Design and Experiment of 1LFQ-325 Pneumatic Reversible Plough

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Abstract A pneumatic reversible plough is developed, which complements to the tractor of 25.7 - 36.8 kW. The plough adopts the cylinder as reversing mechanism between the right and left plough bodies, and the cylinder can substitute the mechanical reversing mechanism. The pneumatic turnover allows the plough to be operated easily and turned over flexibly. Field experiment results show that indicators of plough performance meet the requirements of the relevant national standards.

Key words Pneumatic, Reversible plough, Design, Experiment

Presently, there are two types of reversing mechanism for the 180° reversible plough: one is the mechanical type, for which the driving force is either the lifting force applied by the hanging mechanism during lifting or the weight of plough itself, and the other is hydraulic type, which works relying on the hydraulic mechanism of tractor and using components such as hydraulic cylinder and reversing valve in a reliable manner. The mechanical type is mainly used in light-weight plough, and the hydraulic type is mainly for most of domestic and foreign reversible ploughs[1]. In China, large-medium-sized tractors basically are not equipped with multiple-way valve hydraulic output, so they may not be equipped with hydraulic reversible ploughs[2,3]. In view of the fact that these tractors are equipped with pneumatic brake cylinder, we developed the pneumatic reversible plough matching with tractors of 25.7 - 36.8 kW.

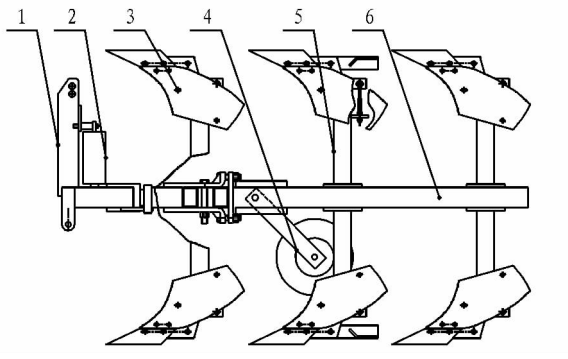
1 Overall design and principle of operation

1.1 Overall construction The 1LFQ-325 pneumatic reversible plough is mainly composed of hanger, plough frame, plough column, right and left plough bodies, depth limiting wheel and cylinder as well as other components. The following Fig. 1 shows overall construction for the plough, and Table 1 lists technical parameters.

Table 1 Technical parameters

Name of parameter	Value
External dimensions (L × W × H) // cm	180 × 97 × 108
Matched power // kW	25.7 - 36.8
Operation speed // km/h	5 - 6
Overall weight // kg	245
Single-coulter width // cm	25
Depth // cm	18 - 22
Production rate // hm^2/h	0.3 - 0.4

1.2 Principle and process of operation The pneumatic reversible plough is attached onto the tractor through a three-point hanging mechanism. Two horizontal levers of the tractor are connected to the lower lug of hanger, and the central level to the upper hanging arm. After the hanging part of tractor is connected, use a high-pressure air hose to connect the outlet air line of brake cylinder of the tractor with the cylinder nozzle on the plough. The three-way switch in the high-pressure air hose closes cylinder piping circuit during transportation to prevent the plough from turning over when the transportation vehicle brakes in emergency, resulting in accidents. During operation, turn on the three-way switch on the high-pressure hose, then operate the distributor lever of the tractor to lower the plough, the tractor advances forward, and weight of the tractor itself forces it to penetrate at penetrating angle for operation of the first stroke. Depth may be adjusted by adjusting the guard bolt of the depth limiting wheel for proper depth. At the time of the plough falling down, the tractor advances forward slowly, and after the required depth is met, it advances at the operating speed. When the tractor comes the end of a field, the plough is lifted, the tractor turns back and aligns with the plough ditch, paddle the brake so that the cylinder drives the plough frame to turn over, release the brake when the frame overrides the middle point slightly, the plough continues its turnover relying on its weight for the complete turnover, and then the plough lowers



1. Hanger; 2. Reversing cylinder; 3. Plough body; 4. Depth limiting wheel; 5. Plough column; 6. Plough frame.

Fig. 1 Construction for 1LFQ-325 Pneumatic Reversible Plough

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for the next stroke.

2 Determination of main design parameters[4,5]

2.1 Determination of total working width Total working width of the plough shall be determined on the basis of effective traction force of the tractor, soil resistance and required depth. Calculation formula is:

$$B = \frac{P_T \eta_t}{ka} \tag{1}$$

where B total working width (cm); P_T effective traction force of tractor (kN); η_t Utilization coefficient of traction force, and η_t = 0.9; k soil resistance, and $k = 8\text{N/cm}^2$; a depth, and a = 18 – 22cm.

With optimization of calculation, the total working width is determined to be 75cm, and for three-furrow plough, the width may be adjusted from 60 cm to 75cm depending on the power and conditions of soil.

