Misr J. Ag. Eng., 25(4): 1174-1183 FARM MACHINERY AND POWER

DEVELOPING OF A HUMAN POWER UNIT

El-Sheikha, M.A.*** **H.N. Abd-Elmageed*****
M.A. Mostafa** **W.F. El-Kolally***

ABSTRACT

This investigation was mainly carried out to develop a power unit using the human power prone cart suitable for small farms. The function designs the power unit is using the human power to provide job opportunities for youth that it made with young men in three systems. This power unit was tested in two soil surface paved and unpaved rods. The experiments were done under four studied parameters namely three reduction ratio (1: 2.5, 1: 3.5 and 1: 4.5), traction mass (25, 50 and 75 kg in unpaved and in paved road were 75, 100 and 125 kg), the drawbar height (30, 35 and 40 cm), tire inflation pressure (1.0, 1.5 and 2.0 bar). To evaluate the performance of the designed unit, the forward speed, slippage, rolling resistance were investigated. From this study it was found that the optimum values were forward speed 2.565 km/hr, slippage1.137 % and draw bar pull 55kg on paved road. On unpaved road the optimum values of forward speed 1.844 km/hr, slippage 3.255 % and drawbar pull 60 kg.

INTRODUCTION

In agricultural mechanization the main power used now is a mechanical power. As a source of power it is expensive, polluted the environment and need a wide road. In Egypt the agricultural road is very narrows specially in the village and between fields. From century ago, farmers all over the world began the field work depending mainly on animal power. But the human power was the safe. The farmers can use safe mechanical mechanisms to do some agricultural operation such as transporting the seeds, chemicals, nurslings and some tools to the field, and any other things from field and plowing planting and harvesting the small fields.

*** Prof. Agric. Eng. Dept. Fac. of Agric. Mansoura Univ.
** Lec. Agric. Eng. Dept. Fac. of Agric. Mansoura Univ.
* Grad. Stud., Agric. Eng. Dept. Fac. of Agric. Mansoura Univ.

Josef Kienzle et al. (2006) stated that human muscles still contribute about 65 percent of the power for land preparation in Africa. A typical farm family that is reliant solely on human power can only cultivate in the region of 1.5 ha per year. This will rise to 4 ha if draught animal power is available, and to over8 ha if tractor power can be accessed. It is quite common to combine available power sources in order to increase the area farmed, or to reduce the burden on humans.

Morris and pollard (1981) pointed out that the main problem for small farmer is shortage of land, not of labor. That's why inputs which raise yields per acre are a better buy than tractor which raise yield per worker. It is now largely agreed that the new and improved technologies to be adopted by the less developed countries must be both appropriate and acceptable. Major variable is farm size. Some 80 - 90% of less developed countries holdings are below Five hectares, which combined with small fragmented plots and complex tendril patterns, limit the market for individual ownership and use of tractor farm power. Here the small tractor is only one alternative. As it stands at present, it's probably an inferior one both technically and financially. They stated that of prime importance is the requirement that farmers be better off a result of using small tractors. However, low prices and low yields within a predominantly subsistence agriculture in the less developed countries restrict the Farmer's ability to adopt new and therefore "risky" technology.

Brian G Sims (2005) tested the human being can haul a load of almost unlimited size given unlimited time theoretically. Then practically the most people can comfortably pull 137 kg with a typical mountain bike and cargo trailer or cargo trike. A person can move load of that weight will depend on his or her physical condition. Someone in reasonable physical condition can generally pull 137 kg load at (16 km/hr) on level ground if there's no wind. A person exerting the same effort could pull a load of 275 kg at a speed of (11 - 13 km/hr).

Malewicki (1983) gave a landmark paper at the International Human Powered Vehicle Association Scientific Symposium, in which he presented that the maximum duration of human effort for various steady power levels. Notice from the paper that an average "healthy human" can produce a steady 0.1 horsepower for a full eight hour period, while a "first class athlete" can produce 0.4 horsepower for a similar period. No more power is available without some rest and recovery. Thus at 0.4 hp the "healthy human" becomes exhausted within 10 minutes.

Through Domier (1978) and Abou Sabe and Henein (1964) finds in the society of automotive engineers co-operative tractor tire testing committee that: The most important factors affecting the drawbar performance are the soil itself and the weight that the tire carries. Also Traction with high power to weight ratio have to travel faster to utilize the available horsepower or use added weight to operate at lower speeds. Inflation pressure has an effect, lower pressures being advantageous on loosed, sandy soil.

