A STUDY ON AGRICULTURAL TRACTORS
STEERING MECHANISM

4-The steering Forces and power on the front wheels

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ABSTRACT

The main aim of this research was to increase the operation efficiency of
agricultural tractor to suit the conditions and potentials of the Egyptian
farmer. This leads to increase the rates of the feddan production and raise
the value of the yield per feddan. This meets the requirement to achieve
the strategic goals of the agricultural development by modifying and
developing the modern technology, especially the agricultural tractors to
suit the local environment in all agricultural operations, including
plowing. Laboratory experiments and statistical analysis for the data of
the research were run and hydraulically steering was designed by suing a
closed hydraulic circuit for the tractor. The main results obtained from
the experiments are summarized in the following main points:

1-Mathematicl equations are derived to find the steering forces.  2-
Minimum values of the steering force and power (5.211 kN, 0.881 kw). 3-
Saving power of the tractor to the maximum extent due to losses in
steering. 4-Decreasing the costs maintaining the tractor by decreasing the
costs maintaining of tractor steering equipments. 5-Decreasing the
repeated technical problems in the steering equipments of the tractors. 6-
The modification suits all the agricultural operations even for small
holdings in Egypt.

INTRODUCTION

The agricultural tractor is the backbone of the Egyptian agriculture
because it does all the different field processes. It must be
improved to suit the conditions and potentials of the Egyptian
farmer to increase the efficiency of its operation. This study aims to
develop steering in particular. It aims to design a mechanism which can
be controlled hydraulically to work on the front land-wheels.


Liljedahl et al. (1959) found that maximum forces were greater than the preload setting on both the “Case and John Deere” tractors. This improbably because the drivers were, for a short time, steering at a rate greater than be the power steering could follow and when the John Deere 70 was equipped with a front–end loader and driven in a figure of eight, power steering reduced the average steering force by 75 percent and the maximum by 67 percent . Under exactly the same conditions, use of the differential brakes had almost the same effect in reducing steering forces as power steering.

Liljedahl and Strait (1962a) assumed the steering forces are approximately the same as if the tractor were in motion on a rigid level plane surface.

Liljedahl and Strait (1962b) assumed the radial force on the tractor wheels when turning is:

\[ F = \frac{W}{g} \times a = \frac{W}{g} \times \frac{V^2}{b} \times \frac{dy}{dx} \]

Where: \( W \): Weight of tractor, \( a \): Acceleration, \( g \): Gravity, \( b \): Wheelbase of tractor, \( \beta = \frac{1}{2} \), \( \beta \): Distance from center of gravity to back wheels of tractor, \( V \): Speed of tractor, \( y \): Position of tractor between the rows, \( x \): Position of tractor along the rows, as shown in Fig. (1).
Richardson and Cooper (1970) found that the use of articulated steering resulted in decreased reactive performance when compared with performance in a straight line. Measures of reactive performance used in reaching this conclusion were drawbar pull and work index. Pull vs. slip and pull vs. soil strength comparisons were also made. Katary (1976) reported that optimum tractor weight to drawbar pull ratio, at maximum reactive power efficiency, is 2.47 and 2.669 on asphalt and stubble field, respectively. Kuipers (1991) found that the open furrow improves fraction acts as a steering aid for the tractor and reduces soil resistances. Nevertheless, systems that avoid subsoil compaction by not driving through the open furrow should be developed further. Younis et al. (1991) reported the increase in the unit draft for chisel plow about 26% when the plowing depth increased from 10 to 20 cm. Sylvio (1993) developed a drawbar force transducer dimensioned for tractor power less than 100 kw this double extended octagonal ring (DEOR) dynamometer was designed to simultaneously measure drawbar draft, vertical and side loads without altering the tractor-implement hitch point configuration. Side loads are derived from the differential draft outputs of the two extended octagonal ring (EOR). Metwalli et al. (2002) showed that when soil conditions were in a good working range for tillage operations, a significant increase in impalement draft was observed with an increase in forward speed, plowing tillage depth and inflation pressure. Metwalli et al. (2004) showed that the power requirement increased by increasing sub-soiling depth by 28.05% and 72.93% at 55 and 65 cm respectively, compared with power at 45 cm depth. The distance between shares had no effect on power requirement at the same depth (in their experiment).

