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Design Development and Evaluation of Mini Tractor Operated Trencher

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ABSTRACT

The mechanization of Indian farms is imperative to enhance input use efficiency, reduce human drudgery, cost of production and to address issues of labour scarcity and timeliness of farm operations. Digging of trenches for laying pvc pipes in sprinkler and drip irrigation system has become drudgery by human labour, more expensive and time consuming. Commercially available machines are high capacity, more cost of operation and not affordable to the small and marginal farmers. To overcome this problems, a small tractor operated trencher was designed and developed. The developed trencher was evaluated in the field at a 1.5,2,2.5 km/h forward speeds. During field trails it was observed increase in forward speed from 1.5 to 2.5 km/h resulted in decrease in depth of trench, fuel consumption and capacity of auger. Increased in forward speed resulted in increase in length of trench.

Key words: *Small tractor, Trencher, Auger and digging blade*

Introduction

Timeliness is the key to success in agriculture. The only alternative to labour seems to be mechanized from every corner of operations involved. Based on operations to be performed, variety of farm machines are designed and developed. Equipments for tillage, sowing, irrigation, plant protection harvesting and threshing have widely been accepted. Farmers with small holdings utilize selected improved farm equipment through custom hiring to increase productivity and reduce cost of production. The small plot size might have been an impediment for use of large tractors but not for adoption of small tractors, power tillers and improved machinery. Hence, there is a need to develop machines which are suitable for small tractors which can be useful to small and marginal farmers. Therefore, to reduce cost of operation and to suit small tractor an endeavor is made to develop a small tractor operated trencher.

Materials and Methods

The design and development of mini tractor operated trencher (22 HP) was carried out at AICRP on FIM Scheme, Hyderabad in the year 2019. The power is taken from the PTO of the mini tractor for operation of trencher (Fig. 1). The trenching mechanism consists of a frame, digging chain with blades, drive shaft and driven shaft, chain and sprockets, and soil delivery auger (Table 1). To transfer the

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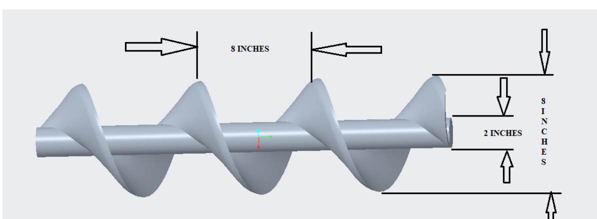
power from Mini tractor PTO to digging boom assembly a gear box was arranged and from the gearbox to the digging boom assembly two 30 mm diameter shafts were arranged, where one shaft is for drive shaft and another is for driven shaft through and sprocket mechanism. On the drive shaft 11 teeth sprocket and on the driven shaft 18 teeth sprocket is arranged with two pedestrian bearings. On the other end of the Mini tractor PTO gear box flange soil delivery auger was fixed to throw the soil in to sideways. The digging boom assembly consists of digging chain with blades, crumber arm and sprockets. A dimension of each digging curved blade was 190 x 65 x 10 mm. The auger with a diameter of 25 mm and a length of 38 mm of each were placed on both sides of the gear box. A tensioner sprocket of 12.8 mm diameter is placed on the center of auger in order to create tightening in digging assembly. A supporting bush of 75 mm length and 50 mm diameter is fixed to the supporting frame of trencher to avoid slagging of digging assembly.

Capacity of auger

The volume of soil thrown by the auger was calculated by using the following formula. (Source: CEMA)



$$\frac{C}{rpm} = \frac{0.7854\,(D_s^2 - D_p^2)PK\ 60}{1728}$$

Where,

C = Capacity (Cubic feet per hour)
rpm = Speed (revolution per minute)
D_s = Diameter of screw (inches)
D_p = Diameter of pipe (inches)
K = Trough loading (percent)
P = Pitch screw (inches)

The diameter of screw, diameter of pipe and pitch of screw was 8 inch, 2 inch and 8 inch respectively. Trough loading percent was assumed as 70 per cent.

$$\frac{C}{105} = \frac{0.7854\,(8^2 - 2^2)8 * .70 * 60}{1728}$$

C = 9.163 * 105

C = 962.115 ft^3/h

Fig. 1. Mini tractor operated trencher digger mechanism

Fig. 2. Mini tractor operated prototype trencher

C = 27.24 m^3/h

Results and Discussion

Field trials were conducted at AICRP on FIM, Rajendranagar and College Farm, PJTASU, Rajendranagar (Fig.3). The performance of the machine parameters like digging depth, width of trench, Speed of operation, digging blade speed, field capacity, fuel consumption were evaluated and presented (Table 2).