Burt and Bailey (1982) stated that tractive efficiency was experimentally optimized for a radial-ply tractor tire. Resulted show that tractive efficiency can be significantly improved by selecting appropriate levels of inflation pressure and dynamic load for particular soil condition. The potential gains in tractive efficiency which could result from the application of automatic controls to field traction situations are explored.

Kllefoth (1966) and Zombori (1967) showed that a decrease inflation pressure increased the drawbar pull at constant travel reduction.

El-Sheikha (1995), said that the tractor drawbar pull increases with increasing the drawbar height. This increase is attributed to the weight transferred due to the increase of the drawbar height. He added that increasing the drawbar height increased the weight transferred to the rear axle which decreased the slip percentage. He said that the lower the tire inflation pressure the larger will be the tire contact area, and consequently, the more will be the tire-ground grip, and vice versa so that the producers recommend lowering of the tire inflation pressure.

Abou-Elmagd (1982) indicated that the slippage percent increased with the increases of tracted weight, and decreased with the increases of ballast at the tractor. He added that the percent of slippage is lower on paved road than that on unpaved one. On other friction surface when the coefficient of friction increases the percent of slippage increased. Also he found that sensible variation happened in rolling resistance force of the drive-wheel by the variation of the load on it. It is clear that rolling resistance force increased as the total weight on the drive-wheel increased.

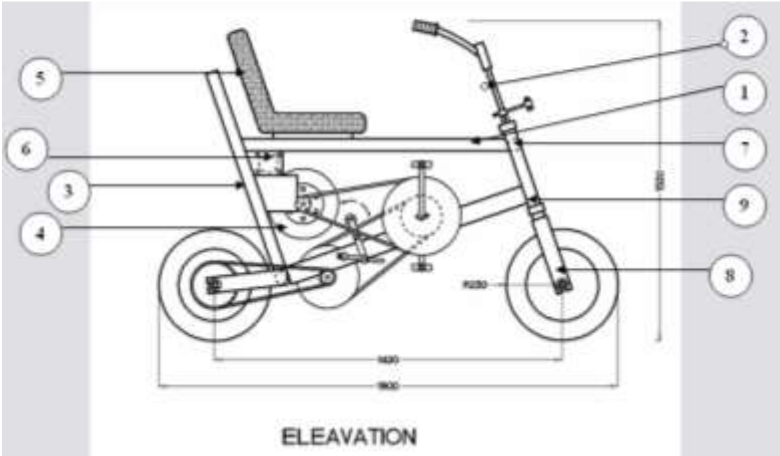
MATERIALS AND METHODS

This investigation aimed to design a safe and simple power unit (human prone cart) used by men and suitable for some farm operations. This study was carried out in Mansoura University at 2007 season. The power units and its operating parts were manufactured and constructed in a local workshop in Mansoura. Its photograph and draw was shown in Figs. (1 and 2). The design human power prone cart specification are: total weight of 90 kg, wheel base of 143 cm, total length of 190 cm total width averaged from 110 -130 cm, total height is 132 cm. the human power prone cart consists of a main frame (square shaped), seat, wheels, transmission system, handle bars, pedal, flywheel and draw bar hitching system.

Experimental design:

The split split plot design in three replicates was used in this study. The experiments of the human power unit prone cart included 162 treatments three reduction ratio (1 : 2.5, 1 : 3.5 and 1 : 4.5),three traction weights in paved road (75, 100 and 125 kg),three traction weights in unpaved road (25, 50 and 75 kg),three drawbar heights (30, 35 and 40 cm), three tire inflation pressures (1.0, 1.5 and 2 bar) and two types of roads (paved Asphalt and unpaved road)each experiment required three plots each of 100 m length.

Fig. 1: The photograph of human powered prone cart.



1	Horizontal Top Tube	4	Flywheel	7	Small Connecting Tube
2	Head Tube	5	Seat	8	Steering Fork
3	Vertical Seat Tube	6	Big Connecting Tube	9	Middle Part

Fig. 2: The sketch of the powered prone cart.

Apparatus and Instruments:-

1-Wooden trailer

2- Instruments: a) Spring dynamometer (double spring balance)

b) Stop watch c) Pressure gauge

Methods of Measurements

To evaluate the performance of the designed human power unit (prone cart) the slippage percentage, forward speed and traction force were measured and estimated.