2-8: The moment:
Liljedahl et al. (1959) indicated that when (33.9 m. N) torque was applied manually to the steering wheel, approximately 25 percent was absorbed by the steering soil. Liljedahl and Strait (1962a) assumed that the moment on the vertical front–wheel spindle, or kingpins, is:

$$M = K \times \frac{dy}{dt}$$
Where: \( K \): is the tractor steering-force parameter which depends upon the speed and configuration of the tractor, \( t \): time, \( y \):position of tractor between the rows (function of time).

Liljedahl and Strait (1962b) assumed the moment on the front wheel spindle due to turning forces is:

\[
M_a = \frac{WC\beta}{gb^2} V^2 \frac{dy}{dx}
\]

And for a four–wheel configuration:

\[
M = \left[ \frac{WC\beta V}{gb^2} + \frac{W_b E \beta \sin \theta}{2Vb} \right] \frac{dy}{dt} = K \frac{dy}{dt}
\]

Where: \( C \): Caster of front wheel, constant equal 2.54cm. \( \theta \): kingpin inclination, \( e \): kingpin offset.

Bahnassi (1999) reported that mobility number as determined from an existing model can be used to specify the contact area, wheel developed torque and net thrust.

2-9: The power:

Liljedahl et al. (1959) stated that power steering reduced average, maximum forces by 50 percent on the “Case” tractor while cultivating corn and steering at a rate greater than the power steering could follow.

Katary (1976) reported the following main points:

1-Rolling resistance horsepower is higher on stubble field than on asphalt and increases by the increase in tractor speed. 2-Tractive power efficiency is lower at higher gear ratios. 3-Unit draft increases by the increase in tractor speed. 4-The slippage horsepower increases by the increase of drawbar pull at the same gear.

Awady (1979) found from his study to select the tractor power to suit the land holdings under the conditions of Kingdom of Saudi and Arab Republic of Egypt that the optimum tractor and implement size ranges between 14 and 17 HP.

Awady et al. (1981) carried out a study on a prototype designed and built by Egyptian “Small–scale agricultural activities project” to replace work stock animals. Their study included measurements of weight and its distribution, tillage capability, rolling resistance, and traction. They found that the total weight is 2600n distributed such that 1950N falls on the rear
traction–tyre and 650N on the front supporting types. The weight /power ratio is thus 371N/HP or 520N/kw –This ratio is so low that ballast weight of some 3000N can be added to the unit. They pointed out also that rolling resistance ranges from 0.31 for motion on paved road at low speed to 0.86 on tilled soil at a higher speed. Although the figures are higher than for a single tyre, they are reasonable for the presence of motion transmission system and roughness of the land surface.

Kamel (1987) reported that the highest power unit (36kw) consumed less fuel per unit rate of work than other power units (23and 28kw)

MATERIAL AND METHODS

A- Tractor:
The Belarus tractor, 65B.HP (48.2kw) was common and widespread under Egyptian conditions. The tractor is multi purpose of the model 10M3-6KM. It was used in this research. The tractor was tested in plowing operation. After modification it was tested at agricultural tractors and machinery research laboratory, Agricultural Engineering Department, Faculty of Agriculture, Al-Azhar University.

A-I: The tractor before modification:
1- Gasoline engine (65 HP, 48.2kw) at 1750 rpm. 2- Wheels (four wheels). 3-Minimum turning radius = 5m.

