

## MODELING OF THE UNIT FOR STRIP TILL, FERTILIZATION AND CORN SOWING

### Summary

The paper presents virtual model of the unit for strip till, fertilization and corn sowing, developed by the Industrial Institute of Agricultural Engineering (PIMR) in Poznań under the project PBS1/B8/4/2012. We discuss the construction of the unit with a particular attention to the position of fertilizer seeder, which sows fertilizer behind soil loosening teeth, and corn seeder, which sows corn in strips of cultivated soil.

**Key words:** strip till, fertilizing, seeding, combined treatment, agregate unit

## MODELOWANIE AGREGATU DO UPRAWY PASOWEJ, NAWOŻENIA I SIEWU KUKURYDZY

### Streszczenie

Przedstawiono model wirtualny agregatu do uprawy pasowej, nawożenia i siewu kukurydzy, opracowany w Przemysłowym Instytucie Maszyn Rolniczych w Poznaniu w ramach projektu PBS1/B8/4/2012. Omówiono budowę agregatu ze szczególnym uwzględnieniem położeń siewnika wysiewającego nawóz za zębami spulchniającymi glebę oraz siewnika wysiewającego kukurydzę w pasy uprawionej gleby.

**Słowa kluczowe:** uprawa pasowa, nawożenie, siew, zabiegi łączone, agregat

### 1. Introduction

Seed drill combinations are more widely used in national agriculture. By simultaneously performing two operations they provide savings of time and fuel, and also protect soil [3], which is less compacted by tractor wheels. More and more frequently manufacturers also offer units allowing simultaneous application of fertilizers. The biggest energy savings are provided by units designed to strip till, sowing and fertilizing, because in addition to performing several operations they simplify soil cultivation, limiting it to tilling only narrow strips of field. Strip till has the advantages of intensive tillage and direct sowing [1], and is used in growing plants sown in rows with wide spacing (eg. corn, beets). The most important advantages of strip till, except energy savings, are protection against soil erosion, conservation of soil water and continuity of biological life in soil profile, and also good conditions for plant growth, thanks to deep soil loosening and application of fertilizer precisely in rows.

Industrial Institute of Agricultural Engineering in Poznań has developed, within the project PBS1/B8/4/2012, virtual model of the unit for strip tillage, fertilizing and seeding corn, which was the basis for subsequent simulation studies and the design and construction of a prototype [4]. Three-dimensional geometric model is base to create computational model used during computer simulations [2], which include kinematics and strength analysis. While developing virtual unit model different positions of components during work and transport were taken into account. The virtual model unit was developed based on assumptions in the draft functional design, in a way enabling weight estimation.

### 2. Functional and design assumption

Virtual model of the unit was developed based on functional and design assumption, which set out the following requirements:

- unit is designed to strip till, fertilize and sow 4 rows of corn at a spacing of 75 cm,
- modular structure allows separable or simultaneous strip tillage with deep fertilizer application and corn sowing with shallow fertilizer application,
- mechanical fertilizer seeder, built on tillage unit,
- pneumatic corn seeder, suspended on tillage unit through coupler.

These requirements impose:

- use of semi-mounted frame and trolley with wheels adapted to the spacing of the rows and hydraulically moved to obtain required transport and working position of unit,
- placement of fertilizer seeder above strip till sections, to allow safe access to the tank, mechanical subsoil application of fertilizer and lift of overloaded tillage sections,
- placement of coupler for corn seeder on trolley, hydraulic adjustment of coupler to obtain required transport and working position of corn seeder at different positions of trolley relative to the unit frame.

### 3. Unit structure

Unit for strip tillage, fertilizing and corn seeding (fig.1) consists of two modules. First module allows simultaneous strip tillage and deep application of fertilizer, second module allows simultaneous corn seeding and shallow fertilizer application. Complete unit consists of:

- support frame with drawbar and trolley with wheels,
- four strip tillage sections,
- fertilizer seeder,
- coupler for corn seeder,
- corn seeder,
- hydraulic system.

**Support frame** is equipped with drawbar and trolley. Drawbar is mounted on front frame grip with pins and adjustable strut. Stand and crossbar, which can swing in the horizontal and vertical plane are mounted on drawbar. Trol-

ley is attached to back frame handlers with pins and two hydraulic cylinders which change its position. Trolley wheels have a spacing of 1500 mm and at work are set between strips of loosed soil.

**Working sections**, which prepare narrow strips of soil for corn seeding and apply fertilizer into soil, are mounted on handlers in the middle of the frame. Complete working section consists of: coulter, wheels, cleaning stars, tooth with tube which applies fertilizer, discs and tube-disc roller. Tooth, discs and roller are mounted on a swing arm with leaf spring overload protection. Soil tillage depth and fertilizer application depth is set by wheels and rollers arrangement.

**Fertilizer seeder** consists of tank, four dosing rotors, rotors shaft, mixer and electric motor to drive rotors shaft and mixer. Tank is supported on main frame with four stands. Below each rotor there is a tube with elastic pipe, where fertilizer falls into tooth tube. Safe access to fertilizer seeder is provided by platform with railing and foldable ladder.

