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Effects of Hydrocylnder Status Changing Plowing Place on Tractor Fuel Savings and Efficiency

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ABSTRACT: A wide range of tillage machines in agriculture allows us to identify several important global trends and prospects for the development of this type of agricultural machinery.
Machinery and tractors are becoming heavier and heavier due to the technologies currently used to grow crops. This leads to an increase in the compaction of the soil layer. As a result, zones of mechanical erosion are formed, soil fertility and crop yields are reduced. Therefore, modern trends in tillage and the creation of tractor units are mainly determined by environmental requirements for the protection of soil from excessive man – made loads.

KEYWORDS: Agriculture, plowing angle, hydraulic cylinder, tractor units, plow body, lemex.

In recent years, in all developed countries of the world, the search for new technological methods to protect the soil from erosion, maintain and increase soil fertility, as well as reduce labor, cost, and energy costs continue.

I. INTRODUCTION

Of course, before studying tillage machines, it is necessary to study the physical properties of the soil and the technological properties of tillage machines. The soil in which the crop is grown differs from ordinary soil in its composition, is in its fertility. Therefore, we selected two types of plowing angles of 75^{O} and 90^{O} and three types of tillage distances of 700, 800 and 900 mm to improve the soil quality of arable lands for these experiments (Alimnazarov O. N. J., 2020).
The results showed that the plow penetration angle at 75^{O} is more efficient than the plow penetration angle at 90^{O} because the tillage distance is more efficient at 700 mm intervals than at other 800 mm and 900 mm distances. (Alimnazarov O. N. J., 2020).
Companies from developed countries in the production of agricultural machinery produce a wide range of semi – automated and automated plowing equipment for plowing on agricultural tractors with a capacity of 30 to 250 kWt. A distinctive feature of the plows currently in production is that all firms produce them in the same series and standardize the components extensively, producing only 2 to 10 to 14 plows, which differ in the number of plow bodies. Rarely do few companies produce tillage plows that use a hydraulic cylinder to plow the topsoil.
A common feature of almost all models of plows is the change in their working width and the design of the frame, which allows you to gradually adjust the width of the plow and remove the body to achieve a rational load when working in different conditions of the tractor. Semi – mounted plow bodies are produced with 5 to 14 and working widths from 1750 to 7000 mm, their average specific weight is from 1000 to 1500 kg for 1000 mm working width, the distance between the bodies is 1000 – 1020 mm and the frame height is mainly 800 – 900 mm.
Besides, the tillage body differs from the fuel consumption of the tractor during tillage in conventional tillage devices by saving fuel on the tractor during tillage with the help of hydraulic cylinder – changing tillage devices. This is because, during the tillage process, the tractor completes the work in a single tillage course on conventional tillage equipment and continues to work back to the starting point, which leads to excessive fuel and time consumption in large areas. In plowshares that change the position of the plow body with the help of hydraulic cylinders, the plow body increases the efficiency by 2 times by changing the position of the plow body by 180^{O}, which leads to excessive fuel

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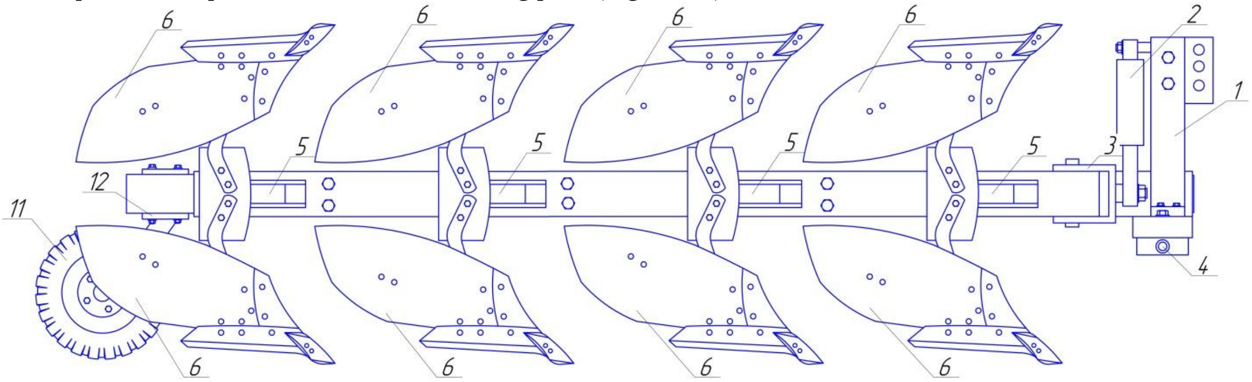
and time consumption in large areas. does not come. However, the above – mentioned plow bodies, which change the position with the help of a hydraulic cylinder, differ from conventional plows in size and weight. In this process, relatively large tractors are used during tillage. Currently, tractors for Class, John Deere, Lemken, and Kverneland agricultural machinery and equipment manufacturers are mainly used for such tasks. However, given the relatively high cost of these tractors compared to conventional tractors used in Uzbekistan, we have designed and tested a hydraulic plow with a plow body hydraulic cylinder, which can be used even with relatively small conventional tractors. Experiments have shown that this plow body can be used in tractors with a hydraulic cylinder, which changes the position of the plow.

