Effects of irregularities of irrigated lots on stable operation of planning units

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Abstract. Study of theoretical attempts to influence irregularities of irrigated lots on the stability of planning units. The laws and regulations of farming mechanics have been used in the research process. The diagram of forces acting on the driven front wheel of the tractor when it overcomes a vertical obstacle is justified. Leveling the fields increases the productivity of planning machines, increases the yield of crops, reduces irrigation water and losses during harvesting, at the same time working conditions of workers and mechanization operators, serving the machine-tractor unit, are improved. Maneuvering the speeds of the planning unit allows compensate the loss of time for idle move, thereby increasing the performance of the unit. Irregularities of the worked lands violate the stability of unit’s travel, which leads to violation of quality of performed work.

1. Introduction
It is known that to increase the production of agricultural products, it is necessary to intensify agriculture, one of the means of which is extensive land reclamation, which provides, as one of the most important measures, the leveling of the surface of irrigated lands. In the complex of planning works, the leveling of the surface of the fields by planners is of great importance, to improve which a lot of work is being done, both in Uzbekistan and abroad [1,2]. In cotton growing, field irregularities reduce the efficiency of using engine power and tractor traction. At the same time, the speed of the machine decreases and its vertical vibrations increase.

Elements of the micro-relief significantly reduce the stability of the tractor movement. The boundaries of dynamic stability when overcoming obstacles in the form of lugs and cavities are reduced to 40-60% of the boundaries of static stability [3]. The main reason for the occurrence of transverse waves in irrigated lots is the dynamic effect of impacts of fast-moving cotton machines on poorly planned and not planned fields. Any slight irregularity of the field forms an initial push and thereby determines the beginning of wave formation. Subsequent movements, repeating this process, already destroy the surface of the field, squeezing the soil at the points of greatest stress, fixing the indentations and elevations in the form of transverse waves. In unplanned areas, when the tractor unit oscillates, which arises additional stress in the parts, loosening the fasteners, accelerating the wear, breakdowns and accidents of machines. In addition, in such fields, maintenance personnel work with high stress and become very tired.

With the increase in the speed of movement of tractor units and the increase in the grasp width, the requirements for the condition of the field surface increase, as in this case, in poorly planned fields the agricultural-technical performance of all machines and units decreases sharply. Field irregularities lead
to the significant increase in the movement path of the units, as well as increase in energy consumption [4, 5].

2. Methodology of research

The article is based on the results of generalization, analysis, expert assessment of experience in designing reclamation machines, their operation according to the generally accepted classical methodology. The methodology for calculating and justifying the choice of optimal sets of leveling and earthmoving machines for the production of earthworks, methodology for coordinating the technical and operating parameters of the wheeled mover of a tractor with agro technical requirements when performing field work, analytical dependencies allowing to determine the traction-coupling and support properties of a wheeled tractor depending on the parameters of the wheel.

3. Results of research

On an uneven, lumpy field, with open and double furrows and tubercles, aggregates cannot move at a sufficiently high speed due to strong push and impacts.

Let the wheel (figure 1.) moving with the forward speed $v$, m/s, meets an obstacle with $h$ height, in m. At the time of the wheel meeting with obstacle there is an impact, lasting $\Delta t$ seconds. When the wheel rolls over the obstacle, the amount of movement increases by the amount.

$$\Delta m \cdot v = m \cdot v \cdot \tan \alpha$$

Until the wheel rises to height $h$. Hence, using the basic equation of dynamics, we determine the force:

$$P = \frac{\Delta m \cdot v}{\Delta t} = \frac{m \cdot v \cdot \tan \alpha}{\Delta t}$$

Where $m$ – reciprocating mass of the wheel, kg.

![Figure 1](image1.png)  ![Figure 2](image2.png)

**Figure 1.** Wheel moving with translational speed, in m / s.  **Figure 2.** Diagram of the forces acting the driven front wheel of the tractor.

It is known that for soil, as for a complex body having the properties of elasticity, plasticity and hardness, the value of deformation can be assumed proportional to the speed and time of impact [6, 7], i.e.

$$a = v \cdot \Delta t; \quad \Delta t = \frac{a}{v}$$
Where \( a \) – the coefficient of proportionality determining duration of impact and characterizing total resilient (elastic) properties of running gear of the tractor and the soil.

\[
P = \frac{m \cdot v^2 \cdot \tan \alpha}{a}
\]

As can be seen, this force is proportional to the square of the speed; the higher the obstacle the greater is force, and the smaller the greater the rolling radius.

The impact force will be greatest for the unit with a stiffer suspension and rim, and the least for the unit with an elastic suspension and on pneumatic tires. Soil condition also matters. The more plastic the soil, the shorter the impact time depends on the speed. Replacing in the above formula the value \( a \) equal to \( \Delta t \cdot \vartheta \) we obtain the value of the force when moving the machine on plastic soil.

\[
P = \frac{m \cdot v \cdot \tan \alpha}{\Delta t}
\]

When the machine moves on well-opened or loose soil, some approach to this equation can be. It should also be noted that the speed of movement determines the periods of action of forces that excite the vibration of the machine and the possibility of resonance [8].

Driven wheels of tractors and other machine mechanisms, significantly worse overcome vertical obstacles than leading ones. This is because the driven wheel rests against the obstacle and the driving wheel tends to overcome it. In figure 2 the diagram of forces acting on the driven front wheel of a tractor when it overcomes a vertical obstacle of height \( h \) is shown.