4- Steering system:
(A): The components: It consists of: (1):Front axle; (2):Steering wheel to track width adjustment mechanism, determining the front wheel toe-in and checking toe-in of steering wheels; (3):Sector, spool, bushing, steering gear case, rack and oil drain pipeline (Fig.2); (4): Steering column, shock absorbers, sleeve, steering wheel shaft and steering wheel; (5): Steering gear, steering arm, steering shaft and warm gear; (6):Hydraulic steering servo, housing, spring washer and front cover; (7):Mounted at the middle position on the tractor.

(B): The disadvantages of power steering: 1- Difficult to repair and maintain. 2-Costs of repair and maintance. 3-The spare parts price is expensive. 4-Complex construction. 5-Mechanical steering system with addition to hydraulic steering servo.
A-2: The tractor after modification:
The tractor was modified to overcome the problems encountered during the experimentation. The specifications of the tractor after modification are the same of tractor before modification but the different are follows:

**Apparatus of power hydraulic steering system:**
It was power hydraulic steering circuit, Fig (3):

**The components:** It consists of: 1- Reservoir (Transmission housing); 2- Filter on intake; 2B-Filter on delivery; 3- Hydraulic pump. It consists of: A-Suction port; R-Lube fillets;


23- Ducts: A-Intake; B- Delivery; C-Return; D-Users on LH side of power cylinder; E-Users on RH side of power cylinder; F-Anti-shock valve discharge; G- Transmission oil cooler; R-Flow regulator; W-Steering wheel.

**B- Devices:**

**B-1: Surveying instruments:**
Tape steel 20m, steel ruler 30cm and arrows were used for measuring and determining longitudinal dimensions. Pins were used for hitching the hydraulic dynamometer from both sides. Steel bolts and plastic threads were used for determining angle.

**B-2: The models:**
Models were made at the central workshops in the Ministry of Agriculture and Land Reclamation, to measure the steering angles. Models for the mechanizms were made of wooden bars, for the various geometrical
dimensions. They generally conform to as small scale of 1:2. The model configurations had the variable dimensions shown in Table (1).

Table (1): The variable dimensions of the models.

<table>
<thead>
<tr>
<th>Configuration No.</th>
<th>Dimensions in mm.</th>
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<tbody>
<tr>
<td></td>
<td>W</td>
</tr>
<tr>
<td>1</td>
<td>960</td>
</tr>
<tr>
<td>2</td>
<td>1110</td>
</tr>
<tr>
<td>3</td>
<td>1260</td>
</tr>
<tr>
<td>4</td>
<td>1410</td>
</tr>
<tr>
<td>5</td>
<td>1110</td>
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Their dimensions consist of fixed dimensions (Cotθ=W/WB, WB=2450, e=70mm, r/W=0.2, TR/W=0.95 and θ = π/2 = 90º). The rest of dimensions are shown in (Fig.6).

A natural-size model was made of steel to Conform with the tractor modifications.

Where: WB=Wheel base, W=Steering pivots distance (1110 mm), r=Steering arm length, TR=Tie-rod length, Φ=Outer front wheel steering angle, θ = Inner front wheel steering angle, e=the distance between tie-rod and hydraulic cylinder base, θ = Upright angle, equal (π/2).

B-3- Hydraulic dynamometer:
A self recording hydraulic dynamometer model (VCD NESS UND REGELTECHNIK GMBH) used for measuring the forces situated on the front wheels. Its capacity is 50 kN and its accuracy is 0.5 kN, by oil-pressure gauge which measures oil pressure. Accuracy of the gauge is 0.1 bar or 10 kPa.