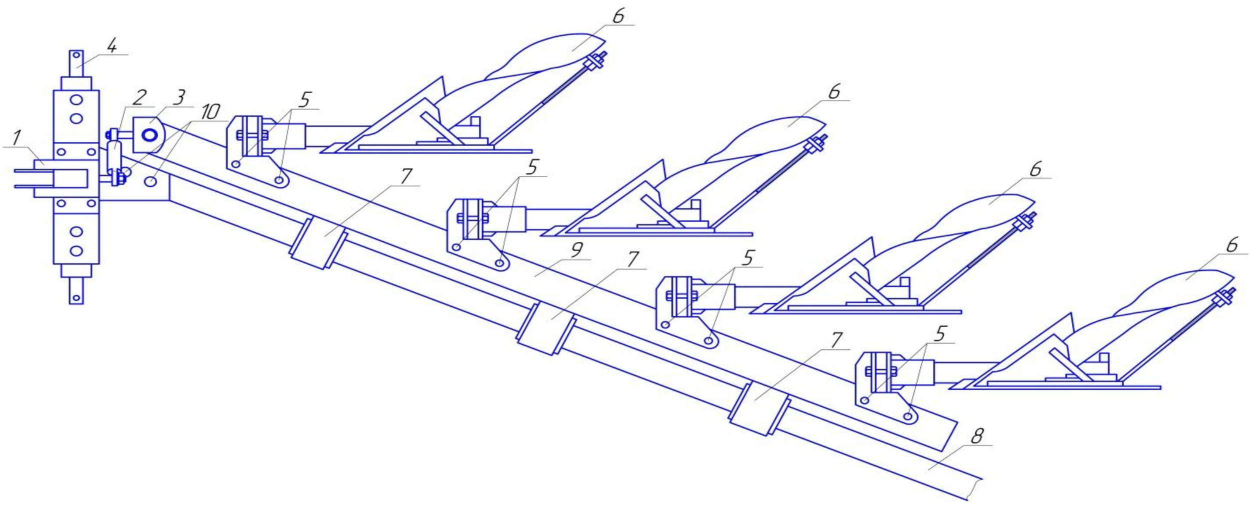
II. MATERIALS AND METHODS

The front frame of this designed plow has three connections to connect to the tractor. The plow used a right and left plowing body on one side of the mainframe, which initially participates in the soil plowing process to the endpoint of the field during plowing and the rest to 180^{O} using a vertical hydraulic cylinder mounted on the plow tower during the return to the starting point. As a result of the rotation, it performs the function of plowing the soil (Alimnazarov O. E. A., 2021).

In this process, the plow consists of the following parts (Fig. 1 a, b):



a)



b)

Figure 1. General view of the plow body, which changes the position of the plow body with the help of a hydraulic cylinder (a); The top view of the plow, which changes the position of the plow body with the help of a hydraulic cylinder (b).

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Tower 1 is used to connect the plow to the tractor, hydraulic cylinder 2 the main cross – section of the plow is shifted to 180^O by rotating the rectangular frame to 180^O. Figure 2 shows the kinematic scheme of its movement.

