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SELF-PROPELLED HARVESTER WITH AN ELECTRICAL TRACTION DRIVE IN COMPARISON TO THE HYDRAULIC TRACTION DRIVE

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Abstract: Sugar Beet Harvesters belong to self-propelled agricultural machinery for trimming, lifting, cleaning and collecting sugar beets. Like most harvesting machines such vehicles are equipped with hydrostatic traction drives to ensure a continuous variable speed adjustment for the harvesting process. These drives are state of the art but rather moderate in efficiency. For further enhancement of efficiency the hydrostatic system was replaced by a diesel-electric traction drive. The two different systems were tested and compared in simulation and field. As a result, improved driving performance at reduced fuel consumption could be achieved.

Keywords: DIESEL-ELECTRIC, HYDROSTATIC, SELF-PROPELLED HARVESTER, SUGAR BEET HARVESTER, EFFICIENCY

1. Introduction

Nowadays modern agriculture utilizes self-propelled harvesters, such as combine harvesters for grain, forage harvesters, harvesters for beets and potatoes or sugar cane and cotton harvesters. This type of harvesting machines is characterized by high productivity in terms of tons per hour or hectares per hour. The vast majority of these self-propelled harvesters are equipped with hydrostatic drive technology, which allows comfortable and fast adjustment of varying ground speeds according to the different harvesting conditions, and which includes reverse operation and quick stop without the need of switching gears or hitting breaks. Other requirements on the propulsion system of self-propelled agricultural harvesting machines are fast response, high torque at low speeds, transport speeds from v = 20 kph up to 40 kph, high efficiency at all load conditions, and slip and traction control in terms of soil protection.

So far, hydrostatic drive systems have met these requirements best, specifically in consideration of weight and cost. However, a major disadvantage of hydraulics is the moderate efficiency [1], especially in the part-load operational range. The spectrum of load cycles in the operation of self-propelled harvesters is characterized by a wide range of operating points which makes the optimization of a high overall efficiency fairly impossible. With regard to high installed engine capacities and rising fuel costs this is essential.

Electric drives are characterized by a higher efficiency compared to hydraulics and with a very slow decrease in efficiency towards the partial load range. Excellent controllability and dynamic behaviour exceed the corresponding capabilities of mechanical or hydraulic drives. Additional advantage is the built-in current and voltage measurement, which delivers information about the drive torque at any time and with high accuracy.

Analysts [2] expect that in future electrification of drive trains will be used in mobile agricultural machinery and implements with the purpose of efficiency increase and functional enhancements. Electrified traction drives of self-propelled harvesters are an important step in that direction.

2. Initial Situation

In a collaborative project Sensor-Technik Wiedemann GmbH, ROPA Fahrzeug- und Maschinenbau GmbH, and TU Dresden implemented a diesel-electric traction drive system in a self-propelled sugar beet harvester (Fig. 1). This machine is characterized by a net weight of about 30 tons, which increases up to 60 tons when the hopper is completely filled with harvested beets. Harvesting operation mainly takes place between autumn and winter, sometimes under very difficult ground conditions. As a result and in comparison to other self-propelled harvesting machines, the power requirements of the traction drive are high, ranging from 100 kW – 300 kW with a very wide distribution of operating points. The annual harvesting area of a beet harvester is between 600 ha and 1200 ha, equivalent to about 75 000 t of sugar beets. An average fuel consumption of 40 to 50 l/ha leads to a fuel cost of about one third of the total operating costs.

3. Hydrostatic Drive Train

The conventional, hydrostatic drive train of the self-propelled, three-axle beet harvester ROPA euro-Tiger V8-3 uses a variable displacement hydraulic pump (Fig. 2, position 9), which is mounted to the main transfer gear box (Fig. 2, position 8). This gear box is located behind the flywheel (Fig. 2, position 7) of the diesel engine and drives another twelve hydraulic pumps for functional components with variable speed.

The hydraulic power unit to drive the vehicle for traction is a variable displacement pump in swash plate design with a rated power of P = 343 kW. The hydraulic power is converted by two hydraulic motors in bent axis design, one with constant displacement (Fig. 2, position 1) and the other with a variable displacement (Fig. 2, position 2). The beet harvester is all-wheel driven by a central gearbox (Fig. 2, position 3) with two gears where both the motors are directly mounted. The first gear enables vehicle speeds from 0 to 14 kph, the second from 0 to 20 kph, optional up to 25 kph.

Power is distributed by a cardan shaft to the front axle (Fig. 2, position 4) and the two rear axles (Fig. 2, position 5 and 6), respectively. The front axle is designed as a portal axle with a central differential gear and planetary final drives. In the first and second rear axle differential gears and planetary gears as final drives are integrated like in the front axle. Furthermore the last axle is equipped with an axle load control. All wheels feature kingpin steering whereas, additionally, an articulated steering is implemented between the front axle and the first rear axle [4].

4. Determination of Load Collectives

For the changeover of the hydrostatic traction drive to the diesel-electric traction drive the current drive requirements on a conventional machine were determined. During beet harvest 2010 a total of about 200 h of harvest and road operation were recorded on two machines. Using drive train pressure and flow volumes, drive performance and traction requirements could be calculated. Data were analysed, transformed into class frequency and residence time distributions, and thus load collectives could be formulated. It was found that the vehicle speed during harvest ranges from 6 to 8 kph.
5. Electric Drive Train

For the electric drive the central drive concept of the hydraulic drive train was kept. The hydraulic pump was replaced by two generators with a rated power of $P = 140 \text{ kW}$ each at a speed of $n = 3000 \text{ min}^{-1}$ [5]. A gearbox was implemented, which is flanged to the former pump drive, shifting the input speed of the generators to a higher range to assure a favourable efficiency of the electrical machines.

The hydraulic motors were substituted by two electric motors with a rated power of $P = 140 \text{ kW}$ respectively at a speed of $n = 3000 \text{ min}^{-1}$ [6]. Here as well a matching gear was mounted between the motors and the gearbox to run the motors at the desired speed. All the electrical machines are identically constructed, permanently excited synchronous machines cooled by isolating transformer oil. The overload capacity of the electric machines is 30 %. A brake chopper limits the maximum DC voltage in the DC link between the generators and electric motors working with a voltage level of 650 V. Additional energy storage in form of a battery or supercapacitor does not exist at the moment.

Currently the mass ratio of electric to hydrostatic drive including the two matching gears is 3.3:1 without considering the cooling.