The forces acting on the wheel are indicated as follows: \( T \) – pushing, perceived by the front wheel from the frame of a tractor, kN; \( R \) - obstacle reaction, kN; \( y \) and \( x \), respectively, vertical and horizontal components of the obstacle reaction, kN.

From the condition of wheel equilibrium, we have

\[
y = G_k; \quad x = T
\]

Forces acting on wheel are connected by equalities

\[
y = x \cdot \tan \alpha = T \cdot \tan \alpha, \quad G_k = T \cdot \tan \alpha
\]

Define the value of \( \tan \alpha \) from ABC triangle:

\[
\tan \alpha = \frac{BC}{AC} = \frac{r - h}{AC}
\]

Where

\[
AC = \sqrt{(AB)^2 - (BC)^2} = \sqrt{r^2 - r^2 + 2rh - h^2} = \sqrt{2rh - h^2}
\]

Substituting in the equality (1) the found value instead of the AC, we obtain

\[
\tan \alpha = \frac{r - h}{\sqrt{2rh - h^2}}
\]

Thus,

\[
T = \frac{G_k}{\tan \alpha} = G_k \frac{\sqrt{2rh - h^2}}{r - h} (kN)
\]
From the above we can conclude that the fields must be well aligned for the successful operation of the units at high speeds. Studies by a number of scientists show that the tractor of the type “Belarus” satisfactorily overcomes irregularities of a field with the height of 0.1 m at a speed of 4-4.5 km/h. However, the tractor unit would not be able to develop useful traction under these conditions at a speed of about 7-7.5 km/h, and at speed of about 10 km/h, the tremors could so intensify that there would be a danger of destruction of the tractor. If this type of tractor were not on pneumatics, but on wheels with a steel rim, then all these phenomena would occur at about half-lower speed. Under these conditions, crawler unit with elastic suspension and pneumatic caterpillar could operate at a speed of 7-10 km/h. Of course, the working conditions of the personnel maintaining the unit on unleveled field greatly deteriorate with increase of speed.

Leveling the surface of the fields, eliminating furrows, potholes and other irregularities is important condition for working at high-speed modes. It should be added that leveling the fields increases the productivity of planning machines, increases the yield of crops, and reduces irrigation water and losses during harvesting, while improve the working conditions of workers and machine operators serving the machine-tractor unit.

From the above formula (2) it can be seen that increase in the irregularities height (h) leads to a complete stop of the tractor, because at \( h=r \) the force \( T \) becomes infinitely large, i.e. when hitting non-driving front wheels on obstacle of height \( h = r \), the tractor will not be able to overcome it even with the maximum value of traction force on the driving wheels.

The speed mode of units during the performance of many mechanized fieldworks can vary within a relatively wide range without any significant change in the quality of work. This fact allows using the variable speed mode of the unit, within the limits determined by the quality of work, to achieve the best economic indicators.

Speed maneuvering is important at sufficiently strong changes in forces of resistance to movement of unit, that is, for strongly detected irregularities of the processed sections. The expediency of maneuvering speeds arises when the units are operating in conditions of pronounced macro-relief, as well as a sharp difference in soil resistance and operational weight of the machines. Speed maneuvering is carried out in order to obtain the highest performance at the lowest cost, which is associated with the best use of engine power.

Frequent deceleration of the unit due to gear shifting can reduce the performance of the planning unit and reduce the quality of the work performed.

The reduction in unit performance due to speed change depends on the length of path travelled by the unit during the shift.

According to Svirshevsky B.S. it is advisable to switch to another gear if:

\[
\left( v_1 - v_2 \right) t_p \geq 2 \cdot v_1 \cdot t_g
\]

where \( v_1 \) and \( v_2 \) – the value of the speed of the unit, respectively, before and after switching the speed, \( t_p \) unit operating time in a new gear, \( t_g \) gear shift time, s.

Coefficient “2” takes into account that the change of speed is made twice. From equation (3).

\[
t_p = \frac{2v_1 \cdot t_g}{v_2 - v_1}, \text{ (s)}
\]

If the operating time of the unit \( t_g \) in a new gear is maximally reduced, which depends on the skill of the machine operator, and then the minimum length of the run will be

\[
L_{\text{min}} = v_1 \cdot t_g, \text{ (m)}
\]

Or
A.F. Zasova during her research found that \( v_1 \) and \( v_2 \) depend on the selected gear of the tractor. The term of equation \( t_g \) characterizes the loss of time when changing the speed of the tractor and depends mainly on the following factors:

- operating conditions of the unit, performed process, speed, load and weight of the unit;
- and shift mechanism;
- individual qualities of the unit driver.

According to experimental data, \( t_g = 1\text{-}10 \text{ sec} \).

4. Conclusions

Research of a number of scientists, including studies of the Department of Agricultural Mechanization of Bukhara branch of Tashkent institute of irrigation and agricultural mechanization engineers showed that with existing designs of gear box and average qualities of the unit driver, the transition to the next stage is advisable if the length of the run with reduced resistance is greater than 100 m. When the length of the run is less than 100 m, the appropriateness of switching to another gear is determined by the qualification of the driver.

Maneuvering the speeds allows increasing the technical and operational speeds of the units, to increase productivity, efficiency and quality of work of the units.

From the above we can conclude that the driven wheels of tractors and other mechanisms are much worse at overcoming vertical obstacles than the driving wheels. This is because the driven wheels rest against the obstacle and the driving wheels strive to overcome it. Maneuvering with the speeds of the planning unit allows compensating the loss of time for idle moves, thus increasing the productivity of the unit. Irregularities of processed lots disrupt stability of unit’s travel, which leads to violation of quality of performed work.

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