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Research Article

PERFORMANCE AND EVALUATION OF SELF-PROPELLED MULTI-PURPOSE POWER UNIT

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Abstract- A self-propelled multipurpose power unit was developed in the laboratory of Farm Machinery and Power Engineering, JNKVV, Jabalpur for small farmers. The prime mower is powered by 5hp diesel engine. V-belt drive is provided for transmission of power from the engine to the traction wheels. An adjustable accelerator wire is connected to the governor for adjusting the engine speed according to the requirement. The worm gear reduction unit is located at the axle having speed reduction ratio of 20:1. A telescopic type frame is provided to support the end of adjustable output shaft with the help of bearing. The handle is modified so as to vary the height from 1.0 to 1.3 m from the ground. The addition lug cage wheel is connected to transport wheel to increase the traction. The developed machine can be used for field preparation, sowing, intercultural operation, water pumping, grass cutting & harvesting and winnowing & threshing in small agricultural fields for winnowing, mower and pumping operations field capacity of the machine was 6q/hr, 0.08ha/hr and 12 l/sec respectively, efficiency of the machine was 90%, 91 % and 93% respectively and fuel consumption 0.6l/hr, 1.47l/hr and 0.8 l/hr respectively.

Keywords- Power unit, Winnowing, Mower, Centrifugal pump

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Introduction

The presence of a large number of marginal and small land holdings farmers (80%) [4] in India approves the importance of power tiller as the most suitable farm power source for field operations, in view of its compact size, low cost and versatility. Power tiller is a walking type small tractor used for agricultural operations in most part of the world. It is mainly used for field preparation sowing and other operations like Inter-culture, mower & harvesting in small agricultural fields. This power unit has gained popularity among farmers due to its rugged and reliable operation. The small holding farmers faced many problems including poor access to modern inputs and credit, poor infrastructure, inadequate access to markets, land and environmental degradation, and inadequate research and extension services. A study about the use of Power Tiller among small farms indicated that there was 70 % increase [11] in yield. The suitability of these small prime movers can further be increased to the greater extent, if it turns out to be suitable for some left out field operations like water lifting, winnowing, cleaning & grading operation then this unit may become the complete self-propelled multipurpose unit. In general, the available power units are developed for a specific kind of work so small and marginal farmers may not be able to purchase different machines for different operations. The solution for such problem can be provided by the development of small multipurpose power unit that may be worthwhile endeavor in this context. This unit must be able to perform the most field operations from tillage to post harvest operations. The availability of multipurpose power unit with the marginal and small farmers may avoid the year round maintenance of bullocks and also the high investment in tractors. This machine must be simple in design and can be fabricated & repaired by village artisans. The structure of power unit must be so simple so it provided better maneuverability and better floatation for kharif crops.

Development of different linkages for easy attachment of power unit with different machines like water lifting pump, mower, winnower etc.

Material and Methods

The present self- propelled power unit was a power weeder for intercultural operation and later on it was further developed as multipurpose Power unit to perform secondary tillage and sowing operation. The machine is sequentially modified to full fill the need of small and medium farmers for different field operations. A new modified unit was initiated to overcome problems of existing machines and for development of output shaft which can accommodate the input shaft of different machines with the help of suitable coupling and linkages for operation of rotary unit, mower, grader etc. This work of modification and fabrication was conducted in the workshop of department of farm machinery and power engineering, college of agriculture engineering, JNKVV, Jabalpur. The materials for fabrication of various components were selected considering requirements as given in [Table-1]. The small holding farmers faced many problems including poor access to modern inputs and credit, poor infrastructure, inadequate access to markets, land and environmental degradation, and inadequate research and extension services. A study about the use of Power Tiller among small farms indicated that there was 70 % increase in yield [8,11].