**Coupler for corn seeder** consists of four arms forming parallelogram and hydraulic cylinders changing its position. Front coupler arm is mounted on trolley and is connected to the main frame with links. Hitches and upper pin hole forming three point linkage for corn seeder are located on rear arm.

**Corn seeder** is second module, apart from pneumatic corn seeding, allows mechanical sowing of starter fertilizer. Seeder is supported by two wheels, at a spacing of 1500 mm, driving, through the gear, corn seeding sections distributors and fertilizer feeders. Seeding sections of coupled corn seeder are located directly behind working sections of first module, so the corn seeds are sown in the middle of soil tilled strip. Starter fertilizer is sown with disc coulters next to corn rows.

**Hydraulic system** of the unit for strip tillage, fertilizing and corn seeding consists of four circuits:

- hydraulic cylinders changing position of the trolley,
- hydraulic cylinders changing position of corn seeder coupler,
- hydraulic motor driving fan of the corn seeder,
- hydraulic cylinders changing position of the row marker.

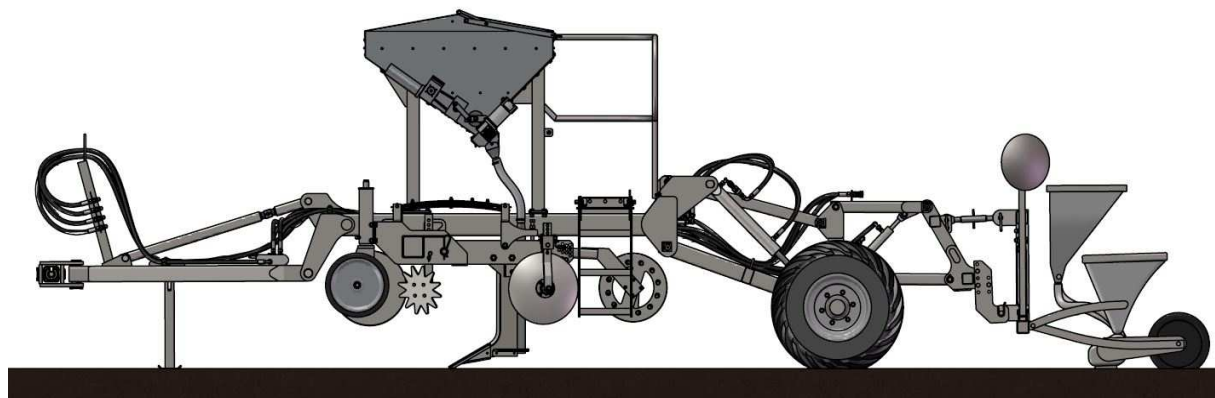
Hydraulic hoses are guided along support frame center beam. Quick couplers of supply hoses powering hydraulic motor fan are connected directly to the tractor. Supply hoses powering hydraulic cylinders are connected to the tractor through hydraulic valve module located on the drawbar and controlled with cord from tractor cab.

#### 4. Position of the corn and fertilizer seeders

Fertilizer seeder was located on the unit so that the overloaded working sections can lift without collision below the tank (fig. 2) and elastic pipe connecting rotors and tooth tubes and without undergoing deformation and blocking fertilizer flow. Safe access to the tank is achieved by use of platform with railing and foldable ladder. Platform also provides an access to the regulation points of central working sections.

Range of trolley and coupler hydraulic cylinders motion was selected to satisfy following positions:

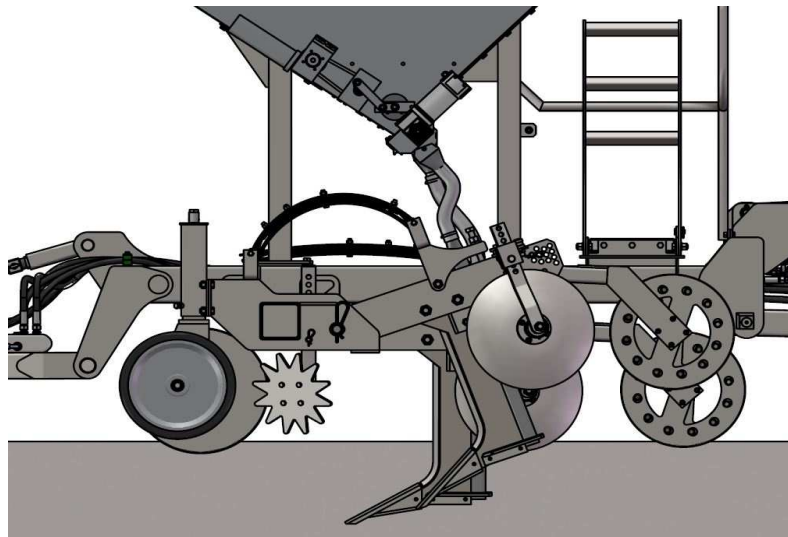
- rest position (fig. 1) with stable support on the ground,
- transport position (fig. 3) maintaining required (minimum 25 cm) clearance,
- working position including three phases during corn seeding from the start to the end of tilled strips:
  - start of strip tillage [lowered main frame with tillage sections and lifted corn seeder (fig. 4)],
  - tillage and corn sowing [lowered main frame with tillage section and corn seeder (fig. 5)],
  - end of strip tillage [main frame lifted on trolley and lowered corn seeder allowing sowing until the end of tilled soil strips (fig. 6)].



