

THE FIREFIGHTING SOIL-THROWER - FIRE-BREAK MAKER FOR LAYING MINERALIZED STRIPS AND EXTINGUISHING GROUND FOREST FIRES

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Abstract: The main attention in the article was paid to the method of fighting forest fires by creating mineralized bands and filling the edge of the fire with soil. Designs of firefighting soil-throwers for extinguishing forest fires based on the tractor "Belarus" and an excavator based on the feller buncher LP-19 are proposed. The proposed designs of forest fire soil throwers make it possible to reduce the efforts to separate soil chips from the massif, to ensure the spreading of soil to various lengths and to overcome obstacles in the form of tree roots.

KEYWORDS: Forest fire, Firefighting soil-thrower, Ground fire, Satellite monitoring, Soil

1 Introduction

The forest is a renewable natural resource [10, 16], and one of the main tasks of forestry is to use the most important property of the forest - its ability to renew, on a scientific basis.

One of the main causes of forest destruction is forest fires. A fire is an uncontrolled combustion process that causes material damage, danger to life and health of people and animals.

The fire situation throughout Russia according to satellite monitoring (ISDM-Rosleskhoz) over the past three years is shown in Figure 1. [5, 8].

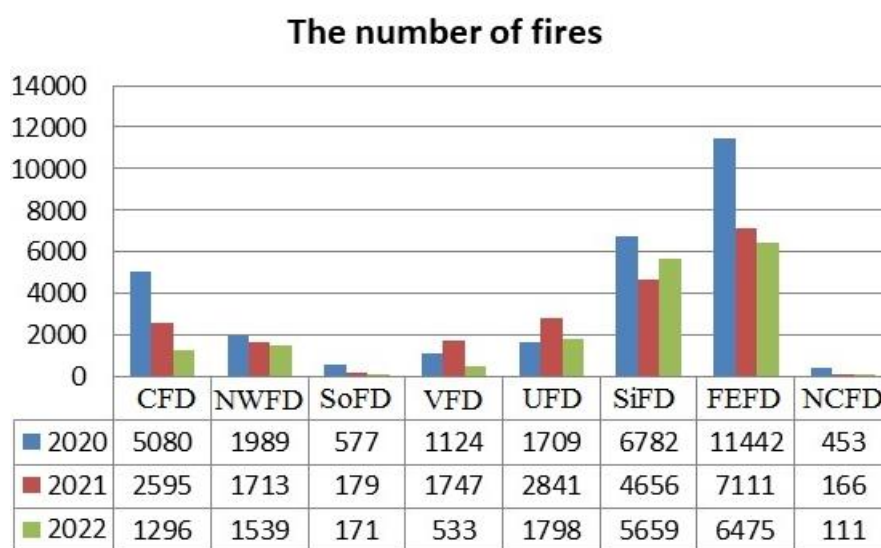
As can be seen from the graphs of forest fires, more than one thousand hectares of forest disappear annually, causing damage to the habitat of various species of animals and plants, worsening the state of the forest ecosystem, which emphasizes the relevance of the research topic [12, 13].

The problem of forest fires is relevant all over the world [1, 4, 10]. Fire trucks can't drive up to the fire site always [7].

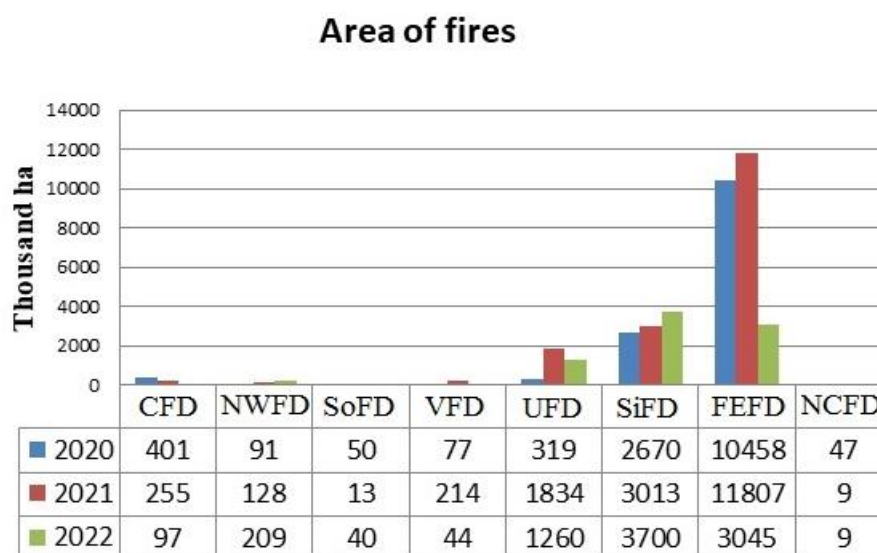
2 Materials and Methods

The purpose of the research is to reduce the efforts to separate the soil layer from the massif with soil spreading and to increase the efficiency of work when working on soils with obstacles in the form of the root system of trees.

