To the design of the working body of the ground gun

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Abstract. The article describes the invention for the creation of mineralized (reference) strips, as well as the justification of the parameters for the design of the grunt mill on the basis of experimental studies. The invention also solves the problem of improving operational performance when laying protective mineralized strips and extinguishing grass-roots fires with soil. This invention involves an increase in operational performance when laying protective mineralized strips and extinguishing grass-roots fires with soil.

1. Introduction
In solving the problem of prevention and control of forest fires, the main part of the time and money is occupied by grass-roots fires of various intensity. As practice shows, today various methods and equipment are used, among which, nevertheless, the use of manual labor and technical developments, which are obsolete and ineffective, prevails.

The analysis of the existing equipment and methods of extinguishing forest grass-roots fires [1] allows us to conclude that the most promising in this regard are prevention (the creation of mineralized, reference strips) and extinguishing with soil.

The invention [2] solves the problem of improving operational performance when laying protective mineralized strips and extinguishing grass-roots fires with soil.

The technical result is to ensure uniform spreading of the soil over the entire width of the mineralized strip.

The specified technical result is achieved by the fact that in a frontal forest fire grunt launcher containing a working body with throwers, a ground throwing mechanism, a control drive for the working body and a guide casing, the new one is that the working body is installed on the swing axis, carried out beyond the center of mass of the working body, closed by a guide casing connected through a lever with a loading hydraulic cylinder for lifting and lowering the working body, is made in the form of throwing knives, designed as a section of the spiral "rod", mounted on the milling disc at an angle $\alpha$ between the trailing edge of the knife and the plane of rotation of the milling disc, rotated relative to the trailing edge in the direction of movement at an angle $\beta$, and closed by a guide casing.

2. Materials and methods
The front-mounted forest fire grunt (figure 1) works as follows. The tractor dump removes the upper part of the soil layer, which may contain materials that support the gorenje process, as well as foreign bodies in the form of stones, etc. In this case, the front forest fire primer is buried in the treated soil to a certain depth $h$ by its own weight, and if necessary, it is loaded with a hydraulic cylinder 7. The power
plant 8, for example, a hydraulic motor operating from the hydraulic system of the base machine, transmits the torque to the shaft of the working body 3 of the frontal forest fire grunt. From the shaft of the working body, the torque is transmitted to the working body 3, which rotates and, when the frontal forest fire grunt moves forward, separates the soil chips from the array, and also throws and evenly distributes the cut volume of soil along the width of the mineralized strip. The uniform distribution of the soil over the width of the mineralized strip is carried out by throwing knives made in the form of a section of the spiral "rod", while the thickness of the soil chips is greater than the path traveled by the tractor during the cutting cycle. Throwing occurs as a result of giving the cut part of the ground different kinetic energy in different areas of the throwing knives. For the direction of the thrown soil, a guide casing 5 is used. When encountering an obstacle, the working body is raised above it, since it is mounted pivotally on the swing axis 4.

Figure 1. General view of the front-mounted forest-fire ground launcher.

The use of the present invention makes it possible to increase operational performance when laying protective mineralized strips and extinguishing grass-roots fires with soil.

Also, according to the above-described invention, an experimental device was manufactured [3], to justify the parameters of the milling cutter, experiments were conducted using the planning theory of a full-factor experiment.

The purpose of this experiment is to clarify the design parameters of the experimental installation that affect the efficiency of the process, namely: the cutting angle of the ground $\alpha$ and the angle of inclination of the cutting edge of the throwing knife to the radius of the carrier disk $\beta$.

Full-factor plan experiment $2^k$, by $k=2$, that is, the regulation of two factors and at two levels is carried out. $Y_1$ - the mass of soil per $1\, m^2$ of the bulk part at the near edge of the furrow being cut [4], $Y_2$ - the mass of soil per $1\, m^2$ of the bulk part in the middle part of the filling, $Y_3$ – the mass of soil per $1\, m^2$ of the bulk part at the far edge of the furrow. The PFE matrix is shown in table 1.
Table 1. PFE $2^k$, matrix, at $k=2$.

| №  | $X_1$ | $X_2$ | $X_1 \times X_2$ | $Y_1$   | $Y_2$   | $Y_3$   |
|----|-------|-------|------------------|---------|---------|---------|
| 1  | +     | +     | +               | $Y_{1cp1}$ | $Y_{2cp1}$ | $Y_{3cp1}$ |
| 2  | -     | +     | -               | $Y_{1cp2}$ | $Y_{2cp2}$ | $Y_{3cp2}$ |
| 3  | +     | -     | -               | $Y_{1cp3}$ | $Y_{2cp3}$ | $Y_{3cp3}$ |
| 4  | -     | -     | +               | $Y_{1cp4}$ | $Y_{2cp4}$ | $Y_{3cp4}$ |

Determination of parameters of normalized variables by formulas (1-3):

$$z_{(i)n} = \frac{z_{(i)\text{max}} + z_{(i)\text{min}}}{2}$$

rationing step:

$$\Delta z_{(i)} = \frac{z_{(i)\text{max}} - z_{(i)\text{min}}}{2}$$

normalizing formulas:

$$x_{(1)} = \frac{z_{(i)\text{max}} - z_{(i)n}}{\Delta z_{(i)}}$$

The levels and intervals of variation are shown in table 2.