6. Simulation and Field Tests

In parallel to the integration of the electric drive system into a real machine, the conventional hydraulic and the alternative electric traction drive were simulated based on the load collectives determined. The simulated multi-body models represent the complete drive train including the diesel engine, the generators and the electric motors (electric drive train) or the pump and the hydraulic motors (hydraulic drive train), the mechanical central drive, and the contact between wheel and soil.

The simulation provides comparative statements for the effectiveness, efficiency, and fuel consumption of the electric and the hydraulic system. The increase in efficiency of the drive train ranges from 20 % up to 30 % in accordance with the simulation results; therefore the fuel consumption is reduced about 20 %.

The first functional tests of the electrified machine were carried out during 2011 beet harvesting period. All driving functions for road and field operation were checked. Subsequently, in April 2012 the electric and hydraulic harvesters were compared in field tests by tractive force measurements, carried out with a tractor-cultivator combination as braking vehicle (Fig. 3).

To record the full-load curve in the operating diagram the maximum vehicle speed was approached in the respective gear. The braking vehicle increased the load continuously until the vehicle speed fell according to the tractive output hyperbola. For the determination of working points within the operating diagram specific vehicle speeds were set gradually as shown in Fig. 4 with bright colours. While increasing the load of the braking vehicle, the harvester speed fell when reaching the full-load curve. During these tests the parameters tractive force, GPS-based vehicle speed, fuel consumption, and performance data in the drive train were recorded, i.e. flow rates, pressures, temperatures, as well as currents and voltages. These parameters were used to calculate input and output power and to create a characteristic diagram for efficiency.

Exemplary tractive force gear 1

![Fig. 4 Theoretical operating diagram](image-url)
The comparison of the two tractive force diagrams (Fig. 5 and Fig. 6) shows in the first gear at low vehicle speed slightly higher maximum tractive forces for the machine with electric drive. In the upper speed range of the first gear higher vehicle speeds can be reached with the electric machine. It can be concluded that the electric drive train is as effective as the hydrostatic drive train; this means the performance limits of the machine with hydrostatic drive train can be realized and even surpassed by the machine with electric drive.

The efficiency of the drive train is calculated as ratio of tractive power and diesel engine output for the traction drive. For \( v = 6 \) kph, which is a vehicle speed representative for the harvesting process, and a full loading cycle of the hopper, the efficiency is \( \eta = 70.5\% \) for the machine with electric and \( \eta = 46.4\% \) for the machine with hydrostatic drive. Due to the high share of time of this operational range a fuel saving between 10 and 20 \% is possible.

### 7. Cost-benefit Calculation

Under the following conditions, a cost-benefit calculation was made:

- general machine lifetime: 5 years
- annual use: 1000 hectares or 650 operating hours (oh)
- specific fuel costs: 1.30 EUR/l
- assumed rate of interest: 6 \%

All quantities are shown in Table 1 and 2. It is found that the electrified system shows significantly higher investment costs compared to the hydraulically driven machine. However, looking at the annual operating costs, the electric system is more economic.

Based on the above mentioned general conditions, a payback period of approximately 3.6 years can be determined for the electric system compared to the hydraulic one.

### Table 1 Investment costs

<table>
<thead>
<tr>
<th></th>
<th>Electric [EUR]</th>
<th>Hydrostatic [EUR]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drives</td>
<td>32000</td>
<td>6400</td>
</tr>
<tr>
<td>Wires/tubes</td>
<td>2500</td>
<td>590</td>
</tr>
<tr>
<td>Safety equipment/pressure control valves</td>
<td>500</td>
<td>100</td>
</tr>
<tr>
<td>Power electronics/valves</td>
<td>Inclusive</td>
<td>150</td>
</tr>
<tr>
<td>Investment costs, total</td>
<td>35000</td>
<td>7240</td>
</tr>
</tbody>
</table>

### Table 2 Operating costs

<table>
<thead>
<tr>
<th></th>
<th>Electric [EUR]</th>
<th>Hydrostatic [EUR]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil change</td>
<td>250</td>
<td>100</td>
</tr>
<tr>
<td>Fuel consumption/1000 ha</td>
<td>49095</td>
<td>60249</td>
</tr>
<tr>
<td>Operating costs/year</td>
<td>49345</td>
<td>60349</td>
</tr>
</tbody>
</table>

### 8. Conclusion and Outlook

Based on the beet harvester ROPA euro-Tiger V8-3, which is conventionally hydrostatically driven, a machine was equipped with a diesel-electric traction drive. On the one side, both machines were compared in simulations with Matlab/Simulink using load collectives for field and road operation determined in advance. On the other side, field tests were carried out. Due to the higher efficiency of the electric system superiority in terms of fuel consumption could be shown. Despite of the higher investment costs, the current design of the electric system has shown an economic benefit. Furthermore the ecological advantage of saving CO\(_2\) will become more important in future. 

During beet harvesting periods of 2012 and 2013 the electrically driven prototype machine has been successfully used in practice. Load peaks and their frequency during operation could be detected by determining load collectives. Identifying the maximum power requirement and its duty cycle enables the extension of the current serial system to a hybrid system using energy storage. If the storage covers the energy requirements of the load peaks, the diesel engine only has to ensure a basic power supply (phlegmatization); so the load for the engine is smoothed [6]. A smaller diesel engine can be chosen if the basic power is supplied at full engine load (rightsizing).

### Literature


RESEARCH ON RELIABILITY OF PLOWS OPERATING IN MOUNTAINOUS CONDITIONS

Katsitadze J., Academician of the Georgian Academy of Agricultural Sciences, Ph. D., full professor; Kapanadze I., Ph. D. of Agricultural Engineering, assistant professor; Kutelia G., MS in Agricultural Engineering; Bidzinashvili I., BS in Agricultural Engineering.

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Abstract: Characteristics of operational reliability of agricultural plows, operating in mountainous conditions were determined on the basis of theoretical and experimental studies. It is shown that these conditions adversely affect their workability, cause intensive wear of working parts of plows, and lead to failures. For this purpose, special coefficient was introduced which takes into account the impact of mountainous conditions on reliability.

A structural-logical scheme for reliability calculations was determined, and at the level of invention, a fundamentally new plow with variable widths was developed, allowing a better use of its operation in the mountainous conditions.