Table-1 *General specification of multipurpose power unit*

1.	Over all dimensions			
	a)	Length (mm)	:	1500
	b)	Width (mm)	:	820
	c)	Height (mm)	:	1000
	d)	Weight (kg)	:	106

2. Dimension of frame : made of MS angle 50×50×5mm
3. Ground clearance(mm) : 450
4. Engine : 5 hp air cooled diesel engine lambordani Greaves
5. Wheel : 640 mm dia. angle iron transport wheel
6. Output shaft : Mild steel Length – 300 mm Dia. - 20 mm

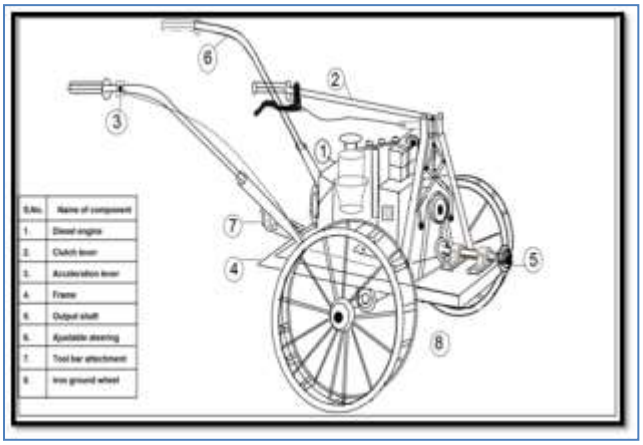

Fig-1 Schematic diagram of multipurpose power unit

Plate-1 Self- propelled multipurpose power unit

Operations of different agricultural machines powered by developed multipurpose power unit:

After completion of the fabrication, the multipurpose power unit was operated in the lab to run-in and ensures trouble free movement of different moving components, evaluated the ease of operation and adjustment of the different components and observe the functional performance of different components. Lubrication of different components were done and the machine was operated idle for some time: Clutch linkage system was engaged and disengaged several times and made necessary adjustment on power transmission system. The machine was operated in the lab. Different parts, nuts, bolts, welding *etc*., were checked during operation for about four hours of continuously operation on the field to see its smooth and un-interrupted operation. The power unit system was observed to work properly. The power was engaged and disengaged several times with the help of clutch handle and it was found that it worked satisfactorily.

After preliminary checking, the tests were conducted at the farm of College of Agriculture Engineering, JNKVV, Jabalpur. The objective was to determine field capacity, efficiency, fuel consumption and cost requirement, ease of attachment, ease of operation to operate machinery with multipurpose power unit.

Operation of winnower

The winnower received the power from output shaft of the self- propelled unit by mounting the pulley on output shaft of prime mover and aligned at 180^0. The size of pulley was (750mm) which was connected to single grooved pulley on winnower speed reduction ratio 1200 to 250 rpm. The rpm of output shaft 1200 and 750mm diameter of pulley through rpm was 250 and 300mm diameter pulley of winnower.

Test procedure

The test involves taking a pair of samples which were at the grain outlet and the bhusa and non-grain outlet. The weights of grain and other material in each sample were recorded. The procedure was repeated for each throughput. The expressions used for calculation is as follows:

Cleaning efficiency

$$E_c=\frac{W_G}{W_{TG}} \times 100 \text{.....[Eq-2.1]}$$

Where,

E_C = Percent cleaning efficiency (%)

W_G = Weight of clean-grain obtained from the sample (kg)

W_{TG} = Total Weight of sample (kg)

Grain Loss percent

$$G_L=\frac{W_{GN}}{W_G+W_{GN}} \times 100 \text{.....[Eq-2.2]}$$

Where,

G_L = Percent grain loss (%)

W_G = Weight of grain material in clean-grain sample (kg)

W_{GN} = Weight of grain material in non-grain sample (kg)

Plate-2 Alignment of output shaft of prime mover and input shaft of winnower

Fuel consumption

The tank was filled to full capacity before and after the test. Amount of refueling after the fuel consumption for the test was recorded. While filling up the tank care was taken to keep the same horizontal and not to leave empty space in the tank. The fuel consumption was measured by volume.

Effective field capacity

The EFC is the actual rate of coverage by the machine, based upon the total time required. The machine was operated with a fixed rotational speed of 250 rpm for 1 hr of operation with continuous feed of grain in hopper work for calculating the average output per hour.