C- Experimental procedures: Forces, moments and power on the front wheel or its equivalents are required to steer the tractor over a given surface. The aim of this test was to determine the consumed power in steering of the tractor under test at average speed, different hydraulic cylinder; its rod-lengths were (70.4, 68.1, 65.8, 63.5, 61.2 and 58.9 cm).
Fig. (2): Diagram of steering gear hydraulic Booster:
1- steering column ; 2- bushing ; 3- steering gear case ; 4- rack ; 5-gasket ; 6- rest 7- lock nut ; 8- screw ; 9- safety valve ; 10- cover ; 11-spherical nut ; 12 – spool ; 13- control valve housing ; 14- worm ;15-sector ;16- oil delivery pipeline ; 17- bolt ; 18- oil pum ;19 – oil suction pipeline ; 20- oil return pipeline ; 21 – oil tank ; 22- oil drain pipeline (Gurevich and Sorokin,1976).
Fig. (3): Schematic drawing for apparatus of power hydraulic steering system.
Four of the loads on front wheels were used (5.0, 5.5, 6.0, and 6.5 kN), speeds were (1st, 2nd, 3rd and 4th gears), four replicates and four of values of W/WB were used (0.39, 0.45, 0.51, 0.58). Five traction surfaces were used (namely, air, concrete surface, clay, sandy clay and sandy surfaces). The tractor having power of 65 B.HP (48.2 kw) was used to draw the tested tractor and the forces and moments were determined through recording hydraulic dynamometer. The measured distance of the test course was fixed throughout the test at 100 meters for each run, and the average speed was calculated relative to the travel time in sixteen replicates, the forces, moments and power at the average speed, different traction surfaces and soil conditions.

D-Using mathematical analysis for the common-center-steering systems of tractors:

Analytical program was derived for 4-bar mechanism (steering mechanism) referring to Figs (4 through 6), based on the mechanism data: WB: wheelbase(2450mm), W: Steering pivots distance(1110mm), r: Steering arm length(222mm), θ0:Initial steering arm angle(8.29º), TR: Tie-rod length(105cm), θ: Inner front wheel steering angle, φ:Outer front wheel steering angle; I: Instantaneous center. Equations of the forces, moments and required steering power are given as shown in Figs (4 through 6).

Tractor engine power required for steering operation can be determined by using the following equation:

$$ P_t = Q \times p $$

The above equation gives: $$ P_t = \frac{F \times v}{100 \times 75} $$

Which can be rearranged to find $$ P_{act} $$ a given $$ P_t $$ and $$ P_{air} $$ as follows:

$$ P_{act} = P_t - P_{air} $$ ....Where: $$ P_t $$ is steering power in kW; $$ Q $$ = Oil pump rate of discharge in m³/s; $$ Q = A \times V $$; A= Piston area in m; p = Oil pressure in kPa; $$ V $$ = the piston speed in m/s. In this case piston forward speed= (0.17m/s); and backward speed= (0.20m/s); $$ P_{act} $$ =Actual steering power in kW; $$ P_{air} $$ =the total (theoretical) steering power for air treatment losses in inside friction in kW.
RESULTS AND DISCUSSION

The study was carried out to indicate effects of the cylinder length and the tractor dimensions at different geometric proportions on the following factors:

(1): Steering force variation with angle:
Figs (4 through 6), illustrate effect of the steering angle, the piston steering angles, constant dimensions of the values of ($F_1$) and ($F_2$ or $F_t$) at different geometric proportions. The steering forces ($F_1$, $F_2$) equations can be derived as follow:

$$T_1 = \frac{wCV^2}{2g(WB)} \cot \phi_{act}$$

$$T_2 = \frac{wCV^2}{2g(WB)} \cot \theta_{act}$$

$$T_1 = T_2 + \frac{wC(W)\nu^2}{2g(WB)^2}$$

$$T_2 = T_1 - \frac{wC(W)\nu^2}{2g(WB)^2}$$

$$F_1 = \frac{T_1}{r \cos \phi} \quad ; \quad F_2 \text{ or } F_t = \frac{T_2 + F_1 \cos (\delta + \theta + \theta_0)}{r \sin (\nu + \theta + \theta_0)} \quad ; \quad or = \frac{T_2 + T_1 \left( \frac{\cos (\delta + \theta + \theta_0)}{\cos \phi} \right)}{r \sin (\nu + \theta + \theta_0)}$$

Fig. (4): Geometry of tractor wheels when turning.
Where: $T_1$: The moment on piston surface due to oil pressure in kN.m; $T_2$: The moment on front wheel spindle due to turning forces in kN.m; $\psi$: The piston angle with vertical axis or perfect angle for piston steering angle equal $(\pi/2 - \omega)$; $\delta$: The confined angle between the vertical line and the vertical axis or the confined angle between the old and new position for tie rod; $\varphi$: The confined angle between the vertical line and new positions for the steering arm; $\theta_0$: Initial steering arm angle $(8.29^\circ)$; $\theta$: Inner steering angle; $r$: Steering arm length, cm.

