12.36
	1710	26.36	64.87	82.09
1800 rpm	1800	44.15	40.77	0
	1780	41.72	43.67	5.75
	1770	40.84	43.34	8.1
	1760	39.52	44.53	11.72
	1745	39	44.74	13.21
	1710	37.46	45.64	17.86
	1640	23.15	70.84	90.71
1600 rpm	1600	40.25	39.95	0
	1590	36.49	43.57	10.3
	1560	35.72	43.67	12.3
	1500	34.12	43.96	17.96
	1490	33.52	44.45	20.07
	1440	31.82	45.25	26.49
	1380	20.49	74.63	96.43

CONCLUSION

It was observed that the maximum axle power of 11.39 hp (8.49 kW) at the engine speed 1945 rpm and axle rpm 76.53 for gear no. 5 for no load speed of 2000 rpm. But at gear no. 4 maximum axle power was 11.31 hp (8.44 kW) at the engine speed 1930 rpm and axle rpm 42.49 for the same no load engine speed of 2000 rpm.

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***Appendix* I**

Dongfeng 12-L Power tiller specification

Engine specification	
Model	S195N
Type	4 cycle horizontal diesel engine
No. of cylinder	1
Cylinder position	Horizontal
Continuous output (HP/rpm)	7/1700-9/1900
Maximum output (HP/rpm)	11.39/1950
Combustion system	Pre combustion engine
Lubrication system	Forced distribution
Cooling system	Water cooling
Starting system	Hand
Fuel tank capacity (L)	10
Lub oil capacity (L)	3.0
Cooling water capacity (L)	2.3
Lighting equipment	6V-25W

Power tiller specification	
Tire dia (mm)	609.6-610
Tire width (mm)	152.4-152
Gross weight of power tiller with engine (approx.), kg	250 kg