KEYWORDS: RELIABILITY, PLOWS, FAILURE, STATE OF SERVICEABILITY, MODELING, RELIABILITY INDEX, LIFETIME, REDUNDANCY.

Among complex operations of cultivation of crops, plowing of the soil is the most important and labor-consuming operation which is carried out by plows.

Plows work in severe soil and climatic conditions - their working parts are affected constantly by sign-variable dynamic loadings, humidity of the soil and the abrasive particles in it, difficult relief configuration and exposition. During work in mountain conditions to these factors are added the small featured plots, inclination, a sinuosity of the processed soil and complication of maneuvering of plows in connection with deterioration of traction indicators of tractors. The specified factors cause intensive wear of working parts, reduction of their durability and, as a result, both gradual, and sudden refusals. The latter cause idling of plows, violation of agrotechnical terms of plowings and reduction of a crop of agricultural production. Therefore, increase of reliability of agricultural plows is very important problem of world significance which solving will give big economic effect.

We developed the general technique for calculation of indicators of reliability of agricultural machinery /1,2/ and continued developing this technique achieving our own method of calculation of reliability of plows which considers the specific of work in mountain conditions and nature of connection of their elements in the structural and logical scheme (SLS).

We entered special coefficient K– which considers influence of mountain conditions on indicators of reliability of plows.

\[ K = \frac{P(H)}{P(H)} \] \( \cdots (1) \)

Where \( P(H) \) - the probability of no-failure operation (PNFO) of plows during the work in mountain conditions.

\( P(H) \) - (PNFO) in flat conditions.

Our research /3,4/ showed that this coefficient fluctuates in limits

\[ K = 0.74 - 0.80. \]

Further, for calculation of reliability, we made the structural and logical scheme of plows which considers reservation by means of the additional case (fig. 1).

Theoretical prerequisites and sequence of calculation of reliability of machines depending on a type of connection of elements are described in detail in our work /2/. Our calculations showed that the use of the reserve case increases the probability of no-failure operation of plows by 8-10 percent.

Generally VBR of plows can be determined by a formula:

\[ P(t) = K \cdot P_1(t)P_2(t) \ldots (2) \]

\( P_1(t) \) - PNFO at sudden refusals;

\( P_2(t) \) - PNFO at gradual refusals.

Our theoretical and experimental studies [5,6] showed that in most cases \( P_1(t) \) - is described by the exponential law, and \( P_2(t) \) - by normal distribution. Then (3) the equation will be:

\[ P(t) = K \cdot \frac{e^{-\lambda T}}{\sqrt{2\pi} \sigma} \int_{e^{-\lambda t}}^{\infty} e^{-\frac{(t-\bar{T})^2}{2\sigma^2}} dt \ldots (3) \]

\( \sigma \) - average quadratic deviation of an indicator reliability;

\( \bar{T} \) - Mathematical Expectation of time of non-failure work, h.

\( t \) - operating time of a plow, h.

\( \lambda \) - failure rate, h\(^{-1}\).

fig.1 The structural and logical scheme of a plow for calculation of reliability.
For probabilistic and statistical modeling of the general characteristics of indicators of operational reliability of the plows, working in mountain conditions, field observations were made by the technique developed by us. For collecting of the statistical materials in special journals were fixed the main indicators of operational reliability - time between failures, an operating time between refusals, a type and group of complexity of refusals, an idle time and restoration, dynamics of wear of working parts and others. Experimental research was conducted in mountain areas of Racha-Lechkhumia and Samtske-Javakheti regions of Georgia (Ambrolauri, Oni, Tsageri, Adigeni, Akhalkalaki and Akhaltsikhe areas).

After mathematical processing of statistical data, the empirical frequency of refusals of plows and frequency (statistical probability, table 1) were determined.

**Table 1.**

<table>
<thead>
<tr>
<th>output (in ha) before failures, interval a…b</th>
<th>middle of the interval</th>
<th>output (in ha)</th>
<th>empirical frequency</th>
<th>statistical probability w_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>10…14</td>
<td>12</td>
<td>53</td>
<td>0,33</td>
<td></td>
</tr>
<tr>
<td>14…18</td>
<td>16</td>
<td>33</td>
<td>0,21</td>
<td></td>
</tr>
<tr>
<td>18…22</td>
<td>20</td>
<td>23</td>
<td>0,14</td>
<td></td>
</tr>
<tr>
<td>22…26</td>
<td>24</td>
<td>20</td>
<td>0,13</td>
<td></td>
</tr>
<tr>
<td>26…30</td>
<td>28</td>
<td>13</td>
<td>0,08</td>
<td></td>
</tr>
<tr>
<td>30…34</td>
<td>32</td>
<td>10</td>
<td>0,06</td>
<td></td>
</tr>
<tr>
<td>34…38</td>
<td>36</td>
<td>5</td>
<td>0,03</td>
<td></td>
</tr>
<tr>
<td>38…42</td>
<td>40</td>
<td>3</td>
<td>0,02</td>
<td></td>
</tr>
</tbody>
</table>

Number of intervals of refusals:

\[ K = 1 + 3,2 \cdot \lg \cdot N \ldots (4) \]

where \( N \) – is a quantity of refusals for \( N=160 \), weget \( K=8 \).

Width of the interval \( h = 4 \) ha \ldots (5)

Further, general characteristics of the distribution of refusals were determined:

- Average value
  \[ \bar{H} = \sum_{i=1}^{k} w_i h_i = 19,3 \text{ ha} \ldots (6) \]

- Dispersion
  \[ D = \sum_{i=1}^{k} (H_i - \bar{H})^2 w_i = 55 \text{ ha}^2 \ldots (7) \]

- Average deviation
  \[ \sigma = \sqrt{D} = 7,45 \text{ ha} \ldots (8) \]

- Variation coefficient
  \[ V = \sigma / \bar{H} = 0,39 \ldots (9) \]

- Failure rate
  \[ \lambda = 1 / \bar{H} = 0,05 \text{ ha}^{-1} \ldots (10) \]

Density of distribution of refusals (differential function of distribution) was determined by formula

\[ f(H) = \lambda e^{-\lambda H} = 0,05 \cdot e^{-0,05 H} \ldots (11) \]

Results of calculations of this indicator are presented in table 2.