Performance index

The term mechanical efficiency is used to describe the efficiency of the machine to operate. It is the ratio of effective field capacity to the theoretical field capacity expressed in percentage.

$$\text{Performance index}(\%) = \frac{\text{Effective field capacity}}{\text{Theoritical field capacity}} \times 100$$

Operation of a mower

A due attention was provided on the fabrication of mower. Cutting unit, Power unit, Power transmission unit, Handle and Transporting unit.Shown in [Plate-1,2]

Plate-3 Attachments with mower

Plate-4 Grass cutting by mower operated by power unit

Cutting unit: Cutting unit consists of ledger plate attached cutter bar. The motion of cutter bar was reciprocating.

Power unit: Power to the machine is provided with the help of power generated from a diesel engine.

Power transmission unit: Transmission of power for the mower was carried out by the V-belt drive. The details of different component are shown in flow diagram [Fig-2].

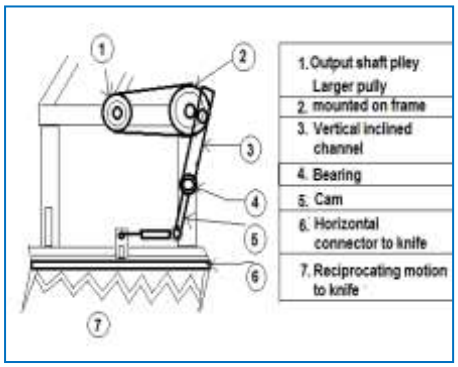

Fig-2 Power transmission in mower

Transporting unit: Transport unit is composed of ground wheels and axle.

Test procedure: The size of plot 10 x 20m^{2}were taken to test the mower for cutting grass.

Observation: Time to complete test run and time was recorded for turning the power unit. Time losses for other reasons like repairing and adjustment of components, filling of diesel was also recorded. Mower was tested and its performance was evaluated by determine following parameter:

A. Cutting efficiency was calculated for power mower. The mower 1 m^2 area of grass cut was selected randomly. Then number of stems present was counting before cutting and then, the number of uncut stems was counted.

$$\textbf{Cutting efficiency} = \frac{(\text{total stems} - \text{uncut stems})}{(\text{total stems})} \times 100 \quad \text{.....[Eq-2.3]}$$

B. Theoretical field capacity: The theoretical field capacity is the area covered by the implement when it is operating at optimum speed over its full width of cut in an hour.

$$\textbf{Theoretical field capacity} = \frac{\text{Speed}\left(\frac{\text{km}}{\text{h}}\right) \times \text{Cutting width (m)}}{10} \quad \text{...[Eq-2.4]}$$

C. Effective field capacity: The Effective field capacity is the ratio of the actual area covered by the implement per unit time. It included the time losses (turning losses). It is measured by operating the mower continuously on the field and there after the area covered and time required was noted thus the effective field capacity was measured in hectare per hour.

D. Field efficiency: The field efficiency is the ratio of effective field capacity to the theoretical field capacity. It is expressed in percentage**.**

$$\textbf{Field efficiency} = \frac{\text{effective field capacity}}{\text{theoritical field capacity}} \times 100 \quad \text{.....[Eq-2.5]}$$

E. Fuel consumption

Simple method of filling and refilling of fuel tank to fuel capacity before and after the test is adopted. Amount of refilling the fuel after the test is fuel consumption for the test

F. Cost of operation

Cost of operation was found out with following formula to find out the feasibility of developed machine.

Cost of operation per ha. = Time taken to cover 1ha × cost per hr.

Operation of water pump

The machine is operated by starting the prime mover which drives output rotating power transmission to water pump input shaft. We have to operate of water pump through by 5hp engine. This multipurpose power unit is most suitable for easy operated, easy transportation, and reduced purchasing cost for other operating unit to drive the water pump.

This recommended data take from the manufacture company.

