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DEVELOPMENT POWER SUPPLY OF THE EGYPTION WATERWHEEL

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ABSTRACT: This research aims to develop waterwhweel power transmission system by adding gearbox instead of the traditional system which use now with the waterwheel. The development keeps the power transmission system from sun, air and weather changes where the traditional system was without covering or protection. This lead to increase the operating life of the waterwheel. From the obtained results the developed system of the waterwheel decreases the consumed energy and saving in the operational costs comparing to the traditional waterwheel transmission system and another common pumping systems. Using this machine save the enviroment from exhausting.

Key word: Development, sakia, transmission system, energy, costs, environment.

INTRODUCTION

The most old land in Egypt irrigate using flooding irrigation system because the most old land including sodium element and clay metal which decreased surface leak to about that cultivation densely grow for example rice, sugar beet, wheat, cotton and berseem. The most types machine which used on extent Nile wadi basin are waterwheel and transmit machine (pumping set for agricultural purpose). Horsey (1984) found that the technical and economic characteristics of a variety of low lift pumping devices are analyses. Water wheels and both portable and fixed axial flow pumps are considered. Animal, electric and fossil fuel drivers are investigated. The analysis is performed specifically for pumping conditions in Egypt and both the economic costs of pumping based on international market prices, and the on farm pumping cost in Egypt are determined. A computer model is developed to aid for pump selection and to perform economic calculations. A six-inch axial pump developed by the International Rice Research Institute is found to be the most efficient low lift pump and, driven by a 3 hp. electric motor, provides the lowest pumping costs. Where electricity is unavailable. The animal powered water wheel is found to provide the least expensive pumping costs. Brookes (1989) indicated that the traditional system of agriculture irrigation is described from Dakhla Oasis, Egypt. Field cultivation in this hyperacid, wind-swept lowland has traditionally been based on wind-blown soil parent materials artificially trapped by windrows and irrigated in a reticulated system by water raised from wells by animal-powered water wheels (sakia). Distinctive bodies of stratified sediment, called 'irrigation deposits', have thus been formed, up to 5 m thick and 1 km superscript 2 in area. Free drainage of irrigation water through these mainly sandy materials inhibits salinization. Patches of these deposits have grown around and down slope from wells, to be abandoned when sufficient water can no longer be lifted to the cultivated surface. The process is renewed in adjacent areas with favorable water supply, and has resulted in the growth of a mosaic of irrigation deposits over Dakhla Oasis since introduction of the water wheel in Roman times. Since the 1950s, this traditional waterwheel and soil-conserving system of land use has been in decline, through replacement by irrigation from deep wells feeding large canals which cross low-lying areas. This has led to salinization, despite recent deceleration of development and efforts to draw off excess water into detention ponds. On the north-west and east outskirts of Dakhla, the extensive level floors of extinct lakes are being mechanically developed into large arable tracts also irrigated from deep wells. Salinization is predictable there too, with counter-productive. Effects on food production for a rapidly growing Egyptian population.

Berry *et al.* (1996). An analytical study was done to deduce the general equations which depict the sakia discharge. The discharge was determined first for a quasistatic rotation, followed by a study of the effect of the speed of rotation. An experimental test was carried out to check the deduced equations, using a plastic model. The experiments showed the validity of the deduced equations. The discharge was found to be inversely proportional to the lift in a parabolic relationship. The discharge per one revolution increased with the increase of the rpm. This study showed that the water wheels with maximum spiral angle equals to 2π have the least momentum losses, while those with spiral angle equals to π have the higher momentum losses.

Morcos *et al.* (1996) found that the mathematical analysis of the discharge ended by a general equation describing the discharge of any type of waterwheel with any specification as long as its bucket curveture follows the spiral of archemedes.

Ruf (1996) indicated that the full account of the development of Egyptian irrigation up to the present day. It is in the present day that the Egyptian farmers (fellahs) are facing the problem of the breakdown in traditional water management practices. Water-wheels (Sakia) are being replaced by pumps. The extra power available to pump owners has resulted in considerable water management problems. Additionally, as responsibility for management is devolved from farmers' organizations and state services, such organizations are in danger of running down. This might leave an anarchic situation.