When solving the task set for the team of authors, the main attention was paid to the method of fighting forest fires by creating mineralized strips and filling the edge of the fire with soil using specialized mechanisms (soil-thrower) and shovels. A soil-thrower is a self-propelled (tractor), or moving due to the operator's traction, machine, which fully copes with this task.



a)



b)

Fig. 1 Number (a) and area of fires (b) by years, where: CFD - Central Federal District, NWFD - Northwestern Federal District, SoFD - Southern Federal District, VFD - Volga Federal District, UFD - Ural Federal District, SiFD - Siberian Federal District, FEFD - Far Eastern Federal District, NCFD - North Caucasian Federal.

When working on this topic, the patent search method is used to obtain information. This method provided for the formation of a knowledge base on the subject of research based on the analysis of sources of patent information. Promising directions for research activities were identified, a forecast was made for the development of science and technology and the dynamics of patenting inventions in this area.

When reviewing analogues, it was noted that most of the previously developed structures have difficulties when working in forest areas near the root system of trees, shrubs and grass turf. It is noted that most of the existing designs do not provide mixing of the soil, but immediately move the layer of soil lying on the surface of the earth and containing flammable needle-foliage into the combustion zone. The authors noted the shortcomings of technical solutions and searched for options to eliminate these shortcomings.

Later, the authors of this article developed new technical solutions in the field of fire extinguishing and tested the novelty of the proposed designs by comparing the author's developments and analogues found during the patent search.

The main design idea proposed by the authors in the process of creating new constructions was the use of a milling mechanism that cuts the roots located in the upper soil layer. This mechanism is installed in front of the soil-thrower, crushes and mixes the roots, needle litter and earth before moving the soil into the combustion zone. The proposed technical modernization combines both developments of the team of authors described in the article. At the same time, each technical solution proposed by the authors of this publication can function independently of each other, and the scope of its further application depends on the equipment of the forestry enterprise with basic tractors.

As a result of checking and comparing similar technical solutions for violation of other people's copyrights, applications for inventions were created, the patent purity of new copyright developments was determined, and patents for inventions of the Russian Federation were obtained.

3 Results

At the Volga State University of Technology, at the Department of Forestry and Chemical Technologies, several designs of forest fire soil throwers have been developed.

The presented design (Figure 2) [14] contains a frame 1, at the bottom of which there are cutters-rippers 2 mounted on a shaft 3. Through a gearbox 4 they are connected to a hydraulic motor 5. Behind the rippers 2 on frame 1, there are two plowshares 6 are rigidly mounted. They are installed in parallel relative to each other and rigidly interconnected, while forming a guide tray for the soil. Behind them is a thrower 7, which is driven by a hydraulic motor 9 through a gearbox 8. In front of the frame 1, a hydraulic cylinder 10 is pivotally mounted, which allows deepening the rippers and plowshares to a predetermined depth and attached to the base tractor 11.

Firefighting soil-thrower works as follows. The stages of operation of soil-thrower thrower are shown in Figure 3. The base tractor 11 enters the working position. With the help of the hydraulic cylinder 10, the frame 1 is lowered and the rippers 2 with plowshares 6 are buried to a predetermined depth. Base tractor 11 starts moving. At the same time, the rippers 2, rotating on the shaft 3 through the gearbox 4 from the hydraulic motor 5, loosen the turf of grass vegetation with simultaneous cutting and removal of the roots of trees and shrubs.

Ploughshares 6, located behind the rippers 2, form a guide tray for the soil, thereby forming a layer of loosened grass turf with cut and chopped roots, and the thrower 7, rotating through the gearbox 8 from the hydraulic motor 9, throws out the formed layer of loosened turf of grass vegetation with cut and crushed roots in the direction of the fire of a ground fire or to the side, when mineralized bands are formed, thereby covering the turf of grass vegetation and forming a layer of soil from it, which prevents the spread of fire during a ground fire.

Another design of the soil thrower proposed by the authors of the article is a design based on an excavator (Figure 3) [15]. This design of the soil thrower includes a power plant 1, a working body 2 in the form of a cutter-thrower.

This working body (Figure 4), installed inside the U-shaped frame 3, with the help of a hydraulic motor 4 is connected to the power-plant 1, such as an excavator. At the bottom of the frame 3, stops 5 are fixed, which are placed beyond the center of mass of the working body. At the same time, the working body is closed from above by a guide casing 6, which is mounted on bearings 7 on its shaft 8 and connected by means of a rod 9, the upper part, with the body of

the U-shaped frame 3. The working body 2 with the help of the hydraulic cylinder 10 has the ability to change the position in the vertical plane, and the U-shaped frame 3 as a whole in the horizontal and vertical planes with the help of the manipulator 11 of the power-plant 1.