1- Determination of slip percentage of prone cart:

Drive-wheel slippage could be calculated from the following equation according to (Barger et. al. 1963):

$$\text{Slip percentage} = 100\left(\frac{R - r}{R}\right)$$

Where:

R= total drive wheel revolution count to traverse the drawbar runway under load.

r = total drive wheel revolution count to traverse the drawbar test runway.

2- Determination of forward speed of prone cart:

Forward speed could be calculated from the following equation:

$$V = \frac{L}{T}$$

Where:

V= forward speed (m/sec.)

L= distance that the unit made from the beginning line to the end line.

T = Time consumed in this distance

3- Determination of traction force of prone cart:

The traction force values are calculated using the spring dynamometer.

RESULT AND DISCUSSION

Effecting of forward speed in paved and unpaved roads

Figure (3) shows the effect of the drawbar height on the forward speed. It can be seen that the power unit forward speed decreased from (2.565 to 1.36 km/hr) in paved road and from (1.844 to 1.16536 km/hr) in unpaved road at redaction ratio (1:3.5) with increasing the drawbar height from (30 to 40 cm). This decrease is attributed to the weight transferred due to the increase of the drawbar height. It was noticed that the greater speed values of the upper curve occurred with the high tire inflation pressure and vice versa. This figure illustrate that the forward speed increased in the paved road than that of unpaved road the highest values are 2.565 km/hr on paved road then the same is 1.844 km/hr on unpaved road the lowest values are 1.36 and 1.16536 km/hr respectively at paved and unpaved roads. It can be seen that the power unit forward speed increases with increasing the tire inflation pressure and it decreased with increasing the tracted weights.

.

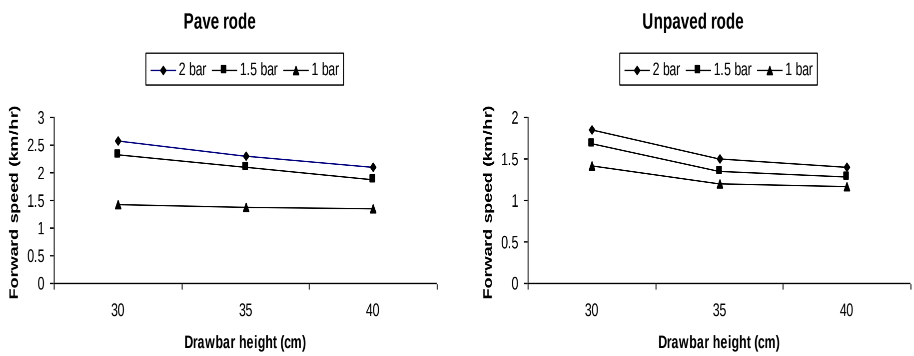


Fig. 3: The effect of drawbar height on the powered prone cart forward speed

Affecting slip percentage on paved and unpaved roads

Figure (4) shows the effect of drawbar height on slip percentage. It was found that increasing the drawbar height from (30 to 40 cm), decreased the slip percentage from (2.545 to 1.137 %) on paved road and from (7.764 to 3.255 %) on unpaved road at redaction ratio (1:3.5). The lower curves were due to the lower tire inflation pressure which led to high contact area with the ground i.e. decreasing the slip. On the other side the higher slip curves were due to the higher tire inflation pressure, which decrease the contact surface area with the ground i.e. higher slip percentage result. This figure illustrate that the slip percentage increased on the unpaved road as paved road the highest value is 2.545 % on paved road while the other is 7.764 % on unpaved road then the lowest values are 1.137 and 3.255 % respectively at paved and unpaved roads. It can be seen that the power unit slip percentage increases with increasing the tire inflation pressure and it increased with increasing the tracted weights.

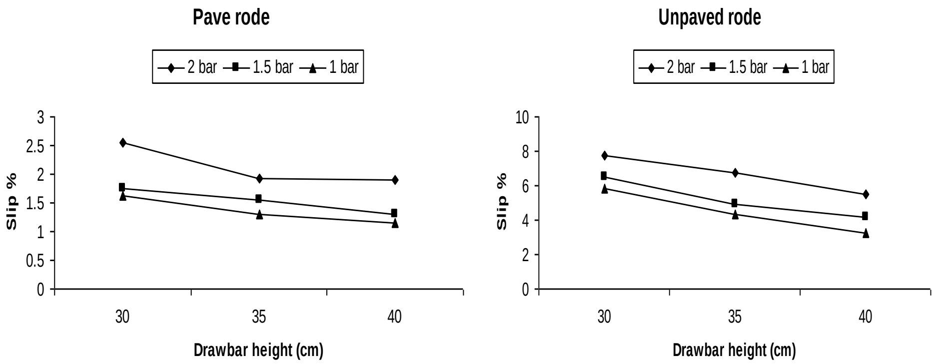


Fig. 4: The effect of drawbar height on the powered prone cart slippage.