The aim of present study is to evaluate the suitability of power transmission system for irrigation in old land and raise the efficiency of this system, the pump efficiency, the specific energy consumption and the machinery costs of two different machinery systems, and its working conditions in the Egyptian irrigation old land And illustrate the important of this machine in save the environment.

MATERIALS AND METHODS

The main objective of this work was raisin the efficiency of water wheel by changing the old power transmission system with transmission system of old tractor and compared this system with the common system in old land (pumping set for agricultural purpose).

Power Source of Waterwheel

Diesel engine type dewets with a brake horsepower (BHP) of 16 hp (11.9 kW). It was single cylinder water cooling engine with a total mass of 355Kg. that engine was provided with a 24 liter capacity fuel tank. The average specific fuel consumption (SFC) of that engine according to the manufacture manual is as 475 (gm.kW/h).

Transmission System Old and New for Water Wheel

In the first the Transmission system in the old system consists of gear group. This gear group consists of 4 gears and 2 pulleys local factors. But the Transmission system in the new system is constant gear box, this gear box consists of 6 gears and 2 pulleys, made in England and type is Sharmis. The specification of this gear group is shown in Table 1 and the specification of gear box is shown in Table 2.

Wheel Saqia

The wheel Saqia was constructed and made from galvanized steel and all parts were joined by rivet. The wheel Saqia was manufactured for re-Assembled with transmission system by shaft diameter of 10cm. the diameter was 300cm and weight 1450kg, the numbers bucket were 10.

Petot Tube

Petot tube was used to determined manometer head pressure.

A steel Tape

20 m length: was used to measure the lengths.

Stop Watch

With accuracy of ± 0.01 sec, was used to record the times.

Methods of Evaluation

The discharge, pump efficiency energy requirements and costs rats, were considered to evaluate the new system.

Determined the discharge for waterwheel (by used quantity of water in channel)

$V = 1/n\ R^{2/3}\ S^{1/2}$(Manning eq.)

Whereas;

$Q = A \times V$ And $R = A/P$

Q= discharge, m^3 /sec. R= radius (half diameter) hydraulic.

A= cross section area of the discharge m^2, V = velocity of flowed water, m/sec.

P= wetted primeter, m

n = factor (0.012 – 0.016)

S = slip of watercourse, m.

Determined the discharge for waterwheel (by used the part flooded of waterwheel)

This method by determination the flooded volume of waterwheel and multiplication with revaluation numbers in minuet.

Area used = area total – area inter but, volume m^3 = Area used × width so, Q (m^3 /min.) = volume of pocket m^3 × number of bucket × the number of revolution per mint.

Pump efficiency

$W(hp) = 9.81 \times Q \times h/270$ whereas h = hydraulic pressure, W= Water power, hp,

$\zeta p = W(hp)/B(hp)$ and B (hp) = brake horse power.

F.C.= fuel consumption whereas, B (hp) = 0.25 F.C.

Machinery cost estimation

The cost of any of water machinery system has been determined by estimating costs of owning the equipment of that system and cost of operating them, in the present study the operating cost, was calculated according to Hunt (1983).

The total machinery system costs were estimated as the sum of each entire equipment or machine costs. The, ownership, operating and total machinery costs could be calculated per-fed. The total machinery costs per-fed has been computed by multiplying by the actual time required by the system to cover irrigation per fed.

Energy requirements

Energy requirements can be estimated according to equation of (Imbaby 1990).

$$EP = FC\ (1/3600)\ PE \times LCV \times 427 \times \eta thb \times \zeta m$$

where:

FC = The fuel consumption L/h.

PE = The density of fuel kg/L (for solar = 0.85). LCV = The lower calorific value of fuel k.cal/kg.

η_{thb} = The thermal efficiency of engine. Thermo-mechanical equivalent = 427

ζ_m = The mechanical efficiency of engine

Engine power= 3.16 x FC k.W.

