IMPROVEMENT OF THE SPRAYER BOOM MECHANISM USING POLYMER-COMPOSITE FRICTION ELEMENTS

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Abstract: *The paper considers the selection of anti-friction materials for the friction units of the boom positioning and stabilization mechanism of the John Deere 732 sprayer. The modernization is aimed at reducing wear and clearance in articulated and guiding joints, because their technical condition directly affects boom stability and the uniformity of working-fluid application. PTFE-based and polyamide composites are compared with Steel 45 in terms of density, compressive strength, friction coefficient, wear resistance and corrosion resistance. The analysis shows that polymer-composite materials are advantageous for low-speed oscillating joints operating under dust, moisture and limited lubrication. A combined polymer-composite element that can perform the functions of a sliding bearing and a spacer bushing is proposed for the most wear-sensitive joints.*

Key words: *sprayer, boom mechanism, friction unit, PTFE composite, polyamide composite, sliding bearing, wear, clearance, anti-friction material.*

The quality of pesticide application depends not only on nozzle characteristics and liquid-delivery parameters but also on the stability of the sprayer boom. Wear of articulated and guiding joints produces clearances that change the spatial position of the boom. Because agricultural booms have a considerable working width, even small clearances in support points can cause noticeable displacement of the outer sections. As a result, nozzle height varies, spray-pattern overlap becomes nonuniform, and local over- or under-application of the working fluid may occur [1]. The John Deere 732 boom lifting, lowering and height-control mechanism contains a system of levers, guides and numerous movable joints. During operation, the most highly

loaded connections are subjected to repeated angular motion, sliding contact, vibration and variable dynamic forces. The source design analysis identifies these joints as the principal locations where wear increases clearance and gradually reduces positioning accuracy. Therefore, improvement of the friction units is a rational way to increase the stability and service life of the boom mechanism.



Fig. 1. Boom lifting and positioning mechanism of the John Deere 732 sprayer

Conventional friction pairs in such mechanisms may use steel elements together with bronze or powder-metal bushings. Under long-term exposure to dust, moisture, vibration and alternating loads, both the bushing and the mating steel surface can wear. Replacing only a worn bushing does not always restore the original geometry when the shaft or pin has also been damaged. For this reason, the use of nonmetallic anti-friction materials is of interest. Polymer composites combine low density, low friction, corrosion resistance, damping capacity and the possibility of operation with limited or no lubricant [2, 3]. The data show that Steel 45 has the greatest compressive strength, but its density and friction coefficient are substantially higher. For the investigated joints, ultimate strength is not the only determining factor. These connections operate at relatively low sliding speed and are more strongly affected by repeated oscillation, contamination, moisture and insufficient

lubrication. Under these conditions, a lower coefficient of friction and improved wear behavior can be more important for preserving the geometry of the joint over a long service period [4]. The polyamide composite has the lowest density, 1.15 g/cm³, and a compressive strength of 136 MPa. Its friction coefficient is higher than that of the PTFE composite but remains much lower than the value given for Steel 45. The material can therefore be considered for bushings, guide inserts and other low-speed joints where low mass, corrosion resistance and satisfactory anti-friction behavior are required. From a tribological point of view, the expected effect of the modernization is associated with three mechanisms. First, the lower friction coefficient reduces resistance to relative motion and the loading of adjacent elements. Second, higher wear resistance slows the increase in clearance and therefore helps preserve boom positioning accuracy. Third, the corrosion resistance and ability to work with limited lubrication make polymer-composite parts suitable for agricultural service conditions, where regular lubrication of every joint may be difficult [5, 6]. The comparative analysis confirms the technical feasibility of using polymer-composite materials in the friction units of the John Deere 732 boom mechanism. PTFE-based composites are the most attractive for joints in which minimum friction and high wear resistance are required, while polyamide composites provide a favorable combination of low density and sufficient compressive strength. Replacing selected traditional friction elements with a combined sliding-bearing/spacer component can reduce wear-related clearances, stabilize the relative position of mechanism links and create prerequisites for more uniform positioning of the sprayer boom during field operation.

References

1. Clijmans L., Ramon H., De Baerdemaeker J. Sprayer boom motion, Part 1: Derivation of the mathematical model using experimental system identification theory. Journal of Agricultural Engineering Research. 2000. Vol. 76. No. 1. P. 61–69. DOI: 10.1006/jaer.2000.0530. ScienceDirect

2. Anlama Y., Yapıcı H. Tribological behaviours of carbon filled polytetrafluoroethylene (PTFE) dry journal bearings. Wear. 1998. Vol. 221. No. 1. P. 61–68. DOI: 10.1016/S0043-1648(98)00258-0. ScienceDirect

3. Babii A. Parameters investigation for independent pendular suspension of sprayer boom. Scientific Journal of the Ternopil National Technical University. 2019. DOI: 10.33108/visnyk_tntu2019.04.090. sj.tntu.edu.ua

4. Güngör K., Demirer A. Dry friction and wear of graphite-filled PTFE composites using Taguchi approach. Journal of Scientific & Industrial Research. 2024. Vol. 83. P. 1161–1171. DOI: 10.56042/jsir.v83i11.8397. or.niscpr.res.in

5. Ooms D., Ruter R., Lebeau F., Destain M.-F. Modelling the effect of passive vertical suspensions on the dynamic behaviour of sprayer booms. Journal of Agricultural Engineering Research. 1999. Vol. 72. No. 3. P. 217–229. DOI: 10.1006/jaer.1998.0366. ScienceDirect

6. Gu D., Zhang L., Song K., Liu S. Significant reduction of the friction and wear of PMMA based composite by filling with PTFE. Polymers. 2018. Vol. 10. No. 9. Art. 966. DOI: 10.3390/polym10090966. PubMed Central (PMC)

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ENGINEERING JUSTIFICATION OF A ROTARY STAND FOR ENGINE REPAIR AND MAINTENANCE

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Abstract: *The paper presents the design and engineering justification of a stationary rotary stand for engine assembly and disassembly during repair operations. The stand provides secure mounting of the cylinder block, controlled rotation about a horizontal axis and convenient access to the lower, side and end surfaces of the engine. The proposed structure includes a welded frame, two uprights with reinforcing gussets, a worm geared drive, a bearing-supported rotary shaft,*