

## A comparison among different kinds of motors with evaluation of power requirements

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### ABSTRACT

Tractors have a large and effective role in agricultural works, and because Iraq is one of the large agricultural countries, so it was necessary to study the types of tractors that are used in performing these works and compare between them to show which one is better and preferable. The subject of the current research paper is based on a comparison, the comparison includes theoretical comparison among these tractors via the laws related to them and practical comparison that included studies conducted on two different types of capacity of tractors (4. D.W.) and (2. D.W.) at different times and conditions. It was determined through practical experience in the fields which tractors are best to work in terms of strength, traction capacity, rolling resistance and percentage of tire slip.

**Keywords:** Power requirement, Puller Weight, Motors with Evaluation, Puller Capacity, Rolling Resistance

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### 1. Introduction

In record time, tractors have become the modern means used for all agricultural requirements, and the diversity of their use increases as they are developed and provided with various accessories. The possibilities of developing or converting tractors are very important, especially in the fields of agriculture, since the use of tractors affect both fields and farms in any season of the year. The engine in the tractor is the heart of the tractor and no tractor can work without a good engine that depends on its performance. This performance may often encounter some malfunctions, but they are mostly minor malfunctions that can be fixed through maintenance.

Over time, many and varied designs of tractors were created and developed on the basis of their different uses. Although these designs can be limited to a few main typical designs, they differ from each other to a large extent in some cases in terms of operation, speed, maintenance and repair [1]. The most important process carried out by agricultural tractor pullers is the pulling process, which is the ability to tow or pull secondary equipment behind the tractor. These equipment's vary according to the nature of the work, including fertilizer spraying, seed spraying, cutting crops, turning the soil or plowing the land and others. As a result of the different nature of the work of the tractor pullers, it was necessary to design it with different types and shapes that suit the conditions in which the tractor puller works. Most of the previous research in this field focused on specific factors from which the optimal type required for the tractor puller was deduced. These factors include:

#### 1.1. Tractor puller weight

Since the increase in the weight of the tractor puller will require a large traction force, and this traction force is obtained by increasing the horsepower of the tractor puller engine, and this process requires an increase in the weight of the engine, which leads to an increase in the weight of the tractor puller completely, and an increase in fuel consumption [2-6].

On the other hand, the increase in weight through additional loads will lead to providing good friction surfaces

between the tractor puller levers and the ground surface, which will be used to reduce slippage in the tractor puller.

### 1.2. Tractor puller capacity

Improving the process of pulling from the tractor puller and increasing the load on the traction shaft leads to an increase in the horsepower required to complete the work, and that the increase in the traction force is not the only main requirement for the agricultural tractor puller, and this depends on the nature and type of work that the agricultural tractor puller performs [7, 8]. To accomplish it, it needs a speed of work more than it needs a pulling force, or it may need a slow speed if the equipment tied behind the tractor puller needs a large pulling force [9, 10].

### 1.3. Rolling resistance

It is the obstacle that the tire faces when driving tractor on different surfaces, and this force depends to a large extent on the type and condition of the surface on which the tractor puller is moving, as well as on the type of way in which the tire of tractor puller touches the ground. The difference in the values of rolling resistance results from the different distribution of weights in each case, as the increase in weight on the metal belts or tire leads to its immersion more in the soil, and this requires additional force to carry the tractor to climb, and in addition to the effect of weight, there is another effect which is the type of soil where the tractor is exposed to a higher rolling resistance in wet soil than if it was moving on solid soil or concrete surfaces. The size of the tire, its pressure, and the design of the sclerotic ribs are all factors related to rolling resistance.

### 1.4. Slip

Slippage is regarded one of the negatives that reduce the efficiency of the work of the tractor, which designers resort to trying to reduce it in different ways and designs. It is known that vehicles in general travel a distance on concrete ground that differs from those that they travel over normal soil and this difference appears clearly, especially if the type of soil of the mud type and the slip rate is the ratio between the distance traveled in both cases. If the slip rate in a tractor puller is 40%, it will travel a distance of (100) meters over concrete ground and a distance of (60) meters over the normal soil for the same period of time.

## 2. Materials and methods of work

### 2.1. Theoretical comparison foundations

For pulling capacity, it must be ensured that increasing the traction force is not the main requirement of the agricultural tractor. This is related to the nature of the work it carries out, on the contrary, we find that the tractor puller that is used in the farm requires to produce a greater capacity useful for pulling, which combines the element of force and speed [11]. Figure 1 shows the relationship between the pulling force and the process speed of the tractor puller.