Table 1. The specification of old power transmission system (gear group) for water wheel

Type	Diameter (cm)	Space – teeth (cm)	(rpm)
Pulley	10.5	-	72
Pulley	100	-	75
Gear	10	2.5	75
Gear	46	2.5	16.3
Gear	27	7	16.3
Gear	100	7	4.4

Table 2. The specification of new power transmission system (gear box) for water wheel

Type	Diameter (cm)	Space (cm)	(rpm)
Pulley	15	-	120
Pulley	90	-	120
Gear	10	2.5	80
Gear	15	2.5	80
Gear	6.5	2.5	20
Gear	26	2.5	20
Gear	14	2.5	20
Gear	55	2.5	5.3

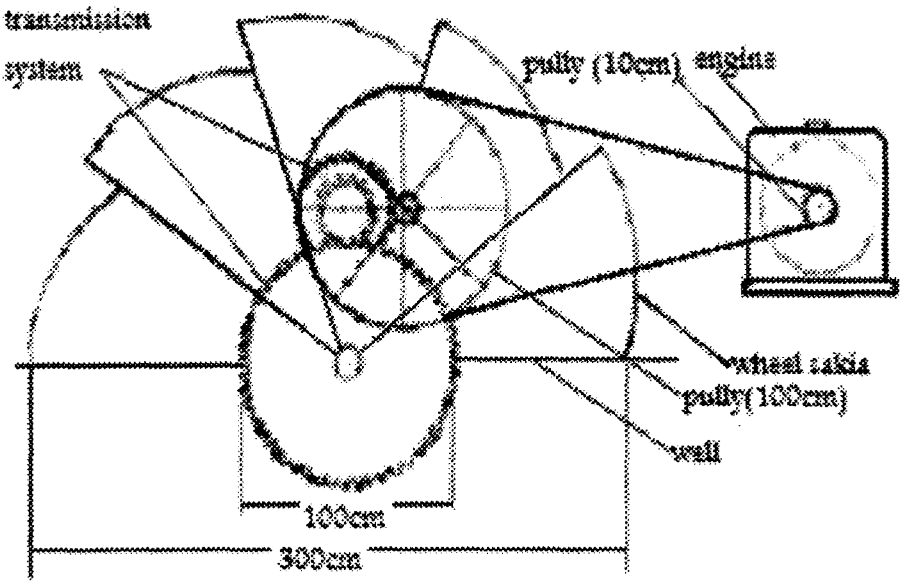

Fig. 1. Schematic of transmission system before development

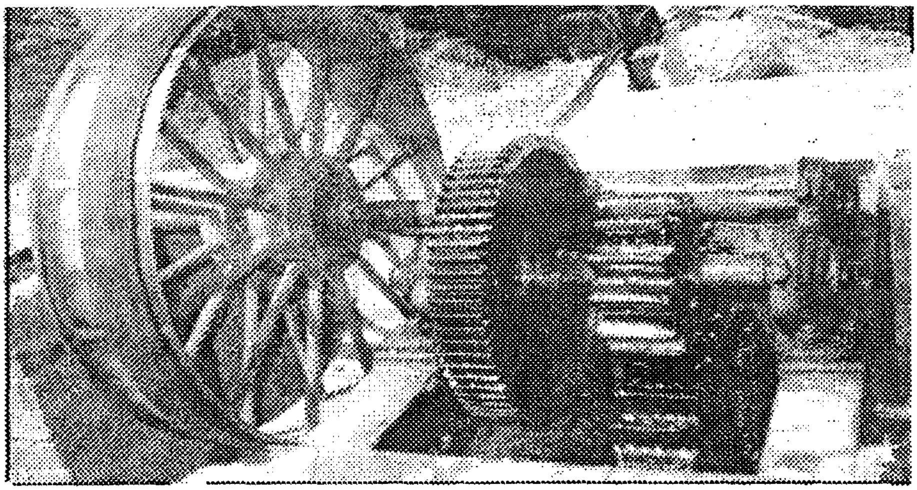

Fig. 2. Photograph of the transmission system before development

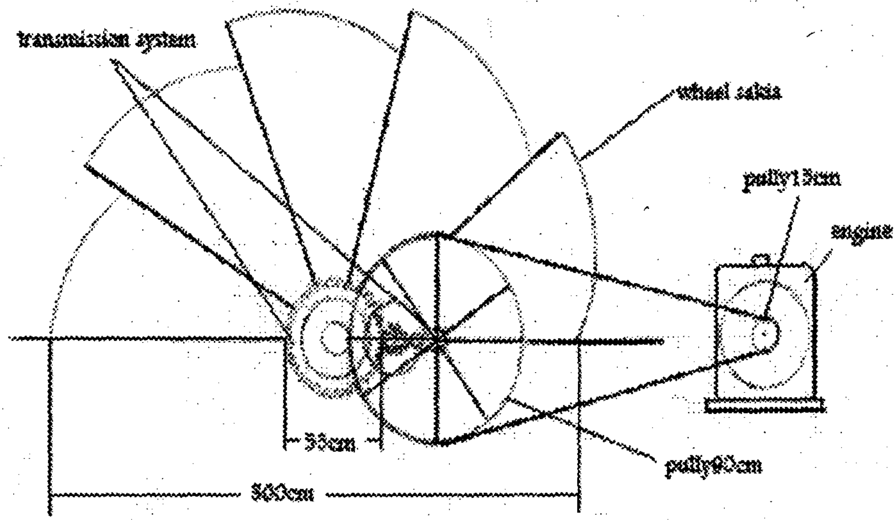

Fig. 3. Schematic of transmission system after development

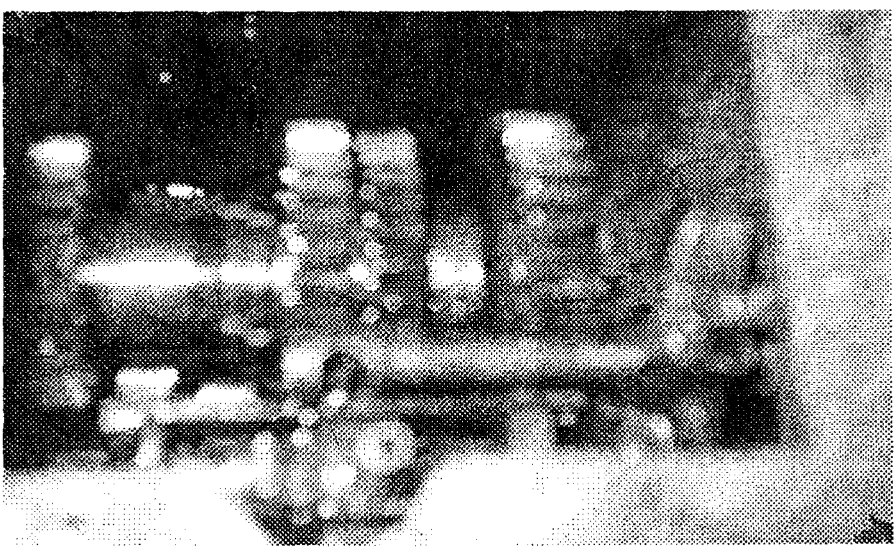

Fig. 4. Photograph of the transmission system after development

RESULTS AND DISCUSSION

Results indicated that the difference between old and new transmission system for waterwheel, performance were as following.

Determine the Discharge for Waterwheel under Two Systems

Table 3 indicated that the discharge from discovery channel which fill at waterwheel (by used the part flooded of waterwheel). The result illustrate that the maximum value of discharge, 18.84 m^3/min.was obtain under new system and height depth of water, but the minimum value was 12.60 m^3/min.was obtain under used old system and low depth of water. Too, Table 4 illustrate that the discharge by used the part flooded of waterwheel the result indicated that decreasing in the values of discharge of old system by 1.23 m^3/min with Low depth of water and 1.11 m^3/min with height depth of water.