5HP PUMP-SET

(Product code: N11.1005)

Pump Specification: (Pump type – Centrifugal)

Pump model	Pipe size (mm)		Rated speed (rpm)	IMP dia. (mm)
	Suc.	Del.		
VA2	80	80	2000	155

Plate-5 Attachments of water pump with power unit

Plate-6 Operation of water pump

Test perimeters

First of all seating the pump set in foundation. Then fitted suction and deliver pipe in coupling and tight all nut and bolts. Arrangement of power unit output shaft to coupled input shaft through by universal joint and attached belt properly. The 1800 rpm set through by rpm lever. Before starting of power engine to fill water in suction pipe:

Observations record:

1) Actual capacity (lit/s);
2) Fuel consumption (l/hr); and
3) Pump efficiency.

$$\text{Pump efficiency (\%)} = \frac{\text{WHP}}{\text{BHP}} \times 100 \quad \text{.....[Eq-2.6]}$$

$$\text{WHP} = \frac{\text{Discharge}\left(\frac{\text{l}}{\text{sec}}\right) \times \text{Head (m)} \times \text{Specific Gravity}}{75} \text{.....[Eq-2.7]}$$

4) Cost of operation (Rs/hr)

Cost of operation

Fixed costs

Depreciation

This cost reflects the reduction in if a machine with use (wear) and time (obsolescence). While actual depreciation would depend on the sale price of the machine after it use, on the basis of different computation method depreciation can be estimated by straight-line method as given below

$$D = \frac{P-S}{L \times H} \text{.....[Eq-2.8]}$$

Where,

D = average depreciation cost (Rs./year);
P = purchase price of the machine (Rs.);
S = residual value of the machine (Rs.);
L = useful life of the machine (years); and
H = working hours per year.

The depreciation cost per hour can be estimated by dividing 'D' by the number of hours the machine is expected to be utilized in a year. Residual value of the machine may be taken as 10 percent of the purchase price.

Interest

An annual change of interest was calculated by taking 10 percent of purchase price of the machine. Interest was calculated by using the formula given below.

$$I = \frac{P+S}{2} \times \frac{i}{H} \text{.....[Eq-2.9]}$$

Where,

I = interest on capital Rs./h;
P = purchase price of the machine;
S = residual value of the machine;
I = interest rate in fraction; and
H = working hours per year, hours.

Insurance, taxes and shelter

Insurance and taxes were estimated taking as 2 percent of average purchase price of machine.

Variable Cost

Fuel

The actual fuel consumption was observed and estimation was done accordingly.

Oil

The cost of lubrications estimation as 10 percent of fuel cost.

Repair and maintenance

The cost repair and maintenance were assumed to be 10 % of purchase price.

Wages and Labour charges

The cost of labour was estimated taking the prevailing rate of Rs. 25/h.

Results and Discussion

The study is related to modification of existing self-propelled multipurpose power unit. The performance evaluation of developed output rotary shaft to operate various machinery like winnower, mower and water pumping under laboratory and actual field condition. It also contains the cost economics. The utility of the same machine may vary with the land holding. The machine can be used for 1000 to 1500 hour per year. A larger farmer can handle larger area. This small walking type tractor costing low may equally usable to the large farmers, as they also involve different practices in small land in different location in the village.

Performance evaluation of developed rotating output shaft in power unit to operate machinery

Operation of winnower

The seed cleaner winnowers consist of a hopper below which oscillating trays are provided for cleaning. A separate blower is used to drive light and fine dust particles. The sieving trays are arranged one over the other for separating material having different sizes. The unit is operated through by developed power unit and electric motor was transmission power by V- belt pulleys. Then evaluate the performance of power unit suitable for operation use in inter culture machinery. Shown in [Table-3] The main object of developed power unit is very suitable for small land holding farmers because the power unit easy transportable, easy attachment by suitable coupling and linkages for operation, less effort and reduce cost of other power operating unit. It saves time of farmer when no electric power source in the field as this unit does not require any electric source to operate.

[Table-3.1] show that the on an average the actual capacity of winnower was 600 kg/hr when operated by power unit and the output capacity of winnower is same when electric motor (5hp) was used. There true it can be said that this machine can successfully be used for winnowing of the grain.