It can be explained by the following equation:

$$P = D * V \quad (1)$$

Where:- P = horsepower of pulling shaft ( hp).

N = pulling power kg.

V = tractor puller speed m/s.

Assuming that the horsepower of the pulling shaft is constant (P = constant). It turns out that there is an inverse relationship between the pulling force and the pulling speed.

$$C = D. V$$

$$D = \frac{C}{V} \quad D = \frac{I}{V}$$

On this basis, it must be worked at a slow speed to obtain a high pulling force.

As for the relationship of the power of the tractor puller motor, the pulling force and the losses, it can be shown from the following equation –

$$D = \frac{V(D+R) \cdot 1.47}{550(1-\mu)} \quad (2)$$

whereas

PE = horsepower of the engine.

$\mu$  = slip losses at maximum horsepower

D = pulling force.

V = speed of tractor puller ( m/h )

R = rolling resistance (1b)

It is noticed that there is a difference in equations (1) and (2), whereby equation (1) is the independent net pulling capacity at the pulling shaft, assuming that there are no power transmission losses entirely from the engine to the pulling shaft.

As for the second equation, it shows us that the second power from the pulling shaft in the case of losses (slippage, rolling resistance), so the amount of power obtained from the pulling shaft in the second equation is less than the power obtained from the first equation because of these losses resulting from the type of soil and the length of the contact area of the excavation with the soil surface.

For net pulling coefficient (  $\mu_{tr}$  ), when evaluating the performance of the pull shaft for the tractor pullers, the ratio between the pulling force from the shaft (Dt) to the weight applied to the driving wheels Wd is taken. The relationship can be shown by the following equation.

$$\mu_{tr} = \frac{Dt}{Wd} = \frac{D-R}{Wd} \quad (3)$$

whereas -

Dt = The final pull force used for pulling.

D = pull shaft force.

R = sum of resistors.

Wd = weight applied to the driving wheels.

The above equation shows that the dynamic weight applied to the wheels in (W.D2.) tractor pullers is mostly concentrated on the rear wheels, so the net pulling coefficient of the tractor puller (W.D2.) is less than the net pulling coefficient of the tractor puller (W.D.4).

On the other hand, the relationship of rolling resistance (Rr) to the strength of the pulling shaft (W) is an inverse relationship whereby the decrease in the value of rolling leads to an increase in the strength of the pulling shaft, because the rolling resistance leads to an increase in the strength of the pulling shaft, and that is because the rolling resistance is the product of the mass \* ground acceleration \* coefficient of rolling resistance). Slippage is one of the negatives that reduce the efficiency of the tractor puller's work, and designers resort to trying to reduce it by various methods and designs. It is known that vehicles in general travel a distance on concrete ground that differs from those that they take over normal soil [12]. And when the coefficient of rolling resistance is fixed for both tractor pullers, the only effect remains the effect of the dynamic weight applied to the driving wheels, and on this basis, the net pulling coefficient of the tractor puller (4WD) is greater than that of the tractor puller (2WD).

## 2.2. Slip

It is difficult to take into account slip values as a basis for comparison because it does not allow the ability of some agricultural tractor pullers to work at a low slip value. Therefore, slip test values are taken that are close to and not identical to the real values at the maximum statistical ability of pulling [13, 14].

The slip value depends on the length of the tire contact area with the soil and the deformation characteristic.

The relationship between the pulling force and the total weight of the tractor puller can be represented as follows

$$D = (X \cdot K - f) \cdot W$$

X = permissible slip coefficient.

$\mu$  = the maximum value of the pulling coefficient.

K = Gearbox Specialization Ratio.

It can be found from the equation:

$$\mu = \frac{C}{P} + \tan Q$$

C = soil hardness

P = tire pressure

Q = The angle of soil resistance to stress is its internal deficiency.

Assuming that the tractor is traveling over a concrete floor, the rolling resistance coefficient is very low, and it can be considered equal to zero.

So the equation will be:-

$$D = X \cdot \mu \cdot K \cdot W$$

$$X = \frac{D}{\mu \cdot k \cdot w}$$

If we set the factors (k.D.  $\mu$ ) and take into consideration the effect of slip weight only, we find that the slip coefficient is inversely proportional to the span weight.

Therefore, the slip coefficient (D.W. 4) is less than in (D.W. 2).