Table 3. The rate of discharge under different heights of water in the channel discovers which fill by waterwheel

Height of water	**Low depth of water**		**Height depth of water**	
Type system	New	Old	new	old
N. revolution, rpm.	5.3	4.8	5	4.5
The heights of water in the channel discover which fill by waterwheel (cm).				
r1	12	10	14	12
r2	10	11.5	18	15
r3	15	12	20	18
r4	13	13.5	10	14
Total	50	47	62	59
Av.	12.5	11.75	15.5	14.75
A, m	0.091	0.085	0.113	0.107
P ,m	0.98	0.96	1.04	1.03
R, m	0.093	0.088	0.108	0.105
V, m/ sec.	2.50	2.43	2.77	2.71
Slip, m	0.038	0.038	0.038	0.038
Discharge, m^3/sec.	0.22	0.21	0.31	0.29
Discharge, m^3/min.	13.68	12.60	18.84	17.41

Table 4. The discharge under different depths of water which can waterwheel arrived it

Height of water	Low depth of water		Height depth of water	
Type system	New	Old	new	old
n. revolution, rpm.	5.3	4.8	5	4.5
The depth of water which can waterwheel pulley arrived it (cm).				
R1	89	89	128	128
R2	82	82	125	125
R3	77	77	122	122
R4	73	73	119	119
T	321	321	494	494
Av.	80.25	80.25	123.5	123.5
Width waterwheel, m	0.20	0.20	0.20	0.20
Area total, m^2	28.25	28.25	28.25	28.25
Area inter, m^2	15.16	15.16	9.78	9.78
Area used, m^2	13.08	13.08	18.47	18.47
Volume, m^3	2.62	2.62	3.69	3.69
Discharge, m^3/sec.	0.23	0.20	0.30	0.28
Discharge, m^3/min.	13.80	12.57	18.45	17.34

Pump Efficiency under Old and New Transmission System

Fig. 5 and Fig. 6 show that the average maximum value, 100cm of water pressure was obtain by using new transmission system and height speed of waterwheel, in addition that the minimum value of 87 cm of water pressure was obtained under used old transmission system and low speed of waterwheel.

In anther hand the maximum value, 3.97 hp. of average water power was obtained by using new transmission system and height speed of waterwheel. Added to that the minimum value, 2.49 hp. of average water power was obtained by using old transmission system and low speed of waterwheel. This data are shown in figs (7 and 8).

After that, the best value of Sakia efficiency was 38.2 % by using new transmission system and height speed of waterwheel. But Fig. 9 shows that the minimum value, 31.24% of sakia efficiency was obtained under used old transmission system and low speed of waterwheel. In anther hand the maximum value of sakia efficiency (38.2%) was obtained under used new transmission system and height speed of waterwheel but the minimum value (31.24%) was obtained under used old transmission system and low speed of waterwheel. So, this data are denoted that using new transmission system the unit of sakia efficiency will raise by 2.6%.

Energy Requirements

The energy requirements for old and new systems were 3.17 and 2.16 kW.hr/fed. Res. But it was 23.94 kW.hr/fed for common system (pumping). So, these results illustrate that the new transmission system was save the energy by 1.01 kW.hr/fed. compared with old system. it, saved the energy by 21.78 kW.hr/fed. Comparing with common system (pumping). This data are shown in fig. 10.

Machinery Cost Estimation

The unit cost of old and new transmission system from the economics point of view is shown in fig. 11. The results indicated that the total fixed costs for old and new transmission system were

1.88 and 0.53 L.E/hr. respectively. While, the total cost for old and new transmission system were 6.62 and 4.56 LE/hr. respectively. When taking the irrigation area in the consideration the results were 3.31and 1.98 LE/fed.hr. These results illustrate that the new transmission system was saved the cost by 2.05 L.E / hr. and 1.33 LE /fed.hr. but the total cost for common system (pumping) was 7.27 L.E/ hr. and 22.03 L.E/ fed. hr.