The performance of trencher is statistically

Fig. 3. Field operation of prototype trencher

Table 1. Specifications of prototype trencher

S.No.	Component	Details
1.	Mini Tractor Model	VST Mitsubishi Shakti MT 224D
2.	Type	3 cylinder 4-stroke water cooled diesel engine
3.	Horse power (hp)	22
4.	Overall Dimensions of the trencher (mm)	1830 x 930 x 1380
5.	Overall Dimensions of digging boom assembly (mm)	1550 x 170 x 850
6.	Number of blades on digging chain	21
7.	Dimensions of each blade (mm)	190 x 65 x 10
8.	Diameter of the soil delivery auger (mm)	646
9.	Pitch distance (mm)	130
10.	Trencher weight (kg)	195

Table 2. Field performance data

S. No.	Parameter	Observations		
		Treatment 1 (Speed 1.5 kmph)	Treatment 2 (Speed 2.0 kmph)	Treatment 3 (Speed 2.5 kmph)
1	Type of soil	Light soil		
2	Forward speed (kmph)	1.5	2.0	2.5
4	Digging blade speed (rpm)	105	105	105
5	Width of trench (mm)	165		
6	Depth of trench (mm)	444.6	418.6	405.7
7	Capacity of the auger (m^3/h)	27.19	22.06	19.40
8	Fuel consumption (l/h)	2.86	2.5	2.47
9	Moisture content (%)	15	15	15
10	Length covered per hour (m)	27.83	32.56	36
11	Number of labor required	2		

analysed by ANOVA using design expert software. The effect of forward speed significantly influenced depth of trench at 1 % level of significance. It was observed that, increase in forward speed from 1.5 to 2.5 km/h resulted in decreased the depth of trench (Fig. 4). The results are concurrence with Moitzi *et al.*

The statistical analysis infers that the effect of forward speed significantly influenced fuel consumption at 1 % level of significance (Table 4). It is observed that, increase in forward speed decreased fuel consumption (Fig. 5). The results are concurrence with Moitzi *et al.* (2006).

The statistical analysis infers that, the effect of forward speed significantly influenced length of trench at 1 % level of significance (Table 5). It is observed