### 3. Discussion

In order to know the best type of tractors that should be chosen to work in the agricultural fields to perform agricultural work, one of the important things on the basis of which the selection was made is the capacity of the tractor, the pulling force, the type of soil, the rolling resistance that the tractor faces, as well as the efficiency of tractor puller and slip and the amount of fuel consumption.

The selection process is carried out in two ways: the theoretical side and the practical one. In theory, we concluded from the research paper that the four-wheeled tractor has the advantage in choosing in terms of the extent of utilization of the power generated by the engine, its low rolling resistance, low sliding, its regular weight distribution, and its high pulling coefficient, and on this basis It is preferred to be used in fragile, sandy and muddy lands, mountains and slopes. From a practical point of view, such lands need continuous use of the maximum power and a high degree of continuity and resistance to overturning, but the four-wheeled tractor requires high maintenance, and its fuel consumption is higher than the fuel consumption of two-wheeled tractor puller and the difficulty of maintaining the drive system which It is often complicated. As for the two-wheeled tractor pullers, it has been shown through the research paper that this type of tractor pullers is not preferred to be used. However, from a scientific point of view, the field of its use is wider than the field of using four-wheeled tractor, due to the ease of maintenance process and low fuel consumption, and because of low rolling resistance on solid land and because of the low slip. To test the tractors, different field experiments should be carried out using both four-wheel tractor pullers and two-wheeled tractor pullers in order to reach to the best use of tractor puller that gives the best results and at the lowest cost, the field experiments should be in different seasons of the year because this has a significant impact on changing the nature of agricultural lands, so that we can take the optimal decision to use the most efficient type of work and the most economically appropriate of both types. Where the size of the tires with a greater pulling force than the (4.D.W.) equal tires, and as a general average, the (4.D.W.) tractor pullers were equal to the tires with 33% greater pulling force than the (2.D.W.) pullers, and that the pulling force of (4.D.W.) tractor puller with small front wheels was 17% greater than the pulling force of the (2. D.W.) puller.

B - Maximum pulling capacity ( MAX, DRAHBAR POWER {KW hp), from table (7) it appears that the (4.D.W.) tractor puller equal tires had a maximum pulling capacity greater than the (4.D.W.) tractor puller with small front wheels, and the latter had a greater pulling capacity than the pulling capacity of the (2.D.W.) tractor puller. This shows that the (4.D.W.) tractor puller with equal tires was able to make better use of the power of its pulling shaft than the (2.D.W.) tractor puller.

In general, the practical results obtained from field experiments show that the average maximum pulling capacity of the (4.D.W) tractor puller constitutes (14%) in general.

As for the (D.W.4) tractor puller with small front wheels, the average capacity of pulling shaft was (7%), which is higher than that of the (2.D.W.) tractor puller. From this it can be concluded that the rate of work

produced by the (4.D.W.) tractor puller is greater resistance than the work produced by the (2.D.W.) tractor puller of the same power. It turns out that the power range of (60-100 hp) in the use of the two types is almost equally dependent mainly on the type of soil applied. In the last range, i.e., the range of high power (more than 100 hp), there is an urgent need to use (4.D.W.) tractor pullers totally, and the reason is due to the need to use the maximum power of the tractor puller to perform the agricultural works with small percentages of losses in power. The above can be clarified by looking at the drawn curve, which shows the relationship between the capacity and the determination of the type of tractor puller used. It is known that the low power resulting from the engine to the pulling shaft (DRAHBAR) does not work completely in performing the pulling process, but rather a part of it is wasted in the form of energy spent in friction and part of it is spent to overcome rolling and slipping. Chart No. (1) shows the percentage of the energy used in the pulling process and the percentage of the energy spent as losses, where this percentage reaches (150%) of the energy coming out of the engine and confines the lost energy as a result of friction among the gears, the gearbox, the driving axles and the shafts of weight. As for the energy lost in rolling resistance, it is the pulling force exerted to push the tire over the soil.

In addition, the sum of the energy lost in friction and the energy spent on rolling resistance is 25% of the total power of the engine. As for the remaining percentage of the energy spent, which constitutes about 25% as well, it is wasted energy to overcome the slip. And the slip value as shown in (Fig. 2) has a direct relationship with the pulling force, as the slip increases as the pull rate increases and decreases with its decrease, taking into consideration that the slip value does not exceed 20% to ensure that a large portion of the energy is not lost.