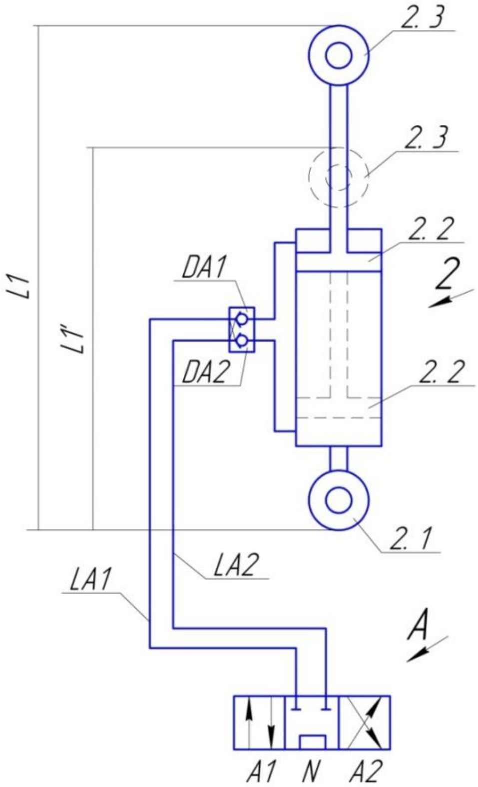

Figure 2. The kinematic diagram of the hydraulic cylinder is shown

According to it, $L1$ is the length of the initial position of the hydraulic cylinder, and $L1'$is the length of the working position, the main cross-section of the adjuster 3 plow is the vertical hydraulic cylinder when rotating the rectangular frame at right angles gives thousands. Figure 3 connects the plow 4 on the trestle to the tractor along the horizontal axis, the plow body adjuster 5 adjusts the plow body to the soil trench, the plow body 6 tilts the plowed soil to 30 – 33 mm, and this the task is performed using remixes (Alimnazarov O. E. A., 2021).

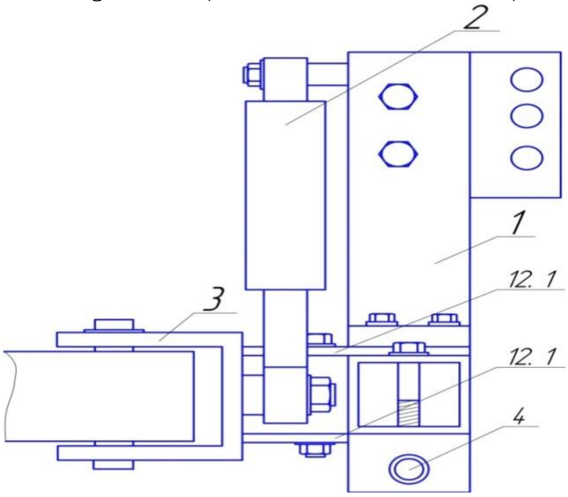

Figure 3. The vertical hydraulic cylinder and the part that provides the parallel between the tower are shown

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The main cross-section of the plow is a rectangular frame. The main cross – section of the plow is rotated on a circular frame. The supports are shown in Figure 7, and in it (upper). The fastening part 7.1, the base fastening part 7.2, the roller radial – support bearing 7.3, and the fastening bolt joint 7.4). The main cross – section of the plow is fixed in a circular frame 8 (length 4500 mm, frame diameter Ø200 mm, thickness 15 mm) and fixed to the front frame, the main cross – section of the plow is fixed. The rectangular frame 9 (length 4000 mm, frame profile 300x400x9 mm), the fastener 10 is fixed to the front frame of the fixed main cross – section circular frame (Alimnazarov O. E. A., 2021).