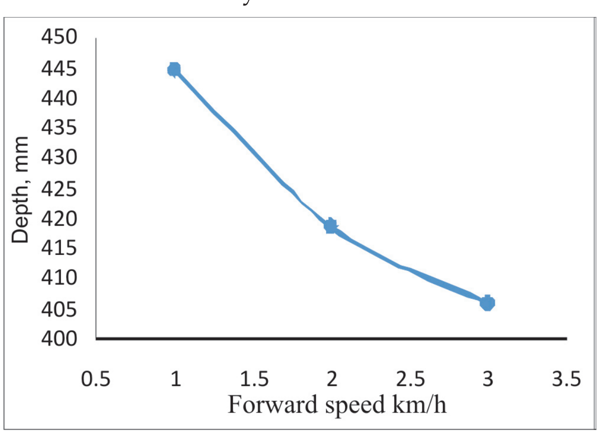


Fig. 4. Effect of forward speed on depth of trench at different speeds

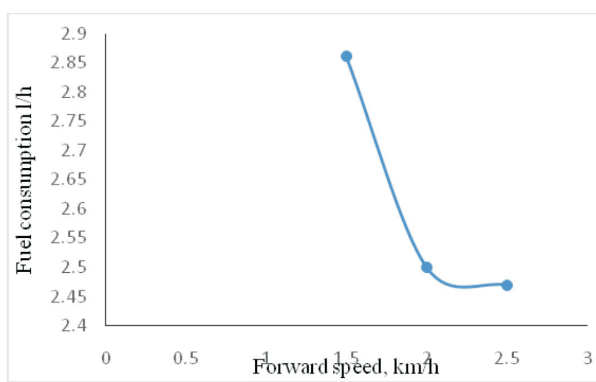


Fig. 5. Effect of forward speed on fuel consumption at different speeds

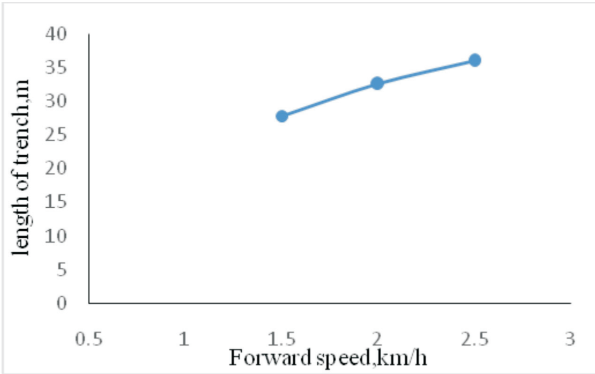


Fig. 6. Effect of forward speed on length of trench at different speeds

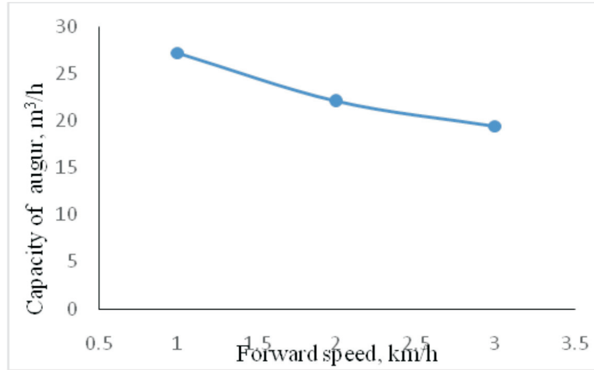


Fig. 7. Effect of forward speed on capacity of auger at different speeds

Table 3. Effect of forward speed on depth of trench

Std. Dev.	3.574602	R-Squared	0.991281
Mean	410.2222	Adj R-Squared	0.986921
C.V. %	0.871382	Pred R-Squared	0.95586
Press	258.75	Adeq Precision	23.52043

Table 4. Effect of forward speed on fuel consumption

Std. Dev.	0.07303	R-Squared	0.978124
Mean	2.513333	Adj R-Squared	0.967186
C.V. %	2.90569	Pred R-Squared	0.889253
PRESS	0.108	Adeq Precision	17.14643

Table 5. Effect of forward speed on length of trench

Std. Dev.	0.896289	R-Squared	0.961773
Mean	32.43333	Adj R-Squared	0.94266
C.V. %	2.76348	Pred R-Squared	0.806478
PRESS	16.2675	Adeq Precision	12.17466

Table 6. Effect of forward speed on capacity of auger output

Std. Dev.	0.729916	R-Squared	0.987237
Mean	21.18889	Adj R-Squared	0.980855
C.V. %	3.444807	Pred R-Squared	0.935386
PRESS	10.78875	Adeq Precision	19.6674

that increase in forward speed increased length of trench (Fig. 6).

The statistical analysis infers that,the effect of forward speed significantly influenced capacity of auger at 1 % level of significance (Table 6). It is observed that increase in forward speed increased decreased the capacity of auger (Fig. 7).

Conclusion

The developed trencher can save the cost of operation by 40 – 50% over manual method and reduces the time of operation and labour by 92.30% and 74% over manual method.

References

Hirpa, G. L. and Delesa, K. 2018. Design and modelling of a light duty trencher for local conditions. *Advances in Science and Technology Research Journal*. 12(1) : 303–311.

Khurmi, R.S. and Gupta, J.K. 2005. *Textbook of Machine Design*, 14th edition, Eurasia Publishing House (PVT.) *Ltd*, Ram Nagar, New Delhi, India.

Moitzi, G., Weingartmann, H. and Boxberger, J. 2006. Effects of tillage systems and wheel slip on fuel consumption.*Energy Efficiency and Agricultural Engineering – International Scientific Conference 7*. **9**: 01-07.

Patel, B.P. and Prajapati, J. M. 2012. Evaluation of resistive force using principle of soil mechanics for mini hydraulic backhoe excavator. *International Journal of Machine Learning and Computing*. 2 (4) : 386-391.

Reece, R. 1964. The fundamental equation of Earthmoving machines. *Proceeding of Institution of Mechanical Engineers*. 179 : 16–22.