Table 1. Pull at 15% slip and maximum D.B. Power

Field No	Pull at 15% slip KN			maximum D.B. Power hp		
	2- wheel drive	4-wheel drive		2- wheel drive	4-wheel drive	
		Uneouci Sized wheels	Equal Sized wheels		Linequal Sized wheels	Equal Sized wheels
1	30	30	34	58	54	64
2	23	24	31	54	54	59
3	21	27	25	50	50	58
4	19	24	27	54	55	62
5	12	16	22	34	46	47

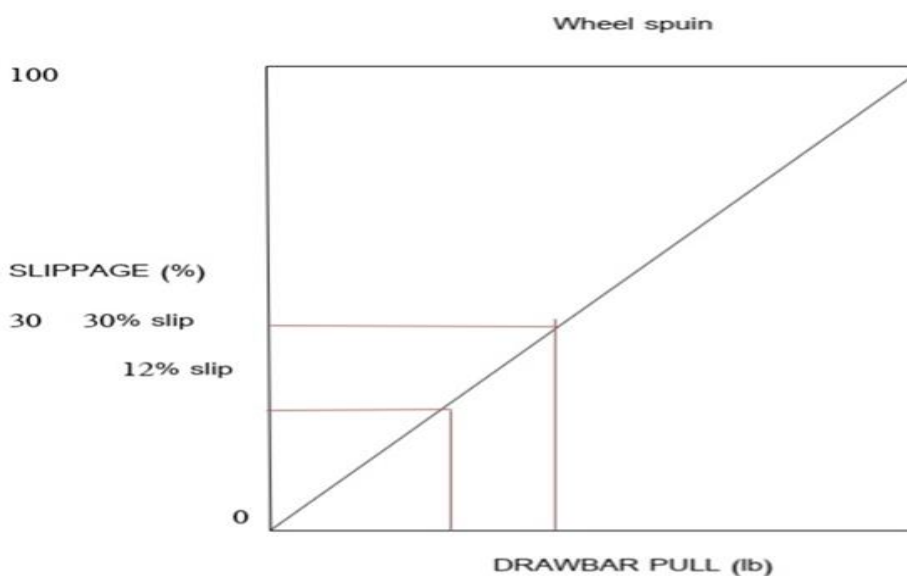


Figure 1. The relationship between the force of the pulling shaft and the slip

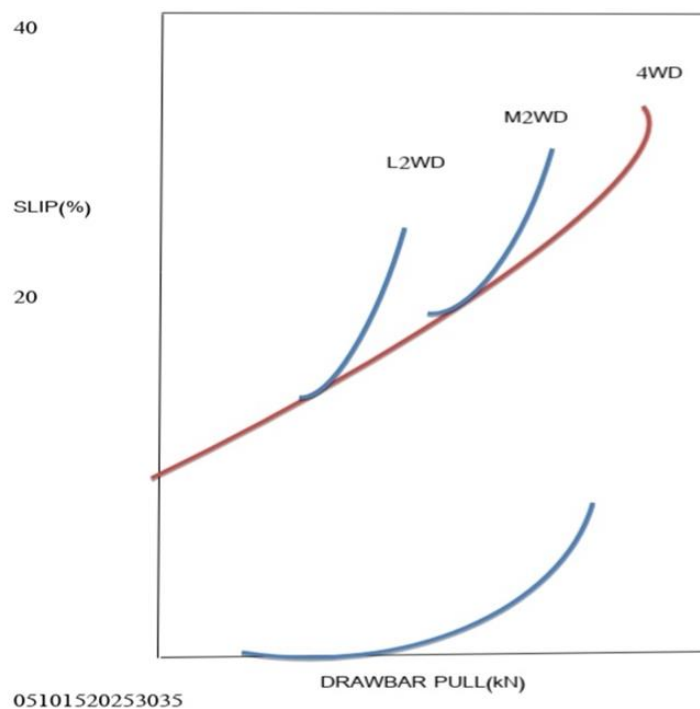


Figure 2. It represents the relationship between the slip and pulling shaft force

#### 4. Conclusion

The most important results in this study is obtained in this current paper show that the tractor puller of (4. D.W.) equal tires had a maximum towing capacity greater than the pulling capacity of the tractor puller (4.D.W.) wheeled small front wheel, and the latter had a maximum pulling capacity greater than the pulling capacity of the tractor puller (2.D.W.).

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