Table-2 *Operation of winnower through developed power unit*

S.No.	Particulars	
	Power source	**Diesel engine**
		5hp, air cooled
		Rpm 1200 -1800
	Location	JNKVV farm field no.2
	Power transmission	V-Belt driven
	Crop	Wheat, GW - 273
	Winnower machine	Overall dimension
	Length (mm)	1500
	Width (mm)	950
	Height (mm)	1250
	Rated rpm	250
	Performance	**Operate by power unit**
1.	Cleaning efficiency (%)	90%
2.	Grain loss (%)	9%
3.	Actual Capacity (kg/hr)	600
4.	Performance index (%)	96
5.	Fuel consumption (l/hr)	0.6
6.	Cost of operation (Rs/hr)	54

Operation of mower:

The field test was conducted for the plot of 20x10m^2 area as per the recommendations by the RNAM Test Codes (1983) to confirm the adaptability of grass cutter to the practical conditions.

Measurement of average height of grass

The average height of grass was found to be 100mm. the cutter was adjusted for cutting of grass for 30mm height. After cutting it was found that actual height of cut did not vary significantly as well the number of uncut grass was also not significant. The details of observations are as below: [Table-3].

Speed of operation

The torque available at the cutting blade was sufficient therefore it coped up with the speed of operator up to 2kmph the effect of grass intensity came in to effect but the difference was not clear as most of the operator worked almost all the time with less than 2kmph speed.

Field capacity

The theoretical field capacity was found to be 0.105ha/hr. as the field is not thoroughly tilled and due to presence of clods the actual field capacity was observed to be 0.08ha/hr (0.64ha/day). While comparing it with bullock pair it is almost double to the pair of bullocks.

Table-3 *Observation recorded for the operation of mower*

S.No.	Particulars	
	(A)Test condition	
	Condition of the field	grass leveled
	Location	Maharajpur farm, CAE JNKVV
2.	Source of power	5hp diesel engine
3.	Attachment	Iron angle frame
4.	Power transmit	V-belt pulley
5.	Speed of operation (km/h)	2
6.	Field size (m^2)	20 × 10
	mower	Overall dimension
1.	Width of cutter bar (mm)	420
	(c)Performance	**Operate by power unit**
	Actual width of cut (m)	0.40
	Avg. height of cut (cm)	3
	Theoretical field capacity (ha/hr)	0.105
	Actual field capacity (ha/hr)	0.08
5.	Uncut stems	7
6.	Cutting efficiency (%)	91
7.	Fuel consumption lit/hr	1.47
8.	Cost of cutting per hr.	Rs.83
9.	Cost of cutting per ha.	799

Field efficiency

It was found that, for an average speed of 2km/hr, the field efficiency for the test plot was 76 per cent.

Operation of centrifugal pump by developed power unit

A comparison was made for the operation of water pump (centrifugal), when operated by developed power unit and electric motor both of equal rated power (5hp) to the surprise if was found that working of pump by electric motor was at par when it was powered by powered shaft (1200-1800 rpm) of the developed unit and linkage was made through universal joint. The great advantage of using this machine is that it is portable and can be used anytime and anywhere and wherever required. The details of observations are as below: [Table-4].

Table-4 *Operation recorded for the operation of centrifugal pump*

S.No.	Particulars		
	(A) Test condition		
	Power source of power unit		
1.	Diesel engine	5hp, air cooled	
2.	rpm	1200 -1800	
3.	Location	O.G.W.U Laboratory, CAE, Jabalpur	
4.	Attachment & Power transmit	Universal joint	
	(b) Centrifugal pump	specification	
1.	Pump model	VA2	
2.	Pipe size (mm)	Suction	Delivery
		7.5	60
3.	Rated rpm	1800	
	(c) Performance	**Operate by power unit**	
	Actual discharge capacity (l/s)	12	
	Fuel consumption (l/hr)	0.8	
	Pump efficiency	93%	
	Cost of operation (Rs/hr)	44	

Conclusion

On the basis of above it can be concluded that the 5hp self propelled power unit developed under the project is a low cost power unit which can efficiently be used for various stationary work and such power unit is found to be most useful prime mover for small and medium farmers.

Application of research: The project was undertaken to develop a self-propelled multipurpose power unit suitable for small farmers. This is a versatile power unit which can be used for field preparation, sowing and inter-culture operation on front output shaft operations like Inter culture operation, water pumping, grass cutting & harvesting and winnowing/threshing in small agricultural fields. The most important component of the project is to enhance the application of this power unit for different mobile and stationary work.

Research Category: Power unit

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