

THE RELEVANCE OF RECTILINEAR MOTION OF TRACTOR UNITS

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All tractor units perform the majority of their work while moving in a straight line. However, deviation from the intended course leads to a decrease in productivity and the quality of work performed. Therefore, directional stability is a crucial aspect in the design of new and modernization of existing tractor units.

When a tractor unit moves, it is subject to external forces from the ground. While the force exerted by the drive ensures the necessary movement of the tractor unit, the force exerted by the working implement often disrupts this movement and leads to uncontrolled deviation from the intended course.

The movement of a tractor unit generally represents a combination of controlled and uncontrolled motion. Controlled motion is provided by the machine operator. Uncontrolled motion is the result of external forces acting on the work tool. In this case, the tractor unit operator is forced to adjust the control inputs.

Eccentric forces from the work tool are often encountered in the operation of road construction equipment [1]. A classic example is the operation of a motor grader paving and widening a road surface (Figure 1). In this case, the work tool is positioned laterally, and the resistance force acting on it can cause the machine to turn [1].



Figure 1 – Work during laying and widening of road shoulders

Directional stability issues are particularly relevant for agricultural tractor units, as proper soil cultivation is the first step to a good harvest. For example, to maintain a straight course with a reversible plow, the operator must adjust the direction of travel every hundred meters.

The mismatch between the plow's working width and the tractor's width results in asymmetry in the plowing units, further exacerbating the tractor's directional stability (Figure 2).

To maintain straight-line movement, the driver must constantly adjust the machine's steering. On wheeled tractors, the steering wheel is adjusted 15-20 times for every 100 meters of travel. On tracked tractors, the clutch control lever is adjusted every 4-6 meters of travel. This leads to increased operator fatigue, a 10-15 % reduction in productivity, and increased wear on transmission components. [2].

Uncontrolled steering can also occur when working with rotary and disc plows, as it is caused by the rotation of the working parts relative to the longitudinal axis of the tractor [3] (Figure 3).



Figure 2 – Tractor with a plowshare ploughing



Figure 3 – Tractor with a rotary plow

Another example of an eccentric external force acting on a working implement is an agricultural tractor with a cantilever mower (Figure 4).

Lateral movement of the mower results in lateral displacement of the working implement's drag force, which can distort its trajectory. To ensure the required quality of work, the tractor operator is forced to perform additional work

cycles to cover untreated areas. This, in turn, leads to additional soil compaction, which negatively impacts soil quality [4, 5]. Reducing soil compaction can be achieved by increasing the contact area of the drive unit with the soil, which is why tracked drives are widely used for this purpose. For example, plowing, as the most energy-intensive operation, makes tracked drives the most appropriate choice [6].



Figure 4 – Tractor with a cantilever mower

Thus, directional stability issues are relevant for virtually all tractor units. Loss of directional stability necessitates constant adjustments to the tractor unit's controls, which increases operator fatigue, reduces process productivity, and contributes to increased wear on transmission components. The need for constant monitoring of the machine's course requires developing control systems that compensate for external forces. This requires studying the motion of the tractor unit, taking into account external forces from the implements.

Reference

1. Shevchenko V. et al. Mathematical model of a motor-grader movement in the process of performing working operations // IOP Conference Series: Materials Science and Engineering. 2020. vol. 985(1). no. 012009.
2. Tarasenko B. et al. Optimization parameters of innovative harrow for sorgo production in Burundi // Bio Web of Conference, 2023, vol. 71, no. 01051.
3. Ghezavati J., Abbasgholipour M., Mohammadi A.B. Modeling and Design of a Disk-Type Furrow Opener's Coulter Its Mechanical Analysis and Study for No-Till Machinery (Combination and Bertini) // The International Journal of Advanced Manufacturing Technology. 2017. Vol. 10(4). P. 63–73.
4. Kumar S. Assessment of power, energy and torque of powered disc through soil // Research in Agricultural Engineerin. 2016. Vol. 53(3). P. 1-9.
5. Mattetti M., Varani M., Molari G. Influence of the speed on soil-pressure over a plough // Biosystems Engineering. 2017. Vol. 156. P. 136-147.
6. Mak J., Chen Y., Sadek M.A. Determining parameters of a discrete element model for soil – tool interaction // Soil and Tillage Research. 2012. Vol. 118. P. 117–122.