2.2 Determination of space between plough bodies and positioning angle of plough body The space between plough bodies is a key parameter. Too small space cannot provide sufficient space for passage of slice of furrow, tending to develop obstacle; and too large space increases length of plough, not only resulting in a waste of steels, but also affecting vertical stability of the unit. Therefore, the required space shall be designed in such way as to ensure the space is minimized provided that the slice of furrow could pass smoothly. As shown in Fig. 2, vertical space between the front plough and the rear plough shall meet requirements in the formula (2).

$$S \geqslant t + b - \frac{1}{2}a \tag{2}$$

$$\alpha = arctg\left(\frac{b}{S}\right) \tag{3}$$

where S vertical space between plough bodies (cm); α positioning angle of plough body; t distance from furrow tip to end of side plate (cm); b width of plough body, and b = 25 cm; α depth, and α = 20 cm. Based on the calculations, S = 60 cm and $\alpha = 22°37'$ are used.

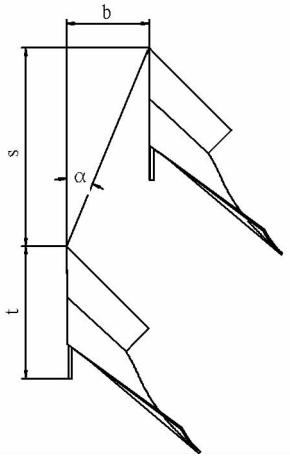


Fig. 2 Diagram for space between plough bodies

2.3 Determination of plough frame height The plough frame height shall ensure that the slice of furrow could turn over under the frame smoothly without soil or grass jamming. Calculation formula is:

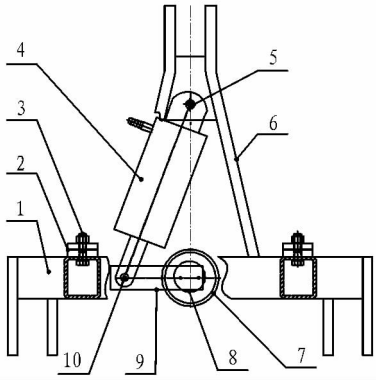
$$H = \sqrt{b^2 + (a_{max} + h)^2} \tag{4}$$

where H space height of plough frame (cm); b width of plough body, and b = 25 cm; a_{max} the maximum width of plough body, and a_{max} = 22 cm; h cutting height, and h = 15 cm.

Based on calculations, the height of plough frame is determined to be 50 cm.

3 Design of main working mechanism

3.1 Design of reversing mechanism The mechanism shall be design in such principle to allow the plough frame to turn either to the left and right by 180°. The frame drives the left or right reversing mechanisms to change the direction, and the important working components are the rotating shaft driving the frame to turn over and the cylinder driving the shaft to rotate. The design construction is shown in Fig. 3. The shaft runs through the shaft sleeve in the center of header at rear of the hanger, an eccentric arm is fixed at front end of the shaft, the cylinder piston is pin-jointed with the arm, and the puller on the cylinder barrel is pin-jointed with hanger. Being interconnected with the tractor, the hanger keeps still when the tractor is in operation, the piston rod drives the eccentric arm, forcing the shaft to rotate, thus the plough frame turning over.

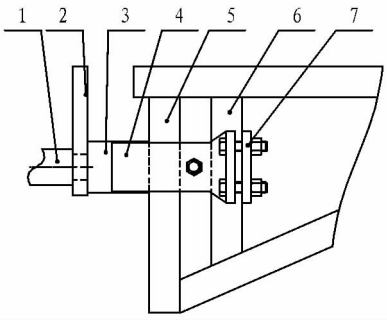


1. Hanging header; 2. Limit plate; 3. Limit bolt; 4. Cylinder; 5. Upper cylinder pin; 6. Hanging arm; 7. Shaft sleeve; 8. Rotating shaft; 9. Eccentric arm; 10. Lower cylinder pin.

Fig. 3 Simplified diagram for reversing mechanism

3.2 Design of offset mechanism for plough frame The working width of plough is smaller than the wheel distance of the tractor, and thus it becomes impossible to plough towards and at the end of field, so an offset mechanism is provided for the plough frame. As shown in Fig. 4, the offset mechanism is composed of the frame limit plate, fixing block of clamping plate, offset clamping plate and connecting plate. Movement of the offset clamping plate along the plough frame can change the horizontal position of the plough body relative to the hanging center.

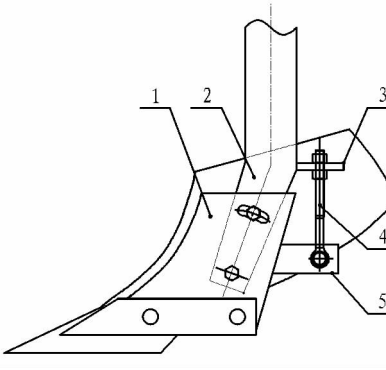
3.3 Design of adjustment mechanism for penetrating angle An adjustment device for penetrating angle is designed on the plough body, of which construction is shown in Fig. 5. Plough



1. Rotating shaft; 2. Limit plate of plough frame; 3. Fixing block of clamping plate; 4. Offset clamping plate; 5. Front header of plough frame; 6. Rear header of plough frame; 7. Connecting plate.