**Table 2.**

<table>
<thead>
<tr>
<th>output (in ha) before failures, interval a…b</th>
<th>middle of the interval</th>
<th>empirical frequency</th>
<th>statistical probability w_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>10…14</td>
<td>12</td>
<td>53</td>
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</tr>
<tr>
<td>34…38</td>
<td>36</td>
<td>5</td>
<td>0,03</td>
</tr>
<tr>
<td>38…42</td>
<td>40</td>
<td>3</td>
<td>0,02</td>
</tr>
</tbody>
</table>

The value of the variation coefficient was assumed to have exponentially.

Integrated function of distribution of refusals of plows and probability of non-failure operation are [4] respectively equal:

\[ F(H) = 1 - e^{-0,05 H} \ldots (12) \]
\[ P(H) = 1 - F(H) = e^{-0,05 H} \ldots (13) \]

These indicators were defined after mathematical processing of statistical data on refusals of the plows working in mountain conditions.

Special attention was paid to types of refusals of plows.

Their analyses showed that the percentage was the following:

- Design refusals -18%,
- Industrial refusals -37%,
- Operational refusals -45%.

Integrated function of distribution and probability of non-failure operation of plows were also defined.

In fig. 2. graphical Interpretation of the results of calculations are given.

**Fig. of 2 Schedules of probability of no-failure operation of plows**

1 Histogram, 2 Polygon, 3-Theoretical curve.

Validation of the mathematical model using Kolmogorov criteria showed that the coincidence probability of theoretical and experimental results is \( p(\lambda) = 0,54 \).

Our further research was directed on the development of constructional actions for increase of reliability of plows taking into account reservation. At the level of the invention it was developed and made a plow with a variable width of capture. Existing similar designs have a shortcoming which comes from a difficult design of the mechanism of capture width variation. Operators are compelled
to perform additional works manually that complicates a plow unitization with a tractor.

At the level of the invention [6] we developed, made and tested an original plow with a variable width of capture which differs from others with simplicity of a design, convenience in operation and with increase in reliability. In addition, it has a reserve element case of a plow (fig. 3).

**Fig. 3. Plough with a variable width of capture.**

1. main beam. 2. front bar. 3. cross bar. 4. case of a plow. 5. hinged system. 6. additional beam. 7. hinge. 8. hydraulic cylinder. 9. yoke. 10. lever. 11. lever. 12. traction. 13. mobile bar. 14. oval axis.

The plow with a variable width of capture is aggregated with a tractor hinged system. For change of width of capture the operator directly in a cabin turns on the lever and oil with a high pressure moves in a hydraulic cylinder which rod moves a yoke and the lever. As a result of it, the additional beam together with the reserve case falls down and holds working position. At the same time by means of the lever the mobile bar moves on an oval axis that promotes increase in width of capture of a plow.

The carried-out field tests showed working capacity and high reliability of the plow developed by us with a variable width of capture which qualitatively carried out soil plowing in the mountain regions of Georgia.

**Conclusions**

1. The technique for calculation of indicators of reliability of plows taking into account mountain working conditions is developed.
2. The structural and logical scheme of a plow for calculation of reliability is made and probabilistic and statistical modeling of indicators of operational reliability is carried out.
3. At the level of the invention is developed and tested the plow with a variable width of capture which differs from the similar plows by simplicity of a design and convenience in operation.

Theoretical and experimental studies were financed by the grant project of Agricultural University of Georgia, “Development of New Materials and Technologies for Increase of Reliability of machines”.

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PERFORMANCE ANALYSES OF WIND MACHINES OF DIFFERENT POWER CAPACITIES USED FOR FROST PROTECTION IN AN ORCHARD

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16059 Bursa/Turkey
dravardar@uludag.edu.tr

Abstract: In this research, the efficiencies of two different wind machines which were set up for the frost protection in orchard have been investigated. Wind machines are located in 150 da lemon orchard in the south of Turkey. The land is belong to Yuregir district of Adana province. Citrus production is one of the widely-held agricultural activities, and it has economic importance for this region. Frost damages occur from time to time on fruit trees due to the climatic conditions. It is a serious problem for fruit growers, and causes economic losses. Wind machines are used in the region for reducing this risk. Power capacities of the wind machines used in the lemon orchard were 130 and 172 hp. Temperature and wind speed were measured at the different distances and heights in orchard for the determination of wind machine efficiency. As a result, it was determined that the moving air layer had prevented the trees from frost, and air temperature of the orchard increased between 0.83°C - 2.11°C.

Keywords: WIND MACHINE, FROST PROTECTION, LEMON ORCHARD.

1. Introduction

The possibility of frost always exists at many regions where deciduous seasonal plants are grown. For instance, the economical loss due to frost is more than the economical loss arising due to all other climatic reasons in USA. Low cost measures shall be taken in order to decrease this loss. The cost of measures is closely related with the frequency of frost, production method and value of product (Snyder, 2001). Keeping the cost of protection as low as possible is very important in respect of profit margin of the producer.

Various methods are being employed in order protect the agricultural products against frost. The damages of loss may be prevented by implementing various methods in combination when required as well as employing a single method. The important thing is the selection of correct and the most effective method, and implementing it in a correct manner. Generally there are two methods on this issue: Passive protection and active protection. Passive protection is taking the measures, prior to the night when frost will be observed, that will assist the protection of product against frost. And active protection is to prevent the natural energy loss at the night when frost is observed through energy intense measures (heaters, water spray, wind machines etc). In this study, wind machines being one of the active protection measures have been addressed.

As operation principle, wind machines perform heat transfer with forced convection. This operation is realized by the rotation of wind machine’s rotor in horizontal axis and thus transmission of air mass to a specific distance. Wind machines, due to being able to rotate also in vertical axis, circulate the air as to scan an area of 360 degrees and enable the wind movement.

Wind machines also enable the perceivable heat flow density to increase downwards. The protection amount to be applied against frost at the place of machine is proportional to the density of hot air layer. Wind machines, used for protection against frost, shall be operated when the temperature is over the critical frost temperature. However, the operation of wind machines is suggested in cases when the difference of temperature in between heights of 1.5m and 10m are high (Snyder, 2001). There exists the automatic start-up option according to ambient temperature on majority of the wind machines. As an alternative to this, the machines may be operated manually by warming of the operators via their mobile phones when the temperature reaches critical levels. Some operators prefer manual start-up due to the non-operation of temperature sensor or high level of ambient wind. At plants where wind speed sensor exists, it is suggested for the wind machines not to be operated when the wind speed reaches 20km/h (Fraser et al., 2008).

