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TRACTOR MOUNTED PTO WATER PUMP

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Abstract: A power take-off (PTO) is a device that transfers an engine's mechanical power and uses it to power another device. These pumps are capable of high flows and are fast to deploy as they mount to the 3-point linkage on your tractor. Available in a range of sizes they are fantastic for farming, irrigation and emergency water transfer during floods and disaster times. Every farmer should have one of these PTO pumps. Instead, use your existing tractor's reliable diesel engine and PTO system to pump water on demand. Power take-off (PTO) is a device that transfers an engine's mechanical power to another piece of equipment.

***Index Terms* – Tractor PTO, Water Pump, Irrigation**

I. INTRODUCTION

Agriculture plays a vital role in Indian economy. Around 65% of population in the state is depending on agriculture. Although its contribution to GDP is now around one sixth, it provides 56% of Indian work force. The share of marginal and small farmer is around 81% and land operated is 44 % in 1960-61. As far as Indian scenario is concerned, more than 75 per cent farmers are belonging to small and marginal land carrying and cotton is alone which provide about 80 % employment to Indian workforce. So, any improvement in the productivity related task help to increase Indian farmer’s status and economy. The current backpack sprayer has lot of limitation and it required more energy to operate. Tractor Power Take-Off (PTO) pumps represents a crucial component in agricultural and industrial settings, offering versatile hydraulic power solutions directly from the tractor's engine. These pumps leverage the rotational power generated by the tractor's engine to drive hydraulic systems, enabling the operation of various implements and machinery. A tractor-mounted PTO (Power Take-Off) water pump is a device that uses the power generated by the tractor's engine via its PTO to pump water. PTOs are commonly found on tractors and are used to transfer power from the engine to other machinery or implements .The water pump itself is typically mounted on a frame or hitch attached to the tractor, and it's powered by connecting it to the PTO shaft of the tractor. These pumps are often used for irrigation purposes in agriculture, providing water to fields or crops. Tractor mounted PTO water pumps come in various sizes and capacities depending on the intended application and the size of the tractor. They are valued for their versatility and ability to provide water in remote areas where electrical power may not be available. These pumps can also be used for firefighting, construction, and other applications where a portable water supply is needed.

1.1 Types water of PTO pump

1. Belt operated PTO water pump

2. Gear operated PTO water pump

Figure No. 01, “Snap of irrigation”

II. LITERATURE REVIEW

1. **Roeber, James B W et.al [2017] :** A PTO data acquisition system capable of measuring and recording torque and rotational speed was developed. The system was based on a commercially available instrumented slip ring torque sensor and data acquisition system used as the PTO device under test (DUT). Two torque sensors were evaluated and one was deemed appropriate for the DUT based on preliminary evaluation and testing. With the mechanization of agricultural operations, agricultural machinery management has become an extensive research field. Sizing tractors and implements to provide the most efficient power transfer has become an ongoing process with advances in technology. Utilization of the rotational power transferred through gear trains from the tractor engine to the power take-off (PTO) shaft is one of the most efficient methods of power transfer to an implement.
2. **Roger M.; Luck et.al [2014]** concluded in his article on rear-mounted power take-off (PTO) systems in agricultural tractors would encompass various aspects including design, efficiency, performance, 11 safety, and technological advancements. Here's a structured approach to conducting such a review. Should more than one ratio between the engine speed and the PTO rotation speed be provided, any change of ratio shall be indicated. In addition, specific design measures shall be taken to ensure that unintentional changes of ratio, particularly in changing to a higher rotational speed, cannot occur.

III. PROBLEM DEFINITION

During irrigation in agriculture electricity and human risk are high to avoid these circumstances a tractor operated PTO pump is used. High ambient temperature can cause the water pump to work harder and generate more heat. In lack of lubrication can cause friction between moving parts, leading to overheating .Gear type PTO pump is not easily meshed.