Fig. 4 Simplified diagram for offset mechanism

supporting plate is connected with the plough column through the upper and lower bolts, the bolt hole on the upper part of supporting plate is an arch hole, and the two ends of the adjustment bolt are connected to the plough column and the supporting plate respectively. Regulating the adjustment bolt can adjust the penetrating angle of the plough body, and the device can be adjusted on separate basis depending on specific conditions of each plough so as to meet the appropriate penetrating angle.



1. Plough supporting plate; 2. Plough column; 3. Upper bolt base; 4. Adjustment bolt; 5. Lower bolt base.

Fig. 5 Simplified diagram for adjustment mechanism for penetrating angle

4 Performance testing

4.1 Testing items Performance testing items include depth and its stability, consistency between depths of positive stroke and negative stroke, consistency between widths of positive stroke and negative stroke, operation rate, coverage rate of vegetations and stubbles, furrow fragmentation rate, penetration stroke and rate of successful turnover.

4.2 Testing method (1) Depth and its stability, working width and its stability, operation rate, coverage rate of vegetations and stubbles, furrow fragmentation rate, and penetration stroke shall be determined in accordance with the relevant provisions of *Mouldboard Plough-Technical Requirements* (GB/T 14225). (2) Determination of consistency between depths of positive stroke and negative stroke and between working widths: the positive stroke means the stroke when the right plough of the pneumatic reversible plough is operating, and the negative stroke means the stroke when the left plough is operating. The difference between the mean of depth of positive stroke (for strokes 1 and 3) and that of negative stroke (for strokes 2 and 4) measured through testing of depth and its stability in accordance with GB/T 14225 is used the deviation value of depth between the positive stroke and the negative stroke; and the difference between the mean of width of positive stroke (for strokes 1 and 3) and that of negative stroke (for strokes 2 and 4) measured through testing of width and its stability in accordance with GB/T 14225 is used as the deviation value of width between the positive stroke and the negative stroke. (3) Determination of rate of successful turnover: assign a skilled operator to conduct 100 turnover cycles continuously at least, and then calculate the proportion of successful turnover in the total cycles.

4.3 Results of testing Following design, prototype trial-production and lot production, 1LFQ-325 pneumatic reversible plough has been subjected to several factory turnover tests and field performance tests, and indicators for all performances in the results of test complied with the requirements of standards.

In August 2009, testing and identification station for farming & stockbreeding machinery in Uygur Autonomous Region of Xinjiang conducted performance testing relative to the plough. Table 2 and Table 3 list testing conditions and results respectively.

Table 2 Testing conditions

Item name	Value of result
Date of test	August 2009
Venue of test	Liugongsan team, Shihezi
Type of soil	Loam
Soil compactness//kPa	52
Soil moisture//%	8.5
Name of preceding crops	Cotton
Average height of stubble //mm	125
Average density of stubbles //plant/m^2	35

Table 3 Results of test

Item name	Technical indicator	Results of determination	
		Positive stroke	Negative stroke
Operation speed//km/h	>5.0	5.7	5.6
Penetrating stroke//m	≤4.0	2.9	2.9
Mean working width//cm	60 – 75	73.4	74.5
Variation coefficient of working width stability//%	≤10.0	6.8	7.1
Deviation of consistency of width between positive and negative strokes//cm	≤5		1.1
Mean depth//cm	18 – 22	19.7	20.2
Variation coefficient of depth stability//%	≤10.0	7.7	7.9

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4 Conclusion

Currently, functions of real estate registration system in various countries generally involve private law function and public law function. Private law function emphasizes clarification of right adscription and maintains transaction security. Public law mainly aims to improve public benefits since no one can obliterate the public welfare of land resource utilization and preservation. Registration validity doctrine of housing land use right is the national requirement based on social public benefits and a reflection of restricting private-right autonomy on the property law. Indeed, we can never ignore the increased burden of parties caused by the registration cost of housing land use right. However, "from an economic point of view, it is reasonable if profits of normally recording boundaries are higher than cost with reference to avoiding occupying or using resources and making it convenient for users to mutually transfer land."

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(Table 3)

Item name		Technical indicator	Results of determination	
			Positive stroke	Negative stroke
Deviation of consistency of depth between positive and negative strokes// cm		≤2		0.5
Furrow fragmentation rate// %		≥65.0	74.1	73.5
Vegetation coverage// %	Underground	≥80	87.3	85.8
	Under 8 cm depth	≥50	69	69.3
Rate of successful turnover// %		≥96%		96

5 Conclusions

1LFQ-325 pneumatic reversible plough not only shares advantages with common reversible ploughs, but also adopts the cylinder as source of power for the turnover mechanism for right and left turnover, which not only substitutes the mechanical turnover mechanism, simplifying construction, but also provides the offset function from the plough frame, so plough is accessible to end of field and stubbles nearby the fruit garden. It is suitable for small irregular fields and fruit garden, so it enjoys bright future of application.

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