From Fig. (7), it is clear that for all the traction surfaces, the theoretical steering forces ($F_2$ or $F_1$) increased with the inner front wheels steering angle ($\theta$). Values of ($F_2$ or $F_1$) varied from about (5.01 to 15.94 kN) at values of ($\theta$) varying from about 0.2 to 50 degrees, respectively for value of $W/WB$ 0.45.
Fig. (6): Steering geometry during a turn of the tractor to the right direction and dimensions of the mechanism ($\theta$: inner; $\phi$: outer steering angles).
(2): Effect of the load and the cylinder length on the steering force and power:
From Figs (8 and 10), it is clear that for all loads, the steering force and power increased with the traction surface loosening. Values of the theoretical steering force \( F_t \) and power \( P_t \) were \((0.860, 6.592, 7.027, 7.393, 7.482 \text{ kN})\); \((0.145, 1.062, 1.188, 1.25, 1.265 \text{ kw})\), also values the actual steering forces \( F_{act} \) and power \( P_{act} \) were \((5.732, 6.167, 6.533, 6.622 \text{ kN})\); \((0.969, 1.042, 1.104, 1.119 \text{ kw})\) at surfaces of about concrete, clay, sandy clay, and sandy, respectively.
Figs (9 and 11), indicate that for all the traction surfaces, the steering force, power increased with the hydraulic cylinder length probably due to the increase of the steering angle. Values of the theoretical steering force \( F_t \), power \( P_t \); the actual steering forces \( F_{act} \) and power \( P_{act} \) varied from about \((4.939 \text{ to } 9.051 \text{ kN})\); \((0.835 \text{ to } 1.530 \text{ kW})\); \((4.216 \text{ to } 7.725 \text{ kN})\); \((0.713 \text{ to } 1.306 \text{ kw})\) at the hydraulic cylinder length varying from about \((58.9 \text{ to } 70.4 \text{ cm})\), respectively.
Figs (8 through 11), show that for all the traction surfaces and the cylinder length the steering force and power increased with the load on front wheels probably due to the increase of the contact area. Values of the theoretical steering force \( F_t \), power \( P_t \); the actual steering forces \( F_{act} \) and power \( P_{act} \) varied from about \((5.127 \text{ to } 6.616 \text{ kN})\); \((0.866 \text{ to } 1.119 \text{ kw})\); \((4.267 \text{ to } 5.756 \text{ kN})\); \((0.721 \text{ to } 0.973 \text{ kw})\) at loads on front wheels varying from about \((5.0 \text{ to } 6.5 \text{ kN})\), respectively.

(3): Effect of the speed and the cylinder length on the steering force and power:
From Figs (8 and 10), it is clear that for all speeds, the steering force and power increased with the traction surfaces loosening. Values of the theoretical steering force \( F_t \) and power \( P_t \) were \((0.86, 6.156, 6.563, 6.902, 6.988 \text{ kN})\); \((0.145, 1.041, 1.109, 1.166, 1.181 \text{ kw})\), also values the actual steering forces \( F_{act} \) and power \( P_{act} \) were \((5.296, 5.703, 6.042, 6.128 \text{ kN})\); \((0.9, 0.963, 1.021, 1.036 \text{ kw})\) at the traction surfaces of about concrete, clay, sandy clay and sandy, respectively.
Figs (9 and 11), indicate that for all the traction surfaces, the steering force and power increased with the hydraulic cylinder length probably due to the increase of the steering angle. Values of the theoretical steering
force ($F_t$), power ($P_t$); the actual steering force ($F_{act}$) and power ($P_{act}$) varied from about (4.623 to 8.47 kN); (0.781 to 1.432 kw); (3.9 to 7.144 kN); (0.658 to 1.207 kw) at the hydraulic cylinder length varying from about (58.9 to 70.4 cm), respectively.

