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A NEW STRUCTURE OF THE STABILIZATION SYSTEM OF A SUSPENDED SPRAYER BOOM[1]

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ABSTRACT

The paper presents a new system that stabilizes a sprayer boom in the vertical plane. The presented system is protected by patent law. The article shows, inter alia, the idea and principle of operation of the stabilization system of the sprayer boom which uses the centre of gravity of the sprayer boom frame suspended on the beared axis of a sprayer. The angle of deflection of sprayer boom arms depends on the height/depth of an obstacle for tractor wheels. The stabilization system is designed for use with a field suspended sprayer and is one of the systems based on passive elements. The main design assumption was to develop a system that ensures a satisfactory level of stabilization of a boom and maintaining acceptable production costs. The presented solution is prepared for realization and for carrying out field research.

Introduction

Effectiveness of chemical plant protection depends on many factors. A biological result is obtained at maintenance of the appropriate type, dose, time limit and conditions of the treatment. An incorrect method of spraying often results in unavailability of the planned effect. It often happens that the spraying treatment is carried out on fields with considerably uneven surface. Such surface causes, inter alia, fluctuations of a sprayer boom in the vertical plane, which results in irregular deposition of working liquid on sprayed plants (Lipiński et al., 2011). On the sprayed area which corresponds to the working width of a sprayer both deposition of too high amount of liquid, namely, its "overdosing" as well as deposition of too low amount of liquid, namely its "underspraying" may take place. Both cases are undesired and the simplest way to avoid them is to ensure that during the spraying treatment a sprayer boom is constantly parallel to the sprayed surface of plants (Hołownicki, 2005; Szulc, 2011; Szewczyk et al., 2010).

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In order to eliminate unfavourable phenomenon, which is fluctuation of a sprayer boom during spraying, stabilizing systems embodied in the structure of sprayers are used. The stabilization systems of a sprayer boom used in sprayers are based on two basic structural systems: a trapezoid and fluctuation (Anthonis et al., 2005; Lipiński et al., 2011; Popławski and Szulc, 2010). Regardless their structure, they are used to limit the boom movements, mainly in the vertical plane. Generally, it should be stated that stabilization of a sprayer boom of a sprayer during its operation is not easy and systems used for this purpose are frequently based on complex technical solutions with a complicated structure and are expensive in realization. It often happens that their value exceeds the cost of the remaining structure of a sprayer.

It forces to search for new solutions, optimal in the context of compromise between the quality of stabilization and costs of making the system. Hence the inspiration to undertake this issue and the attempt to develop a new structure of the stabilization system of a sprayer boom.

The paper shows basic solutions applied in order to stabilize a sprayer boom and a proposal of a new, innovative, mechanical stabilization system of sprayer boom position in the vertical plane was presented.

Objective and scope of the study

The objective of the paper was to present the problem concerning a correct way of leading a sprayer boom over the sprayed objects and discussion on commonly applied stabilization systems of a sprayer boom. Based on the analysis of the existing solutions, a new system that improves stability of a sprayer boom dedicated for small farms, description of which constitutes a basic content of the article, has been described. The presented system was granted patent protection (Lipiński and Sobotka, 2014).

Stabilization systems of a sprayer boom

Operations of the systems which are used for stabilization of a sprayer boom are based on the fundamental physics law. There are two basic structures of stabilization systems. Pendulum systems (fig. 1a) work on one pull rod and joint, whereas trapezoid ones (fig. 1 b) on two pull rods and four joints. A sprayer boom returns to balance under the influence of gravitational force.

Both methods are the simplest in structure and operation. Such a structure favours uncontrolled movements which could unfavourably influence the quality of the treatment. Particularly in sprayers with the boom length exceeding 10 m, correct leading of a boom over the sprayed objects is considerably impeded. In such cases, more complex systems are used, which aim at the correction of sprayer boom vertical and horizontal deflection. Stabilization systems differ with the place and manner of use and are divided into systems which use only passive elements such as shock absorbers or stabilizing springs (Kamiński and Kruk, 2012; Kennes et al., 1999; Rahman et al., 2011), and systems with active elements such as e.g. servomotors controlled based on signals from electronic (most frequently ultrasound) distance sensors (Deprez et al., 2002; Jeon et al., 2004; Tahmasebi et al., 2012).