Researches have been made at different countries in the world on the usage of wind machines. These researches attract attention to the effect of usage of wind machines on the orchards and vegetable gardens. Some examples regarding these studies have been provided below.

Observations have been performed at an orange orchard in Uruguay with wind machines having an engine power of 11kW. When it had been compared with an orange orchard, which is close to the orchard where the wind machine had been installed and which did not have a protection against frost, positive temperature effects and lower fruit damage had been determined (Guarga et al., 2000). It had also been determined that a wind machine with an engine power of 55kW had a positive effect on the temperature level at an almond orchard in Iran (Yazdanpanah and Stigter, 2010). Wind machines used at pear orchard at North Oregon had been operated during the whole autumn, and it had been observed that they had a useful effect against frost (Bates and Lombard, 1978).

There exist different methods for protecting the fruits against frost. It is possible to heat up by the use of technologies operating with fuel oil in order to provide protection against frost by increasing the ambient temperature of orchards. But wind machines show a good performance under conditions of frost. Besides, it minimizes the requirement for labor and is more economic than the heaters consuming fuel oil (Ballard, 1975). There had been increase in the interest for wind machines due to their energy saving feature and usability in all the seasons when compared with other methods of protection against frost (Evans, 1999). Moreover, it causes smoke or air pollution at a lower level compared to other technologies.

The purpose of this study is to reveal the effects of wind machines used to provide solution against the danger of frost which is one of the significant climatic problems of fruit producers. Thus, it is being intended to enlighten the producers regarding the benefits of wind machines and to prevent product losses.

2. Material and Method

Wind machines, being addressed in the study, consist of seven main parts as being tower, staircase, bottom gear box, top gear box, wind rotor, thermic engine used for machine drive and locating platform. Wind machines comprises single wind rotor with two blades connected to each other on the same axis. The blades are connected with an incline of 1°C on vertical axis to the shaft of top gear box from the middle section. The wind machines with a power of 130 and 172HP, addressed within the scope of research, have been indicated in Figure 1.
A thermostat has been connected at 6m distance to the location of the wind machines on which temperature can be adjusted. When the ambient temperature decreases to the temperature set, the engine of thermostat is automatically operating. Thus, monitoring of frost can be realized automatically by the thermostat. Engines operating with LPG and diesel are being used in the operation of wind machines addressed within the scope of study (Figure 2).

**Figure 2: Engines operating with LPG and diesel**

The electric energy required for the thermostat order, which enables automatic operation, is being provided by an accumulator being charged by a solar cell (Figure 3).

**Figure 3: Solar cell provides electric energy**

Technical specifications of wind machines being addressed in the research have been indicated in Table 1, Table 2 and Table 3.

**Table 1: Technical specifications of tower**

<table>
<thead>
<tr>
<th></th>
<th>130 HP</th>
<th>172 HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction type</td>
<td>Cylindrical</td>
<td>Cylindrical</td>
</tr>
<tr>
<td>Diameter</td>
<td>508</td>
<td>508</td>
</tr>
<tr>
<td>Height</td>
<td>10400</td>
<td>10400</td>
</tr>
<tr>
<td>Thickness of material</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Reduction ratio</td>
<td>2/1</td>
<td>2/1</td>
</tr>
<tr>
<td>Revs per minute</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table 2: Technical specifications of rotor**

<table>
<thead>
<tr>
<th></th>
<th>130 HP</th>
<th>172 HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade Material</td>
<td>Rigid fiberglass</td>
<td>Rigid fiberglass</td>
</tr>
<tr>
<td>Number of blades</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Rotor diameter (mm)</td>
<td>5900</td>
<td>6100</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>245</td>
<td>245</td>
</tr>
<tr>
<td>Revs per minute (min(^{-1}))</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>

**Table 3: Technical specifications of thermic engines**

<table>
<thead>
<tr>
<th></th>
<th>130 HP</th>
<th>172 HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel type</td>
<td>LPG</td>
<td>Diesel</td>
</tr>
<tr>
<td>Power (HP)</td>
<td>130</td>
<td>172</td>
</tr>
<tr>
<td>Engine speed (min(^{-1}))</td>
<td>2270</td>
<td>2270</td>
</tr>
</tbody>
</table>

Implementation tests of wind machines had been performed on a lemon orchard of 150da at province of Adana and county of Yuregir. The over the row and between the row distance of trees was 7m. Average tree height was 6m, and average crown width was 6.9m. The land had a triangular structure.

Wind speed and temperature measurements had been performed at distances of 5m, 25m, 50m, 75m, 100m, 125 m on a straight line from the center of wind machines. These measurements had been performed at heights of 0m, 1m, 2m, 3m, 4m, 5m above the ground. Wind speed measurements had been determined by digital display propeller driven anemometer, temperature measurements had been determined by digital display thermometer, the altitude of the region had been determined by altitude meter and ambient pressure had been determined by barometer. The tests had been performed at arid and very cloudy weather when the wind speed was 0m/h.

**3. Results**

Wind machine’s rotor had been designed in a manner as to have an incline of 1o. When the rotor of wind machine rotates for once around its own axis, it provides wind movement by composing vacuum for once and pressure for once to each direction. By the generated wind, the hot air at upper layer is being lowered to lower layers. This wind movement at plant level prevents the freezing of the plant.

At the orchard where the research was held, the altitude had been measured as 19m and air pressure as 1006.4 hPa. The generated air rate at optimum cycle number of the blade (500 min\(^{-1}\)) was 26.376 m\(^{3}\)/min with wind machine having 130HP, and 30.240 m\(^{3}\)/min with wind machine having 172HP. The measured temperature and wind speed values have been provided in Figure 4-7. The data had been obtained at the position in which the machine had generated wind for three times.
When the results of research are examined, it is being observed that the wind speed decreases as getting far from both wind machines of 130HP and 172HP, and thus the effectiveness of wind machine decreases. It is being observed that as the height from the ground increases the value of wind speed also increases directly proportionally. The reason of this is the structure of trees. But, it had been observed that the wind machine generates an air flow even on the ground. This air flow on the ground had been determined as 0.20m/h by measurements made at a distance of 125m for both of the wind machines (Figure 4-5).