IV. OBJECTIVES

1. It can run on tractor having PTO capacity of 540 & 750 rpm , It is also used for running sprinklers, rain gun ,drip irrigation etc.
2. Multi nozzles are used and hence large area of field can be spread at a faster rate.
3. It should have the capacity to pump water at the required flow rate and pressure to meet the specific needs of the application, whether its irrigation, filling tanks, or other tasks.
4. A water pump can drain water from a basement or shallow flooded areas, drain and fill a swimming pool or dam, or alternatively can also be utilized in the irrigation needed for agriculture.

V. DESIGN:

When it comes to the frame design procedure of a tractor-mounted PTO water pump, there are a few key considerations to keep in mind. The frame design plays a crucial role in ensuring the stability, durability, and ease of use of the pump.

Design Procedure of base or frame:

1. First we collect the material according to the requirement of the base or frame, this material is 1.5 heavy iron bar and nuts and bolts, belts, etc.
2. After that we measure the height are required to base and also check the alignment of the PTO shaft.
3. After completing the measurement to cut 1.5 heavy angles or bars to the required size with the help of the cutting machine.
4. After cutting, we welded all the bars and mounted the pedestal bearing on it, after that we put a shaft in the pedestal bearing and checked whether it is fitting in it properly or not.
5. After the shaft was fitted in the pedestal bearing, we removed that shaft and mounted the dead weight on it and then put it in the pedestal bearing and fitted it.

6. After that we mounted the driver pulley on the same shaft and made a base above for the centrifugal pump.
7. Performed drilling and boring operation on the driven pulley to fit the according of the shaft of the centrifugal pump and then mounted the driven pulley on the centrifugal pump.
8. After that we fitted the centrifugal pump on the top base with the help of nuts and bolts.
9. Then we mounted the driven pulley on the shaft of the centrifugal pump and matched it with the driver pulley and attached the belt to it.

Design of driven pulley:

Speed of the driven pulley is 100 rpm
Speed of Driver pulley = 300 rpm
Dia. of Driver pulley = 24 inch
To calculate Diameter of Driven pulley

$$\text{Driven pulley Diameter} = \frac{\text{Large pulley Dia. x Speed of large pulley}}{\text{Speed of Small pulley}}$$

$$= 24 \times 300 \div 1600$$

$$= 4.5 \text{ inch.}$$

VI METHODOLOGY

Construction:

When you connect your pump and tractor for the first time, or change to another tractor, check the length of the PTO drive shaft. If the shaft is too long, you will need to shorten it.

1. Hitch the pump cart to the tractor.
2. Tow the pump to the desired location. Do NOT exceed 10 MPH.
3. Position the pump on level ground as close as possible to the water source.
4. Lubricate the PTO drive shaft universal joints and telescoping tubes.
5. Check the gearbox oil level. Refill with 90W oil if necessary.
6. Install the PTO drive shaft as follows:
   a. If the PTO drive shaft needs to be shortened, shorten the shaft assembly by cutting equal amounts from both halves. Maintain the maximum possible overlap.
   b. Keep the PTO drive shaft as straight as possible to minimize universal joint wear and power loss.
   c. Do NOT operate the shaft at angles exceeding 15 degrees.
   d. For maximum efficiency, the input and output shafts should be parallel to each other. If necessary, the tractor can be maneuvered until the shafts line up.
7. Submerge the foot-valve or strainer to sit directly on the bed of the water source. A slide or float should be used to prevent mud, sand, or other abrasive materials from entering the pump.
8. Connect the discharge plumbing to the pump. Support any long lengths of pipe that will cause unnecessary stresses on the pipe flange.

Working:

The PTO is a separate component from the hydraulic pump. The PTO itself is a gearbox which, when engaged, draws off another source of mechanical energy to provide mechanical energy to the pump. It can increase or reduce the gearing, but a typical PTO to run a hydraulic pump will be at a 1:1 ratio. The actuation of the PTO clutch may be mechanical, pneumatic, or electronic. From there, it's just a matter of the tail shaft of the PTO being connected to the input shaft of the pump to rotate it, and how the pump itself works will depend on the type of pump it could be a gear pump, Generator pump, piston pump, rotary vane pump, etc., and depending on the application, it could be single or multi-stage, it may use pressure compensation or load sensing, etc.
A hydraulic pump drive works by using mechanical power to create fluid flow within a hydraulic system. The drive typically consists of a motor, such as an electric motor or an internal combustion engine, which is connected to the hydraulic pump. When the motor is activated, it provides mechanical power to the pump, causing it to pressurize the hydraulic fluid and create flow. This pressurized fluid can then be used to operate various hydraulic components, such as cylinders and motors, to perform mechanical work. There are different types of hydraulic pump drives, including gear pumps, vane pumps, and piston pumps, each with its own specific mechanism for converting mechanical power into hydraulic energy.