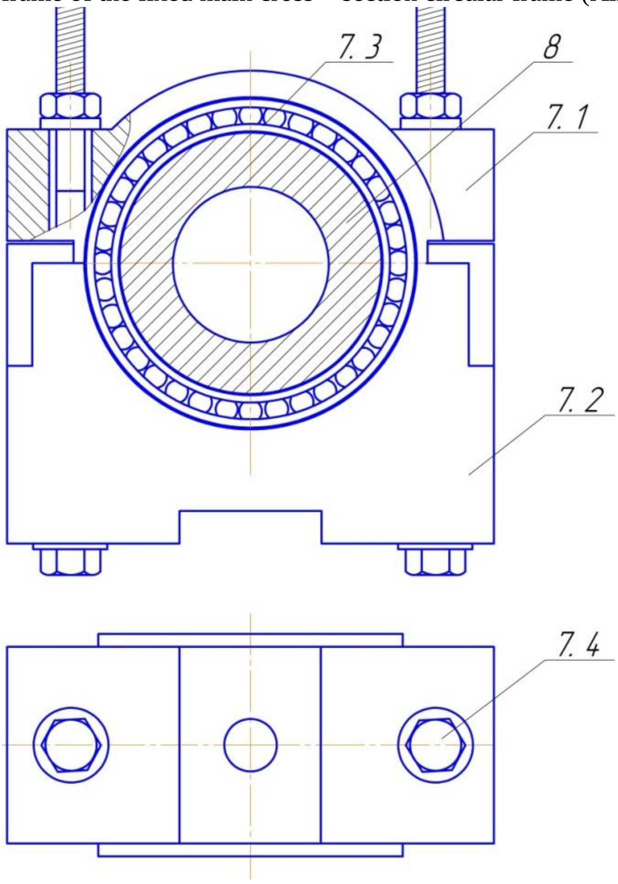

Figure 4 The cross – section of the rectangular frame shows the base that allows the main cross-section of the plow to rotate along with the circular frame.

Lemex plow bodies: Lemex plow bodies are characterized by the width of the cover, the depth of plowing, the angle of inclination of the lemex blade to the plow wall and the angle of inclination of the lemex to the plow bottom, as well as the shape of the work surface. The reason for the production of many types of hulls, which vary in width, is the need to cultivate the land at different depths, depending on local soil conditions and the type of crop. The maximum plowing depth should not exceed 79% of the width of the body cover, is $b = 1,27a_{max}$.

Hence, the studies show that if plowing is assigned at a depth of $a = 270\ mm$, $b = 1,27a = 1,27 \cdot 270 = 350\ mm$, if $a = 300\ mm$ is required, $b = 1,27 \cdot 300 = 400\ mm$ indicates that the housing should be installed (Alimnazarov O. N. J., 2020).

Body parts: The body consists of a lemex, a tipper, support, and a column. Lemex (Fig. 5) cuts a piece of soil from the bottom, separates it from the ground, lifts it slightly, and passes it to the overturner. As the compacted soil moves along the surface of the lemex under high pressure, the blade wears out quickly, becoming impenetrable and narrow. The drag resistance of the impenetrable lemex plug can increase dramatically (up to 30%). The impermeable plow body of the Lemex not only increases its drag resistance but also makes it difficult to sink to the designated depth and does not ensure smooth movement (Alimnazarov O. N. J., 2020).

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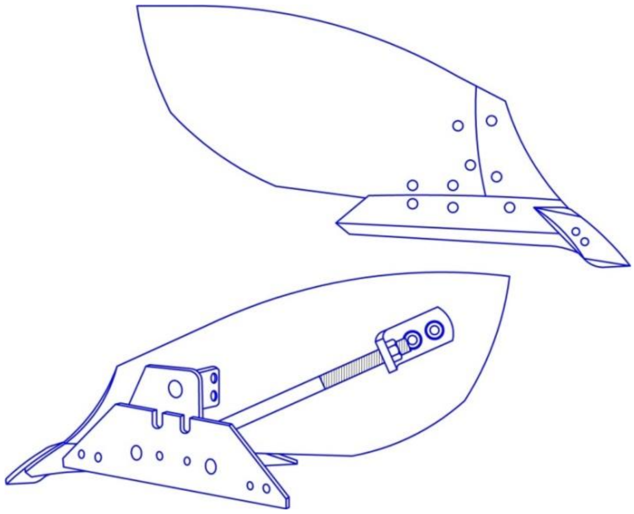

Figure 5. Shown by a designed plow corps

Lemex is made of special corrosion-resistant steel. The designed lemex lasts 2 to 2.5 times longer than a normal lemex. The shape of the lemex is selected according to the type of soil to be plowed. Due to a large number of soil types, lemex also has different shapes: trapezoidal, scaly, triangular, interchangeable beak, etc. (Alimnazarov O. N. J., 2020). The interchangeable beak lemex (Fig. 6) is very simple in structure, inexpensive to prepare and repair, immersed in hard soil faster than other types of lemex and is resistant to corrosion by abrasive elements in the soil. Therefore, due to the use of this lemex in the cultivation of light soils, its strength was increased by heat treatment of the material (Alimnazarov O. N. J., 2020).