Source: author's own study / Źródło: opracowanie własne

Fig. 1. Geometric model of unit strip till, fertilization and corn sowing (resting position)

Rys. 1. Model geometryczny agregatu do uprawy pasowej, nawożenia i siewu kukurydzy (położenie spoczynkowe)



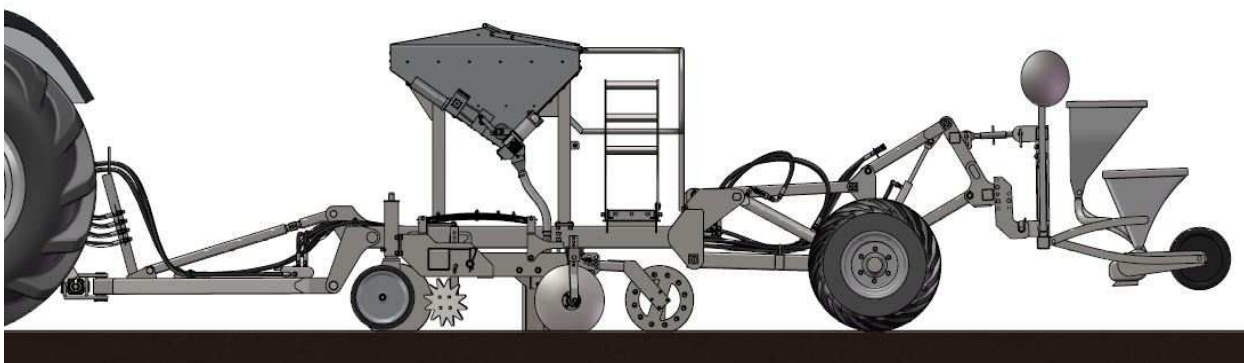
Source: author's own study / Źródło: opracowanie własne

Fig. 2. Overloaded tooth deflection under the fertilizer tank  
 Rys. 2. Wychylenie przeciążonego zęba pod zbiornikiem nawozu



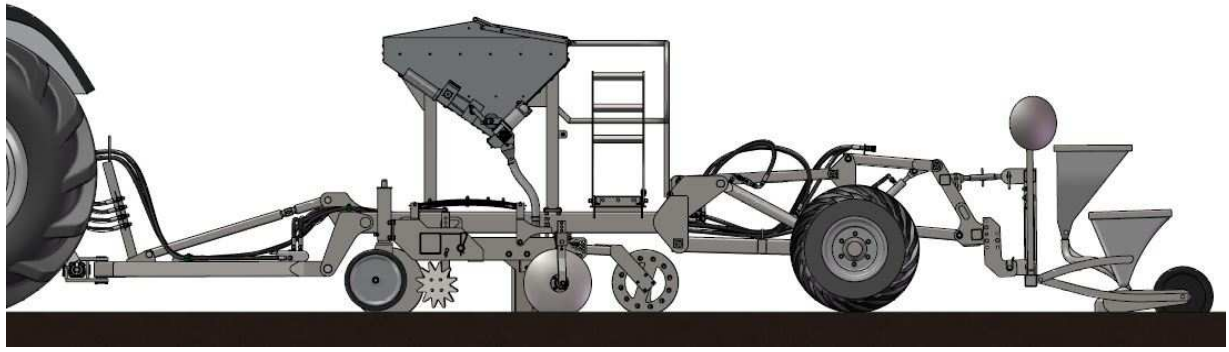
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Fig. 3. Unit in the transport position  
 Rys. 3. Agregat w położeniu transportowym



Source: author's own study / Źródło: opracowanie własne

Fig. 4. Unit in the operating position at the start of the strip tillage  
 Rys. 4. Agregat w położeniu roboczym podczas rozpoczęcia uprawy pasowej



Source: author's own study / Źródło: opracowanie własne

Fig. 5. Unit in the operating position at the start of the corn sowing from the point where strip tillage was started  
Rys. 5. Agregat w położeniu roboczym podczas rozpoczęcia siewu kukurydzy od początku śladów uprawy pasowej



Source: author's own study / Źródło: opracowanie własne

Fig. 6. Unit in the operating position during corn sowing until the end of strip till trace  
Rys. 6. Agregat w położeniu roboczym podczas siewu kukurydzy do końca śladów uprawy

## 5. Conclusion

1. The virtual model of the unit for strip till, fertilization and corn sowing complies with accepted in the project functional and structural assumptions in terms of modularity and required transport and working positions.

2. The virtual model of the unit for strip till, fertilization and corn sowing takes into account the load-bearing profiles and reflects the weight, so it can be the basis for simulation studies.

## 6. References

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