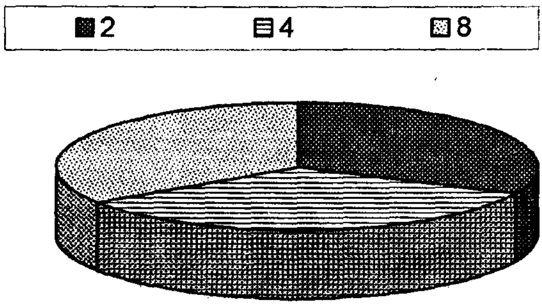

Fig. 5. The relation between height of water and the water pressure used old system

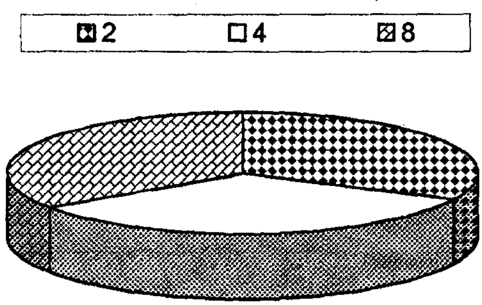

Fig. 6. The relation between height of water and the water pressure used new system

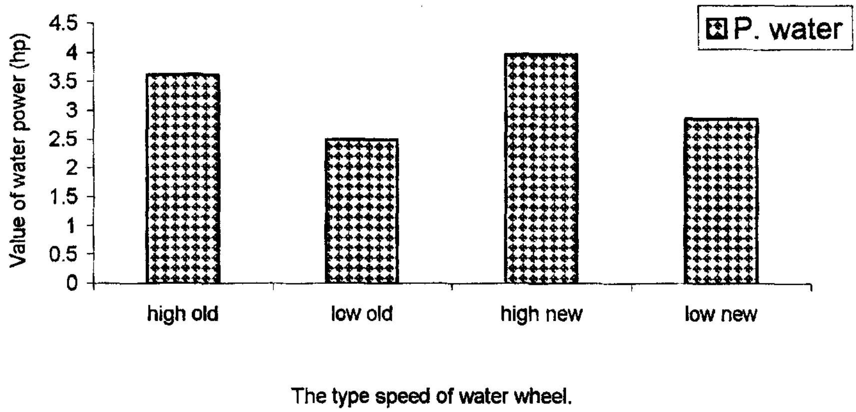

Fig. 7. The relation between speed of waterwheel and water power (hp)

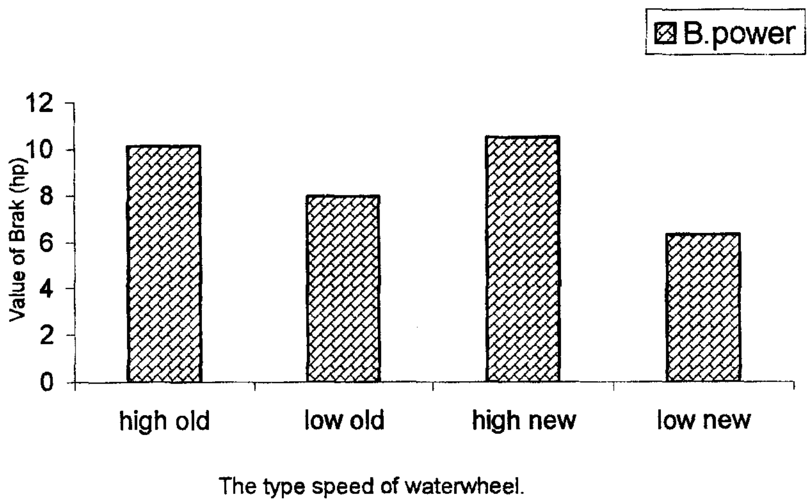

Fig .8.The relation between type speed of waterwheel and brake (hp)