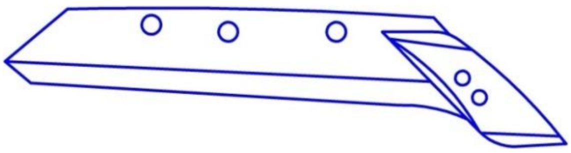

Figure 6. The designed plowing corps showed lemex

Lemexs and their materials: When plowing the soil with agricultural tractors, its parts are eroded due to friction. Therefore, they need to be repaired. In the process of studying the durability of working bodies and spare parts of tractors, it is necessary to determine the laws of their wear. There is a need to develop a computational framework to increase the robustness of the working bodies involved in this process (Alimnazarov O. N. J., 2020).

The abrasive particles in the soil of the working surfaces and the relative speed of movement are determined by the shape and nature of the relative displacement of the particles due to wear under the influence of friction (Severnev M.M, 2011). Experiments show that the wear characteristics of the working parts of agricultural machinery depend on the soil conditions, the specific pressure of the working soil. In an experiment (1), the results of determining the wear of abrasive particles in the soil under the influence of friction and the relative speed of movement showed that the lemex working surface is proportional to the specific pressure of the soil (Blokhin, 2015).

$$I = kN \qquad (1)$$

where k is the coefficient of proportionality, N is the specific pressure.
Depending on the velocity of the abrasive particle, the corrosion equation (2) of the lemex is expressed.

$$I = \mu V^b \qquad (2)$$

where μ and b are constant coefficients depending on the physical and mechanical properties of the soil.
The results of the study showed that to prolong the service life of replaceable parts of agricultural machinery, it was necessary to increase its resistance to external influences by heat treatment of its surface in terms of achieving surface universality and cost – effectiveness.

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Comparing the five variant results of heat treatment of 65Г steel flat specimens on the surface layer studied in the experiment, taking into account the high durability, plasticity and adhesive properties for heavy – duty variable parts of the working bodies of earth – cutting machines, the most effective combinations have increased the hardness using plasma at a temperature of 300^{O} C.
Due to the very rapid heating rate in the plasma, the transformations take place at high temperatures, and this thermally active process has a strong effect on the kinetics of the formation and growth of new phase nuclei. The relationship between the degree of nucleation of austenite and their growth rate changes, and as the temperature increases, the nucleation process of austenite occurs faster than their formation, and the growth rate is quantified from the growth rate. growth i.e. leads to the formation of rotating fine – grained austenite and turns into highly dispersed martensite with high strength properties (Alimnazarov O. N. J., 2020) and (Алимназаров О.М., 2020)

The production of agricultural tractors and implements is one of the most energy – and material – intensive industries, requiring up to 45 – 50 % of fuel and lubricant consumption as a result of tillage. Due to the high annual consumption of replacement parts for tillage machines in agriculture, it is important to reduce operating costs and increase resistance to external influences and reduce the cost of spare parts and increase the level of competitiveness (Канаев, 2018).
Experiments show that in modern agriculture it is necessary to ensure the strength of the product material at the level of 1500 – 1800 MPa during tillage. The impact force should be at least 0.8 to 1.0 MJ/m and the maximum possible surface hardness should be between 60 and 65 HRC (Шилов И.Н. и др., 2010).
Replacement parts of working bodies of agricultural tractors and aggregates are traditionally made of medium or high carbon Ст6, 65Г, У8 and other steels (Канаев, 2018) and (Алимназаров О.М., 2020). The lemex 65Г manganese steel, which is a part of the replacement parts of the working bodies with increased surface hardness in plasma, is made of manganese steel, the chemical composition and temperature of the critical points are given in Table 1.

Table 1. Chemical composition (%) of lemex material and temperature of critical points, ^{O}C.