Table 2. Levels and intervals of variation of factors.

| Factor | Code | Factor level | Variation step |
|--------|------|--------------|----------------|
|        |      | -1           | +1             |
| Ground cutting angle $\alpha$ | $x_1$ | 45           | 55             | 5              |
| Angle of inclination of the cutting edge of the throwing knife to the radius of the bearing disc $\beta$ | $x_2$ | 25           | 55             | 15             |

The regression equation has the following form (4):

$$y = b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 + b_{1,2} \cdot x_1 \cdot x_2$$

All output data were previously checked for abnormality according to GOST 11.002-73 "Applied statistics. Rules for assessing the abnormality of observation results".

According to the method [5], the data obtained during the preliminary experiment were processed using the MS Office Excel application software package, and equations (5-7) were obtained showing the dependence of the soil mass on different sections of the bulk part of the mineralized (reference) strip (by its width) [6] from the cutting angle $\alpha$ and the angle of inclination of the cutting edge of the throwing knife to the radius of the bearing disc $\beta$:

$$y_1 = 6.025 + 0.055 \cdot x_1 + 1.195 \cdot x_2 + 1.125 \cdot x_1 \cdot x_2$$

$$y_2 = 3.585 - 0.085 \cdot x_1 - 0.395 \cdot x_2 + 0.395 \cdot x_1 \cdot x_2$$

$$y_3 = 2.645 - 0.405 \cdot x_1 - 0.305 \cdot x_2 - 0.295 \cdot x_1 \cdot x_2$$

where $y_1$ is the mass of soil per 1 m$^2$ at the near edge of the bulk part of the strip; $y_2$ – ground mass per 1 m$^2$ in the middle part of the bulk strip;
y³ – ground mass per 1 m² at the far edge of the embankment strip;
Based on the experimental data obtained, the graph shown in figure 2 was constructed.

![Graph showing distribution of soil over the width of the bulk part of the mineralized (reference) strip.](image)

**Figure 2.** Distribution of soil over the width of the bulk part of the mineralized (reference) strip.

### 3. Conclusion
The graph shows that the best uniformity of the soil distribution is achieved at the cutting angle of the soil 55° and the angle of inclination of the cutting edge of the throwing knife to the radius of the bearing disc 25°, at which the minimum recommended soil mass of 4 kg/ m² is met [7].

As a result of the experiment, the design parameters of the experimental installation were clarified, namely: the angle of cutting the ground (55°) and the angle of inclination of the cutting edge of the throwing knife to the radius of the bearing disc (25°), which ensures the most uniform distribution of the soil over the bulk part of the mineralized (reference) strip [8]. The results of the study were used in the design of the working body of the plow of the forest combined PLC-5G for the modern forest fire unit LPA-521 of the Rubtsovsky Machine-building Plant.

### References
[1] Fedorchenko I S and Maksimov E I 2009 The analysis of the existing equipment for suppression of forest fires by soil *The collection of works of the All-Russia conference “Young scientists in the solution of actual problems of a science”* 1 192-4
[2] Maksimov E I and Fedorchenko I S Pat. of the Russian Federation RU 2009114066 C2 / No. 2009114066, 13.04.2009
[3] Fedorchenko I S and Maksimov E I 2009 *The experimental device for a soil throwing
(Krasnoyarsk: Krasnoyarsk State Agrarian University) pp 234-9

[4] Orlovsky S N 2016 Fighting forest, steppe and peat fires (Krasnoyarsk: KrasGAU)

[5] Adler Yu P 1976 Planning of experiment by search of optimum conditions (M: Science)

[6] Orlovsky S N 2003 Forest and peat fires. The practice of extinguishing them in Siberia (Krasnoyarsk: KrasGAU)

[7] Ovchinnikov F M and Okhramets T I 2002 Fire-prevention barriers in the woods of Siberia 147

[8] Karpenchuk I V and Palubets S M 2010 Development of peat fire extinguishing tactics using specialized technical means Bulletin of the Command and Engineering Institute of the Ministry of Emergencies Republic of Belarus 2 78-82