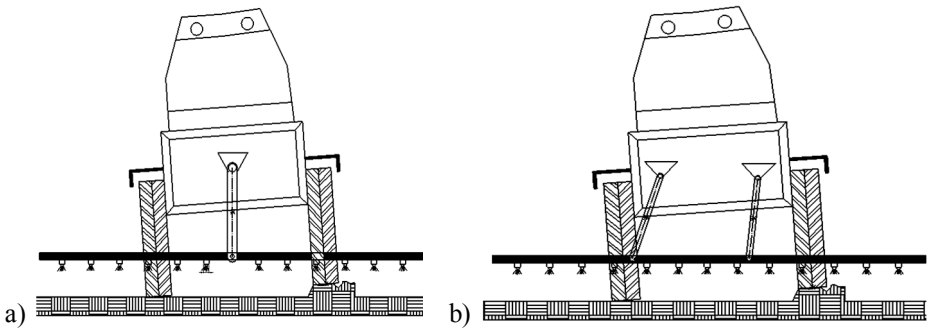

Figure 1. Pendulum (a) and trapezoid (b) stabilization system of a sprayer boom

Regardless the approach, the aim is to always maintain the distance of sprayers from the sprayed plants, because such location of a sprayer boom allows obtaining the highest quality treatment (Szulc, 2011).

Description of the new stabilization system of a sprayer boom

The control system of the sprayer boom leading, which has been shown in figure 2, is a passive system. The basis of the developed solution is the use of the centre of gravity and the force of gravity. In order to keep the boom perpendicularly to the surface (of sprayed plants) connectors and flat bars were used. The leading system of a boom consists of the main frame of a sprayer (1) where a rotation axis is mounted stiffly (2). A sprayer boom frame (3) is suspended on the rotation axis. The rotation axis is mounted in the centre of gravity of the main frame and goes through the centre of gravity of the beared frame of a sprayer boom. On the frame of a sprayer boom there are plugs mounted (4) where arms of a sprayer boom are suspended: left (5) and right (6). Internal ends of the boom arms are connected to leading levers (7) with a lever connector (8), mounted on the axis through cylindrical gum shock absorbers (9).

A stable balanced position of the sprayer boom suspended frame is guaranteed by the use of additional leading elements, i.e. levers, which influence directly the sprayer boom arms. Connection of the axis with a leading connector through cylindrical gum shock absorbers eliminates direct vibrations.

The presented stabilization system is equipped with the connection system which ensures stable position of sprayer boom arms when a sprayer is in the rest state as well as correct lead of the sprayer boom arms during operation of a sprayer. Operation of the stabilization system depends on the position of a sprayer towards the field surface. Each deflection of a sprayer from the parallel surface of a field should be immediately and automatically corrected on the sprayer boom arms.

In order to know the operation of the system better, a case was described when left wheels of a sprayer meet an obstacle in the form of a furrow: a sprayer will deflect from the parallel position and the rotation axis will automatically turn left in the sprayer boom frame. The pressure made by a leading connector, will turn the left arm of the field boom in the vertical plane by such an angle as defection of the entire unit.