Figs (8 through 11), show that for all the traction surfaces and all the hydraulic cylinder length the steering force, power decreased with increasing speed of the tractor. Values of the theoretical steering force ($F_t$), power ($P_t$); the actual steering forces ($F_{act}$) and power ($P_{act}$) varied from about (4.518 to 6.609 kN); (0.764 to 1.117 kw); (3.658 to 5.749 kN); (0.618 to 0.972 kw) at speeds of the tractor varying from about (1st to 4th gears), respectively.

(4): Effect of the W/WB and the cylinder length on the steering force and power:
From Figs (8 and 10), it is clear that for all the value of W/WB, the steering force and power increased with increasing the traction surface loosening. Values of ($F_t$) and ($P_t$) were (0.86, 6.171, 6.578, 6.917, 7.104 kN); (0.145, 1.045, 1.112, 1.17, 1.201 kw), also values the actual steering forces($F_{act}$) and power($P_{act}$) were (5.311, 5.718, 6.057, 6.244 kN); (0.899, 0.966, 1.025, 1.056 kw) at the traction surfaces of about concrete, clay, sandy clay, and sandy, respectively.

Figs (9 and 11), indicate that for all the traction surfaces, the steering force and power increased with the hydraulic cylinder length probably due to the increase of the steering angle. Values of the theoretical steering force ($F_t$), power ($P_t$); the actual steering forces ($F_{act}$) and power ($P_{act}$) varied from about (4.623 to 8.489 kN); (0.783 to 1.435 kw); (3.9 to 7.163 kN); (0.661 to 1.21 kw) at the hydraulic cylinder length varying from about (58.9 to 70.4cm), respectively.

Figs (8 through 11), show that for all traction surfaces and all the hydraulic cylinder length the steering force and power increased with the value of W/WB probably due to the increase of the steering angle. Values of the theoretical steering force ($F_t$), power ($P_t$); the actual steering forces ($F_{act}$) and power ($P_{act}$) varied from about (4.676 to 6.541 kN); (0.790 to 1.107 kw); (3.816 to 5.681 kN); (0.645 to 0.962 kw) at values of W/WB varying from about (0.39 to 0.58), respectively.
SUMMARY AND CONCLUSION

The present study was carried out by using two tractors mounted type chisel plough of 7 tines in two rows locally industrial were used, the Belarus tractor, 65B.HP (48.2 kw) was usage common and widespread under Egyptian conditions. The tractor before, after common and widespread under Egyptian conditions. The tractor before, after modification (this modification allowed tested tractor to decrease the turning radius from 5 to 1.5 m and decrease the friction between the front wheels and the steering equipments) were constructed and tested at agricultural tractors and machinery research laboratory, Agricultural Engineering Department, Faculty of Agriculture, Al-Azhar University. The main results obtained from experiments are summarized under the following main points:

(1): Steering force variation with angle:
The theoretical steering forces ($F_2$ or $F_t$) increased with the inner front wheels steering angle ($\theta$). Values of ($F_2$ or $F_t$) varied from about (5.01 to 15.94 kN) at values of ($\theta$) varying from about 0.2 to 50 degrees, respectively for value of W/WB 0.45.

(2): Effect of the load and the cylinder length on the steering force and power:
The steering force and power increased with the traction surface loosening. Values the theoretical steering force ($F_t$) and power ($P_t$) were
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Fig. (8): Effect of the traction surface, load, the speed, the value of (W/WB) on the theoretical steering force and power.
The loads

5/F

5/P

5.5/F

5.5/P

6/F

6/P

6.5/F

6.5/P

The speed

The theoretical steering force (kN), $F_t$.