No significant change had been observed in temperature changes as getting far from the wind machine. Especially, the difference of temperature in between the ground and 5m height is more distinct. This difference is being preserved as getting far from the wind machines. While for the wind machine of 130HP the average of temperature difference depending on distance for measurements made at ground and heights of 1m, 2m, 3m, 4m, 5m had been determined as 0.82 °C, 0.87 °C, 1.13 °C, 1.37 °C, 1.58 °C, 1.81 °C respectively, these values had been determined as 0.88 °C, 0.93 °C, 1.03 °C, 1.25 °C, 1.73 °C, 2.11 °C for the wind machine of 172HP.

4. Conclusion

As the result of use of wind machines, being among the methods of protection against frost, the product losses may be prevented. Within this scope, the use of wind machines especially during growing products with high economical value is suggested. As the result of tests made at the lemon orchard, addressed within the scope of this study, it had been determined that the wind machines show high performance against the danger of frost.

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ИЗСЛЕДВАНЕ МОМЕНТА И КОЕФИЦИЕНТА НА ТРИЕНЕ ПРИ СРАБОТВАНЕ НА ВИБРОНАВАРЕНИ ПОКРИТИЯ ВЪРХУ СТОМАНЕНИ И ЧУГУНЯНИ ДЕТАЙЛИ ОТ АВТОТРАКТОРНАТА И ЗЕМЕДЕЛСКА ТЕХНИКА

A RESEARCH ABOUT COEFFICIENT AND MOMENT OF FRICTION DURING INTERACTION OF DEPOSITED LAYERS OF IRON PARTS OF AGRICULTURAL AND TRANSPORTING MACHINERY EQUIPMENT

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Abstract: The dynamics of moment and coefficient of friction change is established by experimental research of applied layers upon iron and steel parts through vibrating gas metal arc overlaying. It was established that such layers has a insignificant change of the moment of interaction within the period between 4-th and 14-th hour with rate of 3,5 to 6,5 Ncm which is a sign about transition into a period of established wear regime within shorter time.

Keywords: running-in, friction moment, coefficients of friction, iron and steel parts; agricultural machinery

1. Въведение

Сработването на триещите се повърхности се разглежда като сложен неустановен процес на постепенно изменение на триботехническите характеристики и характеристиките на геометричните и физико-химичните свойства на повърхностните слоеве при триене [1]. Една от основните триботехнически характеристики, които се променят съществено и по които може да се оцени процеса на сработване на триене, е момент на сработване в зависимост от изменение на външните условия, каквито са наварените възстановените покрития или момент на триене.

Целта на настоящата работа е да се установят триботехническите характеристики - момент и коефициент на триене на триеща се повърхност, наварена с вибродъгова технология и оцени непрекъснато и върху смежна среда.

2. Извеждане

За физически модел на триещата се двоица "вал-лager" е избрана двоицата "ролка-сектор" със статистически характеризирана геометрично подобна към наварена повърхност при насрещни условия. За физически модели се използвали два материала за плъзгащи лагери, дизайнерски и нанесени слоеве, включително и покритията, при приети момент на триене и при престъпване на възстановена кривината.
USB 6210. За преобразуването на записаните данни в N.cm e създадена блок схема, по която се отчитат и визуализират за- писваните данни, заложена в задвижващия софтуер NI-DAQmx и софтуерния продукт Lab View. По време на експеримен-ните изследвания, устройството NI-USB 6210 се свързва към USB порт на преносим компютър, а данните от запис на про- цеса на триене при пълзгане в реално време се съхраняват в *.h документ и последващото им обработване се извършва с помощта на софтуерния продукт Microsoft Office Excel. Мо-мента на триене непрекъснато се записва по време на изпитва-нето и се визуализира на екрана на персонален компютър в цифров и в графичен вид.

Резултатите от изследването са представени с графични за-висимости (фиг.1, фиг.5), които показват динамиката на измене-ние на момента и коефициента на триене в процеса на сра-ботване и износване на триещите се повърхности.

Сработването на триене се характеризира с големината на момента на триене в края на натоварването. Стойностите на този момент определят противозадирните способности на триещите се повърхности.

От графicapът на фиг.1 се вижда, че началното изменение на момента на триене в края на натоварването има стръмен харак-терът в първите два часа от изпитването и при трите двойци, като това е по-ярко изразено при еталонната двойка Ст45-БО30. След което се наблюдава почти двукратно намаляване на големината на момента на триене спрямо началните стойности, което е условие за плавно протичане на процеса сработване и установено износване през останалото време на изпитване.

Наварените покрития в газови смеси върху стоманени и чу-гунени детайли имат по-малки моменти на триене в края на натоварването, което показва по-добро сработване с антифрик-ционната сплав БО-30. Това намаляване на момента е свързано с намаляване на коефициента на триене (фиг. 3, а оттам по-висока противозадирна способност в началото на сработване и установено износване. Наварената чугунена ролка има почти двойно по-висок момент от еталонната, което се дължи на по-добrite антифрикционни свойства на чугуна.

Важна трибонтежка характеристика е изменението на момента на триене в процеса на активно сработване. Той пред-ставява разликата между момента в края на натоварването Ми и момента в края на изпитването Мк, отчетен след изтичане на необходимото време за изпитване на триещата се двойца. Влиянието на входните параметри върху изменение на момента на сработване е показано на (фиг.2).

От получените резултати на фиг.2 се вижда, че характера на изменението на процеса на сработване е подобен при еталонната и изпитваните двойци. Активно изменение на момента на триене при сработване протича през първите шест часа от изпитването, след което леко нараства за възстановителните покрития, което е свързано с процеса на сработване на ролката. Еталонна двойца Ст45-БО30 има по-трайно изменение на моменти на триене при сработване от възстановените двойци с наварено покритие върху стоманени и чугунени детайли, като сработването на еталонната двойца е по-продължително и продължава до 10 часа от изпитването.

Анализът на резултатите показва, че възстановените двойци преминават за по-кратко време в режим на установено изменение, също така и при наварените покрития през цялото изпитване спрямо другите две двойци, което дава информация за протеклия процес на сработване.
Коефициента на триене може да се използва за количествена оценка на триенето и сработването. Благоприятното влияние на възстановената чугунена ролка върху процеса на сработване се потвърждава и от резултатите, получени за коефициента на триене в края на натоварването (фиг.4) и в края на изпитването (фиг.5). В периода на активно сработване коефициентите на триене за трите вида двойци намаляват интензивно през първите 4...6 часа, след което до края на изпитването запазват почти постоянни стойности. Коефициентите на триене като производни на съответните момента са по-високи за еталонната двойца.