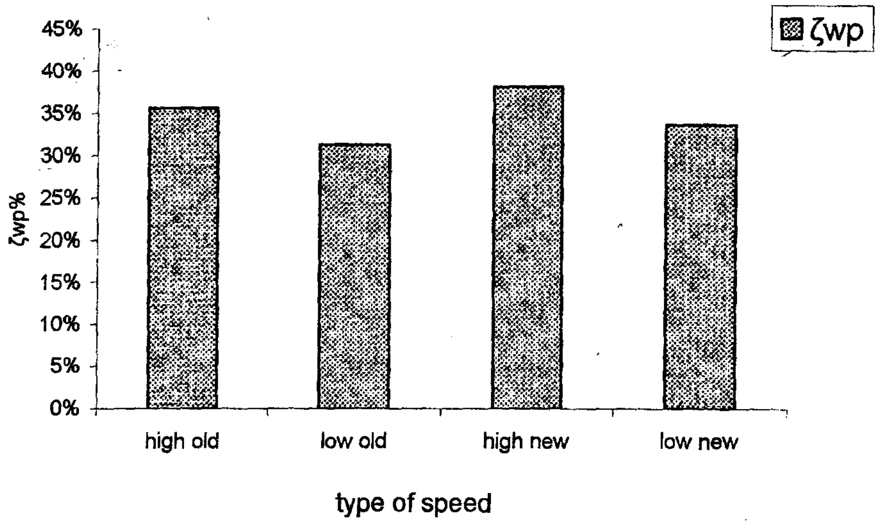

Fig.9. The relation between type of transmission system and efficiency of waterwheel

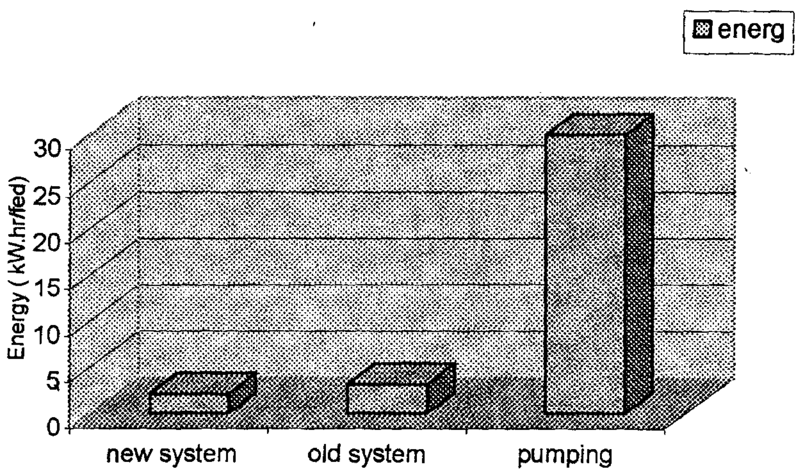

Fig.10. The energy requirements for old and new system for waterwheel and pumping (kW.hr/fed.)

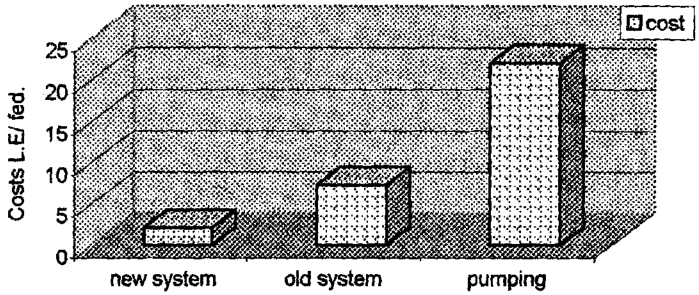

Fig. 11. The costs for old and new system for waterwheel and pumping (L.E/fed.)

Conclusions

The important results can be summarized in the following points. The new power transmission system for waterwheel can be save pump efficiency, by 2.6% too, was saved the energy by 1.01 kW.hr/fed. Compared with old system (21.78 kW.hr/fed) for common system (pumping). These results illustrate that the new transmission system was saved the cost by 2.05L.E/ fed.hr. and 1.33LE/fed.hr.but the total cost for common system (pumping) was 7.27 L.E/ hr. and 22.03 L.E/ fed. hr.