The theoretical steering power (kw), $P_t$.

The hydraulic cylinder lengths (cm, L.).

Fig. (9): Effect of hydraulic cylinder length, load, the speed, the value of $(W/WB)$ the theoretical steering force and power.
Fig. (10): Effect of the traction surface, load, the speed, the value of (W/WB) on the actual steering force and power.
The actual steering force (kN), $F_{act}$. The actual steering power (kw), $P_{act}$.

The hydraulic cylinder lengths (cm, L.).

Fig. (11): Effect of hydraulic cylinder length, load, the speed, the value of (W/WB) on the actual steering force and power.
The steering force, power increased with the hydraulic cylinder length. Values of the theoretical steering force ($F_t$), power ($P_t$); the actual steering forces ($F_{act}$) and power ($P_{act}$) varied from about (4.939 to 9.051 kN); (0.835 to 1.530 kW); (4.216 to 7.725 kN); (0.713 to 1.306 kW) at the hydraulic cylinder length varying from about (58.9 to 70.4 cm), respectively.

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The steering force and power increased with the traction surfaces loosening. Values of the theoretical steering force ($F_t$) and power ($P_t$) were (0.86, 6.156, 6.563, 6.902, 6.988 kN); (0.145, 1.041, 1.109, 1.166, 1.181 kW), also values of the actual steering forces ($F_{act}$) and power ($P_{act}$) were (5.296, 5.703, 6.042, 6.128 kN); (0.9, 0.963, 1.021, 1.036 kW) at the traction surfaces of about concrete, clay, sandy clay and sandy, respectively.

The steering force and power increased with the hydraulic cylinder length. Values of the theoretical steering force ($F_t$), power ($P_t$); the actual steering force ($F_{act}$) and power ($P_{act}$) varied from about (4.623 to 8.47 kN); (0.781 to 1.432 kW); (3.9 to 7.144 kN); (0.658 to 1.207 kW) at the hydraulic cylinder length varying from about (58.9 to 70.4 cm), respectively.

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(4): Effect of the W/WB and the cylinder length on the steering force and power:
The steering force and power increased with increasing the traction surface loosening. Values of \((F_t)\) and \((P_t)\) were (0.86, 6.171, 6.578, 6.917, 7.104 kN); (0.145, 1.045, 1.112, 1.17, 1.201 kw), also values of the actual steering forces \((F_{act})\) and power \((P_{act})\) were (5.311, 5.718, 6.057, 6.244 kN); (0.899, 0.966, 1.025, 1.056 kw) at the traction surfaces of about concrete, clay, sandy clay, and sandy, respectively.

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The steering force and power increased with the value of \(W/WB\). Values of the theoretical steering force \((F_t)\), power \((P_t)\); the actual steering forces \((F_{act})\) and power \((P_{act})\) varied from about (4.676 to 6.541 kN); (0.790 to 1.107 kw); (3.816 to 5.681 kN); (0.645 to 0.962 kw) at values of \(W/WB\) varying from about (0.39 to 0.58), respectively, saving power of the tractor to the maximum extent due to losses in steering and increased the tractor efficiency.

REFERENCES


Metwalli S. M.; Mohammed H.A. Kabeel; Abdul wahed M. Abou Karima; and


دراسة على كفاءة أجهزة توجيه الجرارات الزراعية

4- قوة وقطرة التوجيه

أبوالخير مصطفى محمد سرحان* حسني سلطان القطري** محمد نبيل العوضي ***

تهدف هذه الدراسة إلى معرفة النظام الأمثل لتشغيل وصيانة الجرار الزراعي بصورة عامة والتوجيه والقيادة بصورة خاصة وبالتالي تلبية جهة توجيه آل يتم تشغيله بطريقة هيدروليكية بحيث تعمل كوحدة مجمعة تحت جميع خطوات التشغيل ونقل الحركة إلى عجلات الأرض.