3. Заключение
1. Вибродъгово наварените покрития в газови смеси върху стоманени и чугунени детайли преминават през кратко време в режим на установено износване, съдейки по незначителното изменение на момента на сработване от 4" до 14" час съответно между 5,5...6,5 Нм.
2. Двоицата с навареното в газови смеси с Св 08Г2С покритие върху чугунената ролка има по-ниски моменти на триене в края на натоварването и изпитването в сравнение с останалите две двойци.

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ADAPTATION OF AN EXISTING SOLUTION FOR WORK IN NEW CONDITIONS – AN ANALYSIS OF THE METHODOLOGY

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Abstract: The analysis of the problems to be solved in the engineering practice shows that the adaptation of an existing solution to work in new conditions is one of the most common design problems. For harvesting soybeans and other row crops in the country are widely used headers HPS produced by METAREM - AD Pavlikeni. They were created in connection with the introduction of technology for row harvesting of soybeans in our agricultural production, which is well known and widespread in the world practice. Through the analysis of the collaboration of TISEM - AD, Ruse and METAREM - AD on creating headers HPS, the contents of the engineering preparation for the production, is clarified. On this basis, a model (algorithm) to solve the engineering task of adapting an existing solution to work in new conditions is proposed.

Keywords: DESIGN PRACTICE, HEADERS FOR HARVESTING SOY CROPS, DESIGN MODEL

1. Introduction

Using known methods for system design depending on the solved practical task is crucial for the convergence between theory and practice. The essential feature for the classification of methods for systems design in fundamental research that came out late last and early this century, is the level of innovation [6,7,8,9,10,11,12]. The systematization of methods for system design depending on the solved practical problem occurs rarely in scientific periodicals. The question for clarification and systematization of problems to be solved in the design process in terms of the companies has not found its common solution. Even a cursory analysis of this process shows that the design does not always begin from the "white sheet" and that in their practice design engineers solve problems of a varying scope and complexity.

As a result of earlier conducted studies it was found that in companies were solved three basic problems – an adaptation of an existing (turnkey) solution to work in new conditions, an improvement of a turnkey solution, a combination with precast or creating a new solution. On this basis a generalized model for the design of technical systems is proposed, which is obtained by combining (superimposition) of models (algorithms) for solving the defined four main problems of design [4]. The analysis of the tasks to be solved in engineering practice shows that the task of adapting existing solution to work in new conditions is one of the most common design problems. At the same time, a research on the content of this problem is also extremely rare in scientific periodicals.

For harvesting soy plantings and other row crops in Bulgaria headers HPS are widely used. They are manufactured by METAREM - AD Pavlikeni. They were designed in connection with the introduction of technology for row harvesting of soybeans in our agricultural production inland, which is well known and widespread in the world practice. Through the analysis of the collaboration of TISEM - AD, Ruse and METAREM - AD on designing headers HPS, the content of the engineering preparation for production, is clarified. On this basis, a model (algorithm) to solve the engineering problem of adapting an existing solution to work in new conditions is being proposed.

2. Design preparation for manufacturing of headers HPS

When harvesting soy crops using headers for cereals connected to self-propelled harvesters, huge losses of grain appeared. One way to reduce this is to use special headers. As a research result done by TISEM – AD, it has been found that in the world practice are used two types of headers for harvesting of soy crops - row type headers and headers for merged collection by a floating cutting apparatus. By research study it was found that row headers have a number of advantages over headers for merged collection. In addition to regular technology for harvesting soy plantings, in the conducted study in TISEM – AD, the structure and principles of the headers for row collection that are used most widely in the world practice, have been clarified. The study concludes with a recommendation that the engineering preparation of new production should focus on adapting of an available solution for operating in terms of Bulgarian agricultural production.

The introduction of row technology for harvesting soy crops inland is associated with the beginning of the collaboration between TISEM - AD and METAREM - AD for preparation for the production of a row header, by which simultaneously are harvested six rows of soy plantings planted at a spacing of 70 cm. The collaboration began with systematization of the specific requirements to be met by the row header after its manufacturing and defining limitations to the design. In this connection and in accordance with the current national regulations, technical assignment has been compiled and approved. Based on the technical assignment and the chosen strategy - to adapt an existing solution to work in new conditions, a suitable prototype has been selected. For the prototype additional information was gathered and tests have been conducted in terms of Bulgarian agricultural production. On this basis, changes in the design of the prototype have been marked out, taken into account in the compilation of the adjusted technical proposal.

Fig. 1 Row header for harvesting soybeans HPS

The design continues with development of the technical proposal to the level of detailed design work and to the development of complete technical documentation. Despite of activities duplication and multiple returns to the technical proposal, requirements and limitations to the technical assignment, in this
later phase of the design three stages can be specified – a development of a preliminary (conceptual) design, a development of a detailed design and a development of a complete technical documentation. Founding the design on a prototype significantly facilitates the implementation of the stages of the later phase of the design.

The preparation for mass production of the row header continues with production and testing of a specimen, design and manufacturing of technological equipment and production and testing of the zero series. Following the successful implementation of all stages of the cycle-preparation for production, the mass production of the family row headers for harvesting soy crops, has been reached by HPS METAREM - AD [2,3] (Fig. 1).

3. A model (algorithm) for solving the engineering task of adapting existing (turnkey) solution to work in new conditions

The analysis of the design cycle- preparation for the production of row headers for harvesting soy crops HPS is the basis of the proposed model (algorithm) for solving the engineering task - adapting of the existing solution, created earlier, to work in new conditions (Fig.2). The model is presented as a solved problem on the basis of previously created generalized model for designing of technical systems, obtained by combining (superimposition) of models (algorithms) to solve the four basic design problems. The generalized model itself is part of the developed models for the hierarchical comparison between the life cycle of the technical system, the technical preparation for production, engineering preparation of production, and design, resulting from earlier studies [1,5]. In highlighted in dark in Fig. 2 are shown the steps forming the structure of the model (algorithm) to solve the engineering task of adapting an existing solution to work in new conditions.

The design process starts with the clarification and definition of the problem (Fig.2). The implemented activities for this stage of the four engineering problems from practice can be unified, as the choice of a strategy for solving the task is performed at a later stage.