C	Mn	Si	P	S	Ni	Cu	Ac_1	Ac_3	Ar_1	Ar_3	$M_н$
0.63	0, 1.2	0.35	0.031	0.029	0.25	0.19	721	745	620	720	270

Mechanical properties of hardened heat – treated steel material (hardening from 800 to 820 ^{O}C) (Канаев, 2018). The process after lubrication (air cooling to 340 – 380 ^{O}C) is shown in Table 2.

Table 2. Mechanical properties of 65Г steel depending on the temperature.

Test temperature, ^{O}C	σ_B, MPa	$\delta, \%$	$\gamma, \%$	$\sigma_{0,2}, MPa$
830 ^{O}C solidification in oil. 350 ^{O}C cooling in the air				
200	2200	15	44	1370
300	1670	19	52	1220
400	880	20	70	980

Table 3. Mechanical properties of the studied steel.

σ_T, MPa	σ_B, MPa	$\delta, \%$	$\gamma, \%$	HRC, mm
1220	1470	5,0	38	49

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Table 4. The measurement results are summarized.

	Sample order number					
	1	2	3	4	5	6
Working surface HRC	48,1	50,1	50,7	49,7	48,9	49,2
Back surface HRC	47,9	50	49,8	46,4	47	46,3

The hardness of the lemex working surface is 49 ... 51 in the range of HRC values, while the hardness of the reverse side is in the range of HRC values of 46 ... 50. We can conclude that the hardness of working surfaces is related to the abrasive particles of the soil environment and the hardening of this surface under the influence of plastic deformations (A.M. Михальченков, 2004) and (A.M.Михальченков, 2012). At incomplete temperatures of 750 ... 770 ^{O}C, steels are heat – treated with hypereutectoid, followed by hardening at low temperatures of 150 ... 200 ^{O}C.

Fuel consumption during tractor plowing: Fuel consumption is measured by the fuel consumption for the work is determined by the device calculated in mL (3) for the working length (50 m) (Asharifi, 2009).

$$Q_F = \frac{Q_D \cdot 1000}{W_P \cdot D \cdot 100}\ mL \qquad (3)$$

where: Q_F – fuel consumption $L\ /\ ha$; Q_D– (100 m) tillage length fuel consumption; W_P– machine width (m); D is the length of tillage (60 m).

Percentage of displacement of the tractor during plowing:
Measured by practical and theoretical speed (Alsharifi S. , 2009).

Practical speed of the tractor during the plowing process: The depth of tillage and the process of plowing the soil with the applied speed were determined experimentally. Moisture and tillage depth were repeated three times within the tillage length (60 m) for the soil and were determined using the following equation (4):

$$V_P = \frac{3{,}6 \cdot D}{T_P}\ km/hr \qquad (4)$$

The theoretical speed of the tractor in the plowing process: Without plowing the soil, only the device touches the soil at a speed of 3 km/hr during tillage and the length (60 m) is repeated for both soil moisture and three tillage depths (Alimnazarov O.M., 2020). The calculation of the theoretical speed is determined by the following equation (5):

$$V_T = \frac{3{,}6 \cdot D}{T_t}\ km/hr \qquad (5)$$

where: V_T – theoretical speed $km\ /\ hr$; T_t is the theoretical time (hr).
Using Equation (6), the calculation of the percentage of displacement resulting from the practical and theoretical velocities was performed:

$$S = \frac{V_t \cdot V_P}{V_t} \cdot 100\ \% \qquad (6)$$

Equation (7) calculates the percentage of power expended as a result of the displacement (Asharifi, 2009) and (Alimnazarov O.M., 2020).

$$P_S = \frac{F\,(V_t \cdot V_P)}{270}\ kw \qquad (7)$$

where: P_S – displacement power (kW)

Tractor efficiency in the plowing process: Tractor efficiency is the ratio of the power a tractor consumes for a given period of time to the theoretical power consumed by a tractor (Alsharifi S. M., 2019).

The theoretical size of the tractor: The theoretical size of the tractor is the operating speed, which uses the full width and time of the device and is determined by (8):

$$T_{FC} = \frac{S \cdot W}{C} \qquad (8)$$

where: T_{FC} is the theoretical size of the machine; S – speed is used; W is the sheer width of the device (M) and C is the shear coefficient.