وتحقيق هذا الهدف تم اختيار جرارين من نفس النوع ومحترف حفار سلاح صناعة محلية والجرار المستخدم ماركة بيلاروس (10M3-6KM) ذات قدرة متوسطة متعدد الأغراض 65 حصان ميكانيكي (48.2 كيلووات) شائع الاستخدام تحت الظروف المصرية وأخير لقياس الفلاح المصري والمزارع المصرية وأستعمل الجرار قبل وبعد التعديل (وهو التعديل يسمح بتقليل نصف قطر الدوران من 5 إلى 1.5 متراً وكذلك تخفيف الاحتكاك بين العجلات الأمامية وأجهزة التوجيه) أُختير في معمل أبحاث الآلات والجرارات الزراعية بقسم الهندسة الزراعية كلية الزراعة - جامعة الأزهر.

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلي:

1- تأثير زاوية التوجيه الداخلية على قوة التوجيه:

قوة التوجيه النظرية تزداد بزيادة زاوية التوجيه الداخلية وقيمها تتراوح بين (0.94-0.5) كيلوطن عند زوايا التوجيه الداخلية تتراوح بين (1.5-0.5) درجة على الترتيب.

2- تأثير الحمل وطول الأسطوانة الهيدروليكية على قوة وقطرة التوجيه:

قوة وقطرة التوجيه تزيد بزيادة الحمل الواقع على العجل الأمامي وقيم قوة وقطرة التوجيه النظرية تتراوح بين (0.98-0.7) كيلوطن عند أحمال تتراوح بين (5.0-0.5) كيلوطن.

1- قوة وقطرة التوجيه تزيد بزيادة سطح التلامس وقيم قوة وقطرة التوجيه النظرية تتراوح بين (0.98-0.7) كيلوطن عند أحمال تتراوح بين (5.0-0.5) كيلوطن.

2- قوة وقطرة التوجيه تزيد بزيادة سطح التلامس وقيم قوة وقطرة التوجيه النظرية تتراوح بين (0.98-0.7) كيلوطن عند أحمال تتراوح بين (5.0-0.5) كيلوطن.

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3- تأثير السرعة وطول الأسطوانة الهيدروليكية على قوة وقدرة التوجيه:

1- قوة وقدرة التوجيه تزداد بزيادة فكك سطح التلمس وقيمتهم النظرية تتراوح بين (0.86-6.170، 0.145-1.112، 0.567-0.811، 1.057-1.211 كيلو وات) وقيم قوة وقدرة التوجيه الفعلية تتراوح بين (4.620-5.311، 0.390-0.580 كيلو نيوتن) عند سرعات تتراوح بين (الأولى والرابعة) على الترتيب.

2- قوة وقدرة التوجيه تزداد بزيادة السرعة وقيم قوة وقدرة التوجيه النظرية تتراوح بين (0.86-6.170، 0.145-1.112، 0.567-0.811، 1.057-1.211 كيلو وات) وقيم قوة وقدرة التوجيه الفعلية تتراوح بين (4.620-5.311، 0.390-0.580 كيلو نيوتن) عند سرعات تتراوح بين (الأولى والرابعة) على الترتيب.

4- تأثير W/WB وطول الأسطوانة الهيدروليكية على قوة وقدرة التوجيه:

1- قوة وقدرة التوجيه تزداد بزيادة تفكيك سطح التلمس وقيمتهم النظرية تتراوح بين (0.86-6.170، 0.145-1.112، 0.567-0.811، 1.057-1.211 كيلو وات) وقيم قوة وقدرة التوجيه الفعلية تتراوح بين (4.620-5.311، 0.390-0.580 كيلو نيوتن) عند سرعات تتراوح بين (الأولى والرابعة) على الترتيب.

(1) توفير القدرة المفقودة في التوجيه
(2) زيادة كفاءة الجرار.