Affecting on drawbar pull on paved and unpaved roads

Figure (5) shows the effect of drawbar height on the drawbar pull. It can be seen that the drawbar pull increased from (35 to 55 kg) on paved road and from (40 to 60 kg) on unpaved one with increasing the drawbar height from (30 to 40 cm) at redaction ratio of (1:3.5). This increase is attributed to the weight transferred by increasing of the drawbar height. It was noticed that the greater drawbar values of the upper curve occurred with the lower tire inflation pressure and vice versa. This figure illustrate that, it is well known that the lower the tire inflation pressure the higher will be the surface contact area of the tire with ground, and consequently, the more will be the tire ground grip and vice versa so that the producers recommend lowering of the tire inflation pressure, especially when the power unit is moving on the unpaved road not on paved one. The highest value is 55 kg on paved road then the same is 60 kg on unpaved road then the lowest values are 35 and 40 kg respectively at paved and unpaved roads. The traction coefficient gave the maximum values at the lower tire inflation pressures and the higher drawbars.

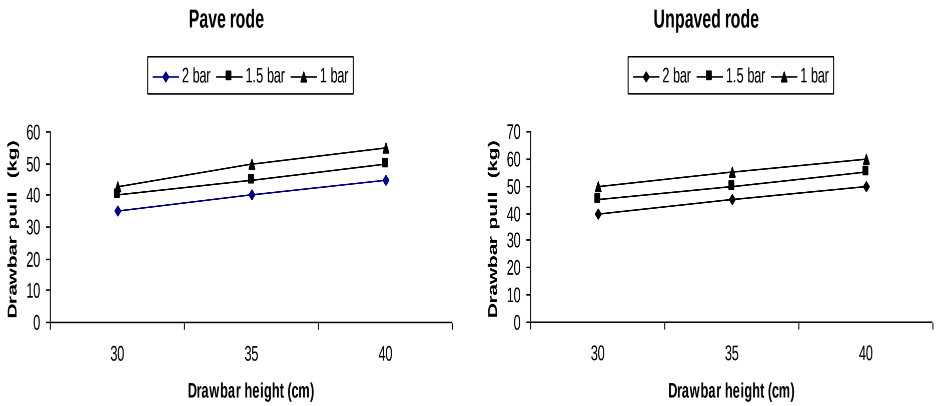


Fig. 5: The effect of drawbar height on the powered prone cart drawbar pull.

CONCLUSION

This study concluded that the human power unit prone cart suitable studied parameters are reduction ratio, traction weights, drawbar height and tire inflation pressure on paved and unpaved road to obtain the optimum forward speed 2.565 km/hr, slippage1.137 % and draw bar pull 55kg on paved road. On unpaved road the optimum forward speed 1.844 km/hr, slippage 3.255 % and drawbar pull 60 kg.

REFERENCES

Abou Sabe, A.H. and N.A. Henein (1964) Tractor testing in U.A.R. Alex. Journal of Agric. Res. Fac. of Agric. Alex. Univ. Res. Bulletin No. 10.

Abou-Elmagd, A.E. (1982). Develop a small one-wheel drive tractor as a replacement of draught animals in the small farms and traction operation in Egypt. Fac. of Agric. Man. Univ.

Ali, O.S .and E. Mckkyes , (1978).Traction characteristics of lugs for tires .Trans ASAE .21(2) :239 – 243,248.

Burt, A.C, A.C.Bailey (1982) load and inflation pressure effect on tires .TRANSACTION of the ASAE. 25(4). 881-884.

Domier .W.K.(1978).Traction Analysis of Nebraska Tractor Test . ASAE Vol.21 .N2 224 – 248.

Douglas, M. (1983). The international human powered vehicle association scientific, USA: Human Kinetics Books.

EL – Sheikha , M.(1995) . A study on factor affecting traction coefficient of tractor in Egypt .J. Ag. Eng., 12(2)283 – 296.