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Tractor Size: The size of a tractor is the actual stage of the work and is determined by (9):

$$E_{FC} = \frac{A}{T} \qquad (9)$$

where: E_{FC} is the effective machine size; A − distance (hr); T − time.
The calculation of the efficiency of the tractor is determined by (10).

$$F_E = \frac{E_{FC}}{T_{FC}} \cdot 100\% \qquad (10)$$

III. RESEARCH RESULTS

The plow body, which is used in conventional tractors in Uzbekistan, is relatively inexpensive, durable, lighter than previous plows, and can be used even in conventional tractors with relatively small capacity. We designed a rotary plow and tested it experimentally. Experiments have shown that this plow body can be used in tractors with a hydraulic cylinder to change the position of the plow (Alimnazarov O. N. J., 2020).

Tractor Fuel Consumption: The fuel consumption under the influence of soil entry angles is shown in Table 5. The effect of 75^O soil entry angles on the plow resulted in a plow body with minimum fuel consumption of 9.55 L/ha. Due to the effect of the 90^O plow body on the soil entry angles, the minimum fuel consumption was 11,264 L/ha, which increased fuel consumption due to the high pressure during the plowing process. These results show that fuel consumption is more efficient at a processing distance of 700 mm than at a processing distance of 900 mm. The results showed fuel consumption of 9,958, 10,375 and 10,891 L/ha. Due to the high resistance of the plow body lemex to soil resistance, fuel consumption did not increase with increasing travel and processing distances. The most effective results showed that the fuel consumption was 9,082 L/ha when the plow body penetrated the soil at 75^O and the tillage distance was 700 mm (Alimnazarov O. N. J., 2020).

Percentage of displacement during plowing: A decrease in the percentage of displacement led to an increase in tillage distances. The processing distances were 8,935, 9,653 and 10,682 % respectively. The reason for this was the increase in tillage distances and shear coefficient as a result of the tillage resistance of the soil. Table 6 shows the percentage of displacement, which showed that the plow penetration angle was significantly more effective at 75^O than at 90^O, and was 9.303 % and 10.264 % respectively. These results showed that the penetration of soil into the soil at an angle of 75^O to the tillage was effective at a tillage distance of 700 mm.

Tractor efficiency: The effect of soil entry angles on the plow is shown in Table 7, % of tractor efficiency. The efficiency of the tractor with a plow angle of more than 75^O was 71.786 %. The low efficiency was 69.339 % on a tractor with a soil penetration angle greater than 90^O. The decrease in tractor efficiency was due to high pressure, and in the tillage machine, which changed the position of the plow body using a hydraulic cylinder during tillage, there was an inverse relationship between the plow entrance angles and the tillage distances. A distance of 700 mm showed better tractor efficiency than a working distance of more than 900 mm. The results were 71,963, 70,598 and 69,127 %, respectively. The best result (73.610 %) was the tillage distance obtained at 700 mm of plowing and the angle of entry of the plow into the soil at 75^O.

Table 5 shows the effect of tillage angles and fuel consumption L/hr at tillage distances.

Duration of plowing angles of the soil	Tillage distances, mm		
	700	800	900
75^O	9,082	9,656	9,915
90^O	10,833	11,095	11,866

Table 6: Effects of tillage angles and tillage distance on displacement %.

Duration of plowing angles of the soil	Tillage distances, mm		
	700	800	900
75^O	8,715	9,092	10,103
90^O	9,155	10,214	11,261

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Table 7: Percentage of the effect of tillage angles and tillage distances on machine efficiency.

Duration of plowing angles of the soil	Tillage distances, *mm*		
	700	800	900
75^{O}	70,816	69,221	68,418
90^{O}	69,213	68,411	67,526

IV. DISCUSS THE RESULTS

The invention relates to a plow that changes the position of the plow body using a hydraulic cylinder to connect it to a tractor. Three plowshares and a hydraulic cylinder are located on the front frame of the plow. It is a vertical hydraulic cylinder that alternates the plow bodies on one side of the plow frame, and the position of the parallel adjusters is adjusted to the front working width of the variable length relative to the front plow frame. The plow body is adjusted and the tractor rear wheel moves on the cultivated soil or the surface of the uncultivated soil.