A) Following are the steps used for PTO water pump working.

1. Close the priming pump drain cock.
2. If the primer pump is mounted on the pressure side, open the isolating valve.

3. Prime the system using the primer pump. The system is primed when water comes out of the primer and pumping the handle becomes very difficult.
4. If the primer pump is mounted on the pressure side, close the isolating valve.
5. If fitted, switch the EPU (Engine Protection Unit) to the start mode.
6. Start the tractor and engage the PTO shaft.
7. Open the throttle to approximately 50% of the maximum PTO speed for the pump. The pump should slowly begin to build pressure and discharge water.
8. If the pump fails to discharge water, disengage the pump to the PTO drive shaft and stop the tractor. Re-prime the pump and try again. If the pump fails to discharge water after a second attempt, stop the tractor immediately and examine the pump for possible problems.
9. Check that the lever on the discharge priming valve raises, the pressure registers on the pressure gauge, and that the packing gland is dripping water.
10. Allow the pipeline to fill slowly. Do NOT run the tractor above half speed until water is seen emerging from the distribution system continuously for two minutes without intermittent air discharge.
11. When the system has filled, increase the tractor PTO speed until the full operating pressure is reached.

Figure No. 02, "Actual Snap of PTO water pump"

B) How to Stop the PTO Pump

1. Slowly decrease the PTO speed.
2. Disengage the power to the PTO drive shaft.
3. Stop the tractor.

Table No. 01: Comparison table of 5HP electrical motor with 4X4 PTO pump.

SN	Parameters	Electric Motor Method (5 HP)	PTO Pump Method
1	Driving Medium	Electricity	Tractor PTO
2	Distance Travelled	4000 Feet	4000 feet
3	No. of Nozzles	10-12	22-24
4	Duration	8 hrs. (As it is provided by MSEB)	14 hrs.(2 Shifts)
5	Area Covered	0.5 acre per day	2 acre per day
6	Fuel Consumption	As per MSEB Unit Rates	Max. 1.5 lit /hr.
7	Consumption Cost	@1800 Rs. Per acre	@1100 Rs. Per acre

8	Human Efforts	More human efforts as well as mental fatigue	Less human efforts & no mental fatigue.
9	Initial Cost	34,000/-	39,000/-
10	Overall Agriculture Income	36,000 Rs. Per acre (6X6000)	60,000 Rs. Per acre (10X6000)
11	Agriculture Maintenance cost	2800 per acre	No Maintenance Cost
12	Overall Income difference	Rs. 24,000/- per acre	

1. Above parameters doesn't include initial seed, fertilizer, spray costing.
2. The common parameters such as labour cost for agriculture work, pipe shifting etc. is not included.
3. Electricity consumption rates is subject to subsidy provide by MSEB.
4. We have assumed 8 hrs. of electricity with no illegal connections, practically there are lots of illegal connections on a single DP. Due to this there may be a chance of DP breakage, if happened it will take around 1 week to repair, which leads to waste crucial time of irrigation.

VII COST COMPARISON

Before estimating cost comparison, let us make some assumption.
1. Consider 20 acre of land for irrigation.
2. Labour charge for shift changing remains same.
3. Cost difference is for Bengal gram.
4. Idle Travelling distance of water is about 3000 feet.
5. Bengal gram needs water in between 30-45 days for maximum output.
6. Final output cost will not include cost like seed, spray, fertilizer and operation cost. It will remain same in both cases.