![Fig. 2 A model (algorithm) for solving the engineering problem of adapting of an existing (turnkey) solution to work in new conditions](image-url)
Feasibility studies are crucial for the successful problem resolving. The main part of the activities at this stage can also be unified. Based on the feasibility studies it should be answered the following two questions: which are the requirements and limitations to the problem solution and which of the four alternative strategies will be used to solve the problem. Requirements and restrictions to the problem solution are classified in the technical assignment. As it became clear with the performed analysis, the technical assignment for developing of row headers for soy crops HPS was developed and approved according the currently valid national regulations.

The main differences between the four defined design tasks are the optional activities for choosing or synthesis the technical proposal. The feasibility analysis, as a part of the cycle - preparation for the production of row headers for soybeans HPS, shows that the definition of the adjusted technical proposal for solving the engineering task - adapting the existing solution to work in new conditions, is preceded by choosing a suitable prototype and detailed output information for the selected prototype. Discovering the activities content for selecting or synthesis of a technical proposal, involved in solving other three design tasks can also be performed by an analysis of relevant tasks successfully solved by the engineering practice.

The activities performed at the second design phase, could also be unified regardless to the design problem - the solution returns to the base model (Fig. 2). Using a prototype for solving the problem significantly relieves the steps implemented at the later design phase. By developing a conceptual design a transition from the first design phase (the functional phase) to the second design phase (object phase) is done. The technical proposal is developed to a level of a complete preliminary design. Within the next stage the preliminary design is in turn developed to a level of a detailed design. Based on the clarified interaction and mutual disposition among the executive organs during the preliminary (conceptual) design, the development of the detailed design is transferred to a parallel design of components from different hierarchical levels. The complete design is reached after multiple calculations for strength dimensioning and defining the structural and functional interfaces between the components. The design ends with the completion of the technical documentation. By the means of the technical documentation the next stages of the cycle - preparation of production are completed.

4. Conclusion

Through analyzing the collaboration between TISEM - AD and METAREM - AD on developing headers HPS the contents of the cycle - preparation for production has been clarified. Based on it a model (algorithm) for solving an engineering problem - adapting of an existing solution to work in new conditions is proposed. The model is presented as a solved problem based on the previously created generalized model for designing of technical systems, obtained by combining (superimposition) of the models (algorithms) to solve the four basic tasks of the engineering practice – an adaptation of existing (turnkey) solution to work in new conditions, an improvement of a turnkey solution, a combination with precast or creation of a new solution.

5. References


1. **Introduction**

A crucial requirement during the grafting of apple rootstocks is the avoidance of mechanical contact between the grafted scion and the grafting area with hard objects [2,3], which can cause damage to the scion or its displacement relative to the rootstock. This leads to the destruction of the product. Mechanical contact is possible during the grasping of grafted rootstocks by the planting clip, transportation, and at the shoe. To avoid mechanical contact during grasping and transportation of the grafted rootstock by the planting clip on the planting machine, it is necessary to have a planting clip design that allows stable grasping of the grafted scion outside the scion zone and will transport the scion.

2. **Experimental sample**

To avoid mechanical damage to the grafted scions, it is necessary to stabilize the grasping of the planting clip and keep the center of gravity at point O, Fig.1.

![Fig. 1. Insertion point of the plant holder on the scion](image)

1. Grafting clip; 2. Grafted and grafted rootstock; m. O – center on the weight line of the grafted plant holder.

The width of the grasping jaws \( b_{ЗЧ} \) is determined from the condition that the center of gravity of the grafted and grafted rootstock always falls between the jaws to meet this requirement it is necessary:

\[
(1) \quad b_{ЗЧ} \geq 2D_{ЦТ}
\]

where \( D_{ЦТ} = 8.1 \text{ cm} \)

If the practical accuracy of the confidence interval is determined by the formula 1 for the width of the clip, it is calculated as:

\[
(2) \quad b_{ЗЧ} \geq 16.2
\]

Manufacturing of the grasping jaws with this width is impossible. Constructively, it is possible to manufacture the clip with a size:

\[
(3) \quad b_{ЗЧ} = 9 \text{ cm}
\]

However, not all grafted and grafted rootstocks can be grasped in the zone of their center of gravity.

Based on theoretical studies [1], a design was developed for the grafting clip that satisfies the physical-mechanical parameters of grafted and grafted apple rootstocks and ensures stable grasping and transportation.

Fig. 2 shows the design of the developed grasping clip. It consists of:

1. Stop.
2. Spring.
3. Pin with a roller.
4. Stand.
5. Mobile jaw.
6. Fixed jaw.

The fixed jaw – 6 is mounted immovably on the stand – 4, while the mobile jaw – 5 is hinged. Closing the mobile jaw is carried out by the spring – 2, while opening it is carried out by the pin with the roller – 3. The grafting clip is mounted to the planting machine through an opening Ø 11.

The grafting clip is mounted in a different way from other planting clips, where grasping is carried out by rubber jaws, while in this clip grasping is carried out with an elastic plastic strip mounted on the mobile and fixed part of the grasping clip. Stability of grasping on the grafted and grafted rootstocks is achieved through the elastic deformation of the plastic strip when grasping the rootstock, which ensures grasping on the rootstocks of one kind and from another through the same roller on the axis of the rootstock holder.

The effect of the clip is noted when grasping the rootstocks and the grafted rootstocks are mounted in the space between the strips of the jaws and the stop (Fig. 2), which is mounted to the fixed jaw of the clip. Additional tension on the plastic strip and consequent increase in stability of grasping is carried out by the length of the jaws of the clip and the stress curve of the grafted strip. The clip design is carried out for a different layout of the rootstocks in the area of the rootstocks on the clip and the stop.
чрез изработване на двете челюсти на щипката с различна широчина (фиг. 2).

Ограничителят –1 (фиг. 2) е монтиран неподвижно към неподвижната челюст на засаждателната щипка. Той осигурява:

- еднакво позициониране на присадените и вкоренени ябълкови подложки спрямо засаждателната щипка, а от там и равномерност на засаждането.
- ограничава захващането на присадените подложки, като им предпазва калемите от повреждане.
- служи за опора на захванатите присадени подложки от еластичните пластмасови ленти. Пространството между тях (лентите и ограничителя) е с клиновидна форма, като по този начин лентите притискат подложките една към друга, а поради „ефекта на клина” и към ограничителя. По този начин се подобрява захващането и позиционирането на присадената подложка спрямо засаждателната щипка.

Така разработените засаждатели щипки са монтирани на дисков садачен апарат, който е изпитан и е на работа в разсадника на фирма „Савел – Агро” – ООД, Пловдив.

3. Литература


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