The angle of rotation of the plow can be adjusted depending on the width of the tractor, and the angle between the working width of the pre-selected plow can be adjusted. The distance from the rear wheel of the tractor to the edge of the furrow is always parallel to each set working width. This allows for a flat plowing of the soil during tractor plowing (Laumann B. W., 2009).

On one side of the plow frame, there is a vertical hydraulic cylinder, which alternates between plowing bodies with right and left turning plow bodies when returning to the starting point and back. Through the hydraulic cylinder, the plow frame is returned to the working position after the turning process.

It is known from the above-mentioned type of plow body hydraulic cylinder reversing device (Laumann B. W., 2009) that this plow body is the first vertical hydraulic cylinder and has two parallel adjusters, one of which is a straightener. and the other connects the horizontal hydraulic plow frame to the front frame. The position of the adjuster relative to the front frame can be changed by the first hydraulic cylinder (Laumann B. R., 2013).

The invention relates to a plow that changes the position of the plow body using a hydraulic cylinder to connect it to a tractor. The three links of the device and the vertical hydraulic cylinder are located on the front frame of the plow. It is a horizontal hydraulic cylinder for connecting the plow body to the alternating plow frame, and the position of the parallel adjuster is adjusted to the working width of the tractor at a variable length relative to the front plow frame.

The angle of rotation of the plow, which changes the position of the plow body with the help of a hydraulic cylinder, can be adjusted depending on the width of the tractor, and the right and left plow bodies are located on one side of the plow frame. The turn is used alternately using a vertical hydraulic cylinder. The working width of the pre – selected plow varies between the angles relative to the working width of the tractor. A second horizontal hydraulic cylinder is used to ensure that the distance from the rear wheel of the tractor to the edge of the furrow is constantly parallel to each specified working width. This makes it possible to plow the soil evenly while plowing the tractor.

(Laumann B. W., 2009) it is known from the invention that this plow body hydraulic plow is a vertical hydraulic cylinder and has two parallel adjusters, one of which is the adjuster and the other is the horizontal hydraulic cylinder that connects the plow frame to the front frame for connection to the tractor. The position of the adjuster relative to the previous frame can be changed inwards and outwards employing a second hydraulic cylinder using a second horizontal hydraulic cylinder (Laumann B. R., 2013).

The designed plow applies to the plow that changes the position of the plow body using a hydraulic cylinder, which differs from previous inventions in that it has two mutually parallel mainframes, a movable and the plow. Consisting of diamond frames, the fixed frame is fixed to the front frame and the movable frame is rotated around the fixed frame using three-step supports. This ensures that the resistance forces generated during the tillage process are distributed along the entire length of the plow frame (Alimnazarov O. E. A., 2021).

The plow body uses a hydraulic cylinder to increase the resistance of the positioning plow to external influences, is radial, and longitudinal forces, and to produce a low – cost tillage plow to replace locally produced imports, application to agriculture.

We have done this by improving the design of the plow body that changes the position of the existing plow body using a hydraulic cylinder, in this plow we recommend, its main log section is fixed to the front frame with a circular frame

fixed and the main the cross – section of the rectangular frame is rotated around this frame using three bearing supports, and no welded joints were used in the assembly of this device.
This ensures that the resistance forces generated during the tillage process are distributed along the entire length of the plow frame and allows the replacement parts of the plow that have become unusable.
The essence of the design is that the vertical hydraulic cylinder, which rotates the mainframe at 180^{O} in a tillage plow with a hydraulic cylinder, has a simple structure and can be used on non – automated mechanical tractors (Alimnazarov O. E. A., 2021).

V. CONCLUSION

The plow body has two mutually parallel mainframes of the plow, which change position using a hydraulic cylinder, consisting of a movable and a fixed frame, the fixed frame is fastened to the front frame, and the drive the receiving frame is rotated around a fixed frame using three supports. No welded joints are used in the assembly of this device, which does not differ from the static loading properties of the device during dynamic loading and allows you to replace parts that have become unusable. Ensures that the resistance forces generated during the plowing process are distributed along the entire length of the plow frame. This prolongs the life of the plow and saves fuel on the tractor.

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