Conventional Method (By using Electric Motor)

8 hrs. of Electricity is provided by MSEB.
Considering all legal connection on single electric DP, which is quite possible.
So a 5HP motor will run a 10-12 nozzle which will cover 0.5 acre of land per shift (Per day).
No. of days to cover a 20 acre of land = 40 days
So only 10 acre of land is covered under irrigation.
So output of Bengal gram is

Table No. 02: Cost estimation agriculture land with partially irrigation & without irrigation

SN	Parameter	With Irrigation	Without Irrigation
1	Land Covered	10 acre	10 acre
2	No of Bengal gram bags per acre	10	06
3	Today's price per bag	Rs. 5500 per quintal	
4	Net output	5,55,000/-	3,33,000/-
5	**Total Output**	**Rs. 8,88,000/-**	
6	**Electric Consumption cost**	**18,000**	**----**
7	Gypsum Fertilizer Cost	24,000	----
8	Labor Cost	4000	----
9	**Total Fertilizer cost**	**28,000**	**----**

So final output cost will be
= Total Output – (Electric Consumption cost + Total Fertilizer cost)
= 8, 88,000 – (18,000 + 28,000)
= 8, 42,000/- will be earn by 20 acre of land. (Approx.)
PTO Water Pump Method (By using 18 HP Tractor)

7 hrs. for a single shift is sufficient as pressure is constant.
So it will run a 22-24 nozzle which will cover 1 acre of land per shift.
We can also run 2 shifts in a single day.
So total acre of land covered in a single day= 2 acre
No. of days to cover a 20 acre of land = 10 days

So considering some errors it will hardly take 12 days to cover a 20 acre of land with no mental fatigue.
So output of Bengal gram is

Table No. 03: Cost estimation of agriculture land with irrigation.

SN	Parameter	With Irrigation
1	Land Covered	20 acre
2	No of Bengal gram bags per acre	10
3	Today's price per bag	Rs. 5500 per quintal
4	**Total Output**	**Rs. 11,00,000**
5	**Diesel Consumption cost**	**22,000**

So final output cost will be
= Total Output – Diesel Consumption cost
= 11, 00,000 – 22,000
= 10, 78,000/- will be earn by 20 acre of land. (Approx.)

So the cost output difference between two methods is Rs. 2, 36,000 approx. for 20 acre of land.
Per acre output difference will be Rs. 11,800/-

VIII Result and Discussion

1. Pumping Capacity The pumping capacity of the tractor-operated PTO water pump was evaluated under varying operating conditions. The results indicate that the pump achieved a maximum flow rate when operated at 540 revolutions per minute (RPM) PTO shaft speed. The flow rate decreased linearly with decreasing PTO shaft speed, reaching a minimum at 400 RPM.

2. Pressure Performance Pressure performance tests were conducted to evaluate the pump's ability to generate sufficient pressure for irrigation and other water distribution applications. The pump maintained a consistent pressure across the entire operating range, indicating reliable performance under different load conditions.

3. Fuel Consumption Fuel consumption measurements were taken to assess the efficiency of the tractor-operated PTO water pump. The pump consumed an average of 1.5 liters of diesel fuel per hour during continuous operation at maximum load. Fuel consumption varied slightly with changes in PTO shaft speed but remained within acceptable ranges.

4. Fuel Efficiency The observed fuel consumption rates indicate that the tractor-operated PTO water pump offers excellent fuel efficiency, consuming relatively low amounts of diesel fuel per hour of operation. This is advantageous for farmers seeking to minimize operational costs and reduce environmental impact.

IX CONCLUSION & FUTURE SCOPE

Conclusion: It is concluded that by using PTO water pump, a farmer can save valuable time during irrigation; also he can reduce his mental fatigue of electricity problems. Now coming towards economic growth, so by using PTO water pump, he can earn more profit as he is not dependable on any other source for irrigation. It is easily movable from one place to another place, so less human efforts is required for shifting.

Future scope: In the above model we had shown a single water pump is mounted on a single shaft, but we can also use two water pump on a single shaft on a single PTO of a tractor, But at the same time we required a two C section driver pulley that need to be balanced on a single shaft. Only the condition is that both water pump should have a same RPM rating which we could match with the tractor RPM. By using this we can save more time as well as covered a maximum area on a given day with less human efforts, though this lead to slightly increase in diesel consumption, but it is economical.

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