Kienzle, J. (2006). Farm power and mechanization for small farms in sub-Saharan Africa, Food and agriculture organization of the United Nations Rome

Kliefoth, F. (1966). The determination of traction-coefficient curves for synthetic farm tractor field test. Cited by Burt and Baily (1982).

Koolen . A.J, and H.Kuipers (1983) .Agricultural soil Mechanics, 105 – 139, Berlin. Germany .Springer – Verlag .

Morris, J. and S. Pollard, (1981). "How small tractors can stall development". International Agricultural Develop. Nov. Dec.

Sims, B. (2005). Bike gearing and gear inches, Bikes at Work Inc. 129 Washington Ave. Ames, IA 50010 515-233-6120.

Zombori, J. (1967).Drawbar pull tests of various traction devices on sandy soils .j. Cited by Burt and Baily (1982).

<u>الملخص العربي</u>

تطوير وحدة قدرة باستخدام الطاقة البشرية

محمد أحمد الشيخة*   هشام ناجى عبد المجيد*****

محمد عبد الفتاح مصطفى   وائل فهمي القللي***

الهدف الرئيسي من الدراسة هو تطوير وحدة قدرة تعمل بواسطة الشباب تناسب المساحات والحقول الصغيرة. وقد صممت هذه الوحدة لكي توفر فرص عمل أفضل للشباب حيث أنها تعمل في منظومة من ثلاث شباب.

وقد تم تقيم و دراسة هذه الوحدة على نوعين مختلفين من الطرق (طريق ممهد أسفلت و طريق غير ممهد ترابي). وقد تمت التجارب تحت أربع عوامل دراسة أساسية وهم نسبة التخفيض حيث تم استخدام ثلاث نسب تخفيض (١: ٢,٥ , ١ : ٣,٥ , ١ : ٤,٥) والعامل الثاني الأحمال المضافة فكانت هذه الأحمال في الطريق الممهد (٧٥ , ١٠٠ , ١٢٥ كجم) وفي الطريق الغير ممهد (٢٥, ٥٠, ٧٥ كجم) والعامل الثالث ارتفاع عمود الجر حيث استخدم ثلاث مستويات للجر (٣٠, ٣٥, ٤٠ سم) من سطح الأرض والعامل الرابع الضغط داخل العجل حيث تم تحديد ثلاث ضغوط مختلفة للعجل (١,٠, ١,٥, ٢,٠ بار) وذلك لتقييم أداء الوحدة المصممة فتم قياس السرعة الأمامية للآلة وحساب نسبة الانزلاق وحساب قوة الشد للآلة.

وقد أشارت النتائج إلى النقاط الهامة التالية:-

- أن السرعة الأمامية للآلة تقل مع زيادة ارتفاع عمود الجر كما أن أعلى سرعة تقدمية كانت مع أعلى قيمة لضغط الهواء بالعجل و كانت السرعة التقدمية للآلة في الأرض الممهدة اعلي منها في الأرض الغير ممهدة.
- وأن نسبة الانزلاق تقل مع زيادة الارتفاع لعمود الجر كما أنها تزيد بزيادة الضغط داخل العجل , وكانت نسبة الانزلاق في الطريق الغير ممهد اعلي منها في الطريق الممهد.
- وأن قوة الشد تزداد مع زيادة ارتفاع عمود الجر للآلة ولكنها تقل مع زيادة الضغط داخل العجل, وكانت قوة الشد في الطريق الغير ممهد اعلي منها في الطريق الممهد.

وأفضل سرعة أمامية للآلة كانت ٢,٥٦٥ كم/ساعة و نسبة الانزلاق ١,١٣٧٪ و قوة الشد هي ٥٥ كجم و ذلك في الطريق الممهد, أما في الطريق الغير ممهد فكانت أفضل سرعة أمامية للآلة هي ١,٨٤٤ كم/ساعة و نسبة الانزلاق ٣,٢٥٥٪ و قوة الشد ٦٠ كجم و ذلك عند نسبة تخفيض ١:٣,٥ لكلا النوعين من الأراضي.

*** أستاذ الهندسة الزراعية- قسم الهندسة الزراعية – كلية الزراعة – جامعة المنصورة.

** مدرس الهندسة الزراعية- قسم الهندسة الزراعية – كلية الزراعة – جامعة المنصورة.

*طالب دراسات عليا - قسم الهندسة الزراعية – كلية الزراعة – جامعة المنصورة.