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تطوير مصدر القدرة لسواقى الرى المصرية

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أجري هذا البحث لرفع كفاءة استخدام سواقى الرى وبيان أهمية هذه الآلات القديمة من حيث توفيرها للطاقة مع قلة تكلفة الرى بالنسبة للفدان. وقد أجرى بحث ميدانى على عدد من اكبر مراكز محافظة الشرقية مساحة لمعرفة مدى انتشار الآلة(الساقية) فقد وجد أن الآلة مازالت تستخدم على نطاق واسع بعدل ٧٦,٢% كما يتم استبدال مضخة الرى الزراعية بالساقية وذلك بمشاركة عدد من مالكى الأرض الزراعية فى ظل ارتفاع أسعار الطاقة وقطع الغيار .وذلك من خلال بحث إمكانية استخدام منظومة نقل قدرة قديمة (لجرار قديم) بديلا للمنظومة التقليدية المستخدمة لتشغيل السواقى البلدية وتم التقييم للنظامين تحت اقل وأعلى سرعة من خلال حساب معدلات التصرف للساقية بطريقتين (١- حجم الماء فى القناة المكشوفة ٢- حجم الجزء المغمور من الساقية) و كفاءة الساقية (حساب

القدرة الفرملية والقدرة المائية) والطاقة المستهلكة للفدان والتكاليف للفدان. وتم أيضا مقارنة هدا النظام بأكثر وسائل رفع المياة انتشارا وهى (مضخة الرى الزراعية)

وقد أشارت النتائج إلى النقاط التالية:

١- ارتفاع معدلات التصرف تحت استخدام نظام نقل القدرة المستبدل مع السرعة الأعلى وقد أعطت ١٨,٤٥ لتر/دقيقة بينما اقل قيمة سجلت تحت استخدام النظام القديم والسرعة المنخفضة فكانت ١٢,٥٧ لتر/دقيقة.

٢- ارتفاع كفاءة الساقية تحت استخدام نظام نقل القدرة المستبدل مع السرعة الأعلى حيث وصلت الى ٣٨,٢% واقل قيمة تحت استخدام النظام القديم والسرعة المنخفضة فكانت ٣١,٢٤ %.

٣- الطاقة المستهلكة للفدان: سجلت أعلى قيمة للطاقة المستهلكة تحت استخدام نظام نقل القدرة القديم فكانت ٣,١٧ كيلوات ساعة/فدان. بينما قيمة الطاقة تحت نظام نقل القدرة المستبدل كانت ٢,١٦ كيلوات ساعة/فدان أما الطاقة المستهلكة لأكثر النظم شيوعا وهى (مضخة الرى الزراعية) فكانت ٢٣,٩٤ كيلوات ساعة/فدان.

٤- ارتفاع تكاليف استخدام الساقية لنظام نقل القدرة القديم فكانت ٣,٣١جنية/فدان ساعة بينما التكلفة تحت نظام نقل القدرة المستبدل كانت ١,٩٨ جنية/فدان ساعة أما التكلفة لأكثر النظم شيوعا وهى (مضخة الأغراض الزراعية) فكانت ٢٢,٣ جنية/فدان ساعة.من خلال هده النتائج يتضح أهمية استبدال نظام نقل القدرة بالنسبة لسواقى الرى وأهمية استخدام السواقى فى توفير الطاقة والتكاليف.

٥- أن استخدام سواقى الرى يؤدى إلى حماية البيئة من التلوث الناتج من احتراق الوقود لكثرة استخدام مضخات الرى الزراعية حيث ان استخدام الساقية يوفر ٢١,٧٨ كيلوات ساعة/فدان من الطاقة المستهلكة.

أثبتت الدراسة إمكانية استخدام صندوق تروس لجرار (كهنة) كمنظومة نقل حركة فى تشغيل السواقى البلدية بديلا للمنظومة التقليدية المنتشرة حاليا لما لها من عائد فى زيادة تصرف السواقى مع رفع كفاءتها وتدنية متطلبات الطاقة اللازمة لتشغيلها بالإضافة الى نقص تكلفة رى الفدان بالمقارنة باستخدام مضخات الرى خاصة فى الحيازات الصغيرة للأراضي القديمة.