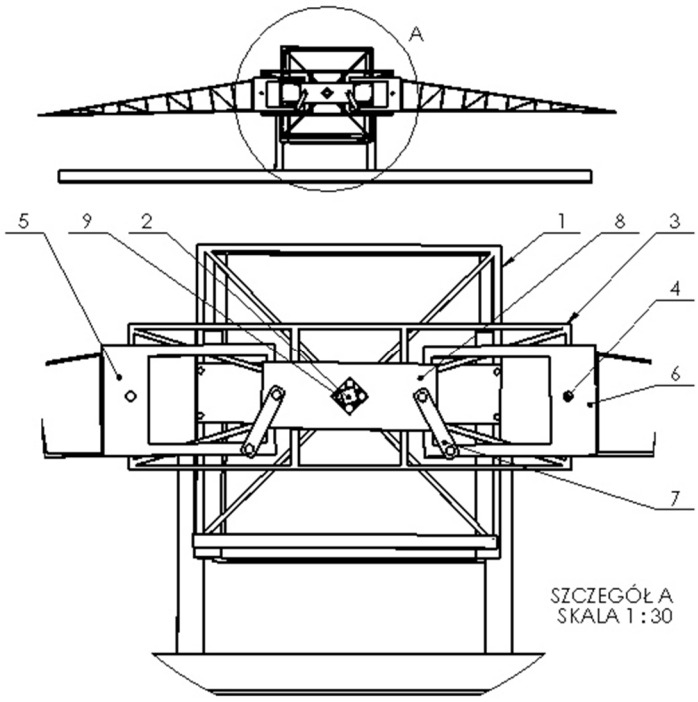

Figure 2. The stabilization system of a sprayer boom - view from the back in the spread position along with an enlarged A detail: 1 – main frame of a sprayer, 2 – rotation axis, 3 – sprayer boom frame, 4 – plugs, 5 – left arm of sprayer boom, 6 – right arms of sprayer boom, 7 – leading levers, 8 – lever connector, 9 – gum shock absorbers.

Analogically, the right arm of a sprayer boom will drop in the opposite direction to the arm of a boom so that the entire boom is positioned parallel to the surface of a field (fig. 3). It means automatic correction of the boom position. In case, a tractor drives with its right wheels into a furrow, the system will act identically but in the reverse order.

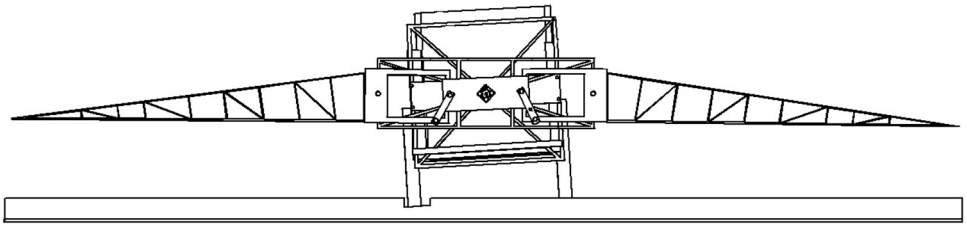

Figure 3. Operation of the stabilization system after left wheels of a tractor drive into a furrow

Summary and conclusions

The presented system is a modern technical solution, which ensures stabilization of a sprayer boom suspended on a tractor in case it meets obstacles during spraying. For this purpose, the suspension system of a sprayer boom in the centre of gravity was applied. It uses deflection of the unit towards the deflection of the relevant side of a sprayer boom. The presented system is a typical mechanical solution, relatively simple in its structure, which reacts directly when a sprayer meets obstacles. The system may be used in suspended sprayers dedicated for smaller farms. The suggested solution includes vertical movements of a sprayer boom, which result from the change of angle from the horizontal position of a sprayer. However, it does not include side horizontal movements. Work is carried out to construct a prototype of the described solution. Further, research aiming at assessment of the effectiveness of operation of the stabilization system in field conditions is planned.

An estimated cost of production of a prototype stabilization system of a sprayer boom is approximately five thousand PLN and includes costs of purchase of materials and construction of the stabilization system of a sprayer boom ready to be mounted on a field sprayer.

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NOWA KONSTRUKCJA UKŁADU STABILIZACJI BELKI POLOWEJ OPRYSKIWACZA ZAWIESZANEGO

Streszczenie. W pracy opisano nowy układ stabilizujący belkę polową opryskiwacza w płaszczyźnie pionowej. Zaprezentowany układ jest chroniony prawem patentowym. Artykuł pokazuje m.in. ideę i zasadę działania układu stabilizacji belki polowej, wykorzystującego środek ciężkości ramy belki polowej zawieszonej na ułożyskowanej osi opryskiwacza. Kąt wychylenia ramion belki polowej uzależniony jest od wysokości/głębokości przeszkody napotkanej przez koła ciągnika. Układ stabilizacji przeznaczony jest do zastosowania z opryskiwaczem polowym zawieszanym i należy do systemów opartych na elementach biernych. Głównym założeniem projektowym było opracowanie układu zapewniającego satysfakcjonujący poziom stabilizacji belki przy zachowaniu akceptowalnych kosztów produkcji. Zaprezentowane rozwiązanie jest przygotowywane do realizacji oraz przeprowadzenia badań polowych.

Słowa kluczowe: opryskiwacz polowy, jakość oprysku, układ stabilizacji belki polowej