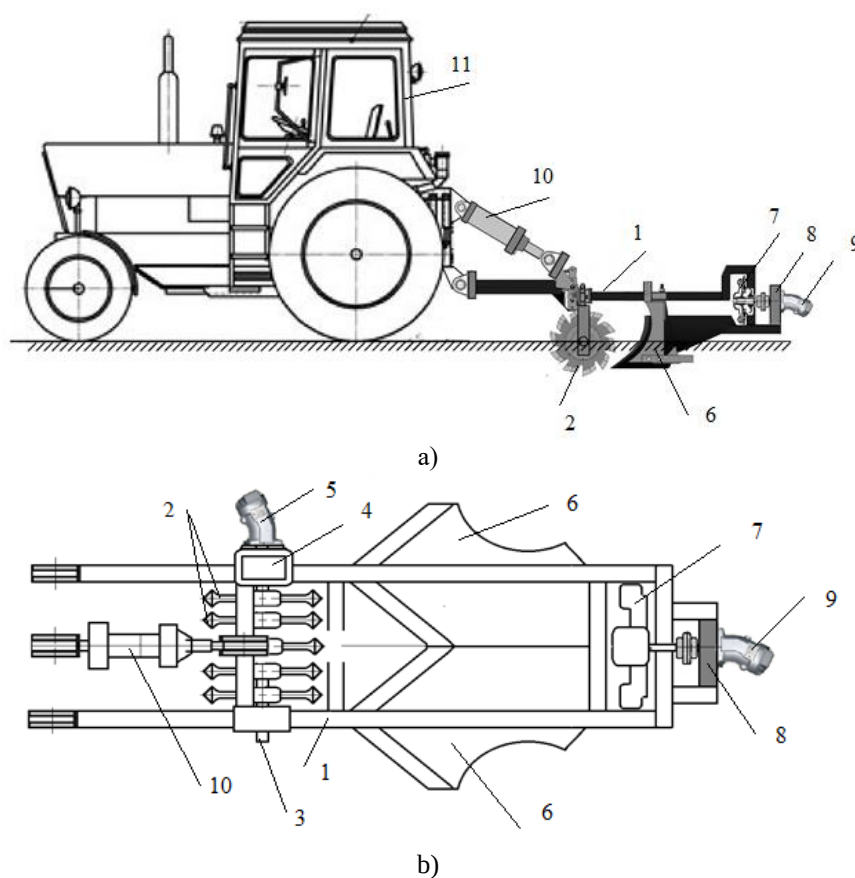


Fig. 2 Firefighting soil-thrower: a - side view, b - top view.

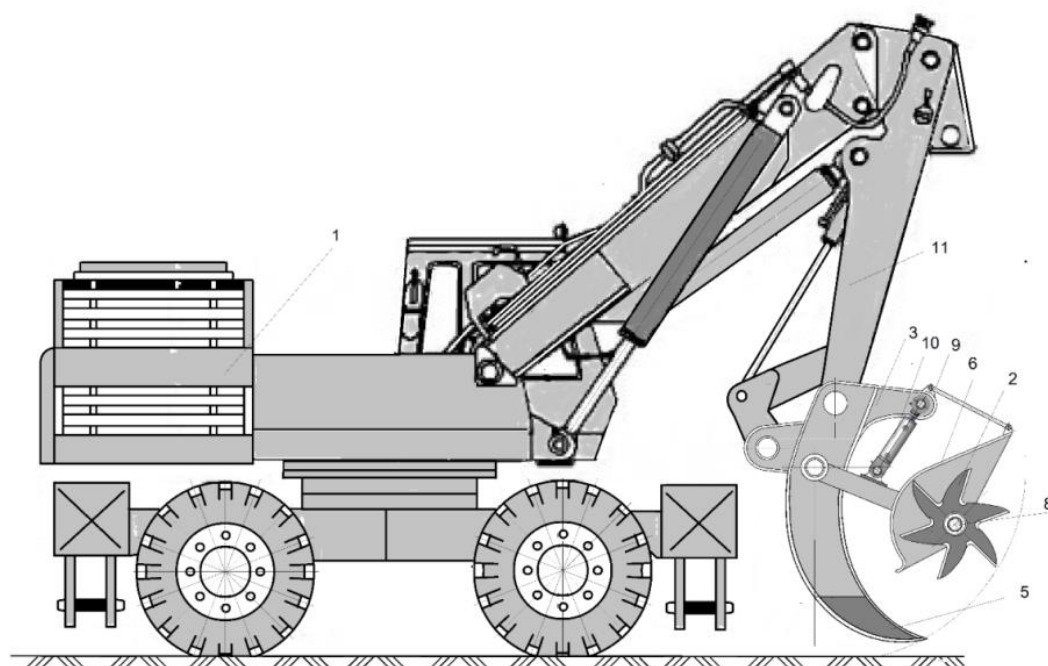


Fig. 3 Excavator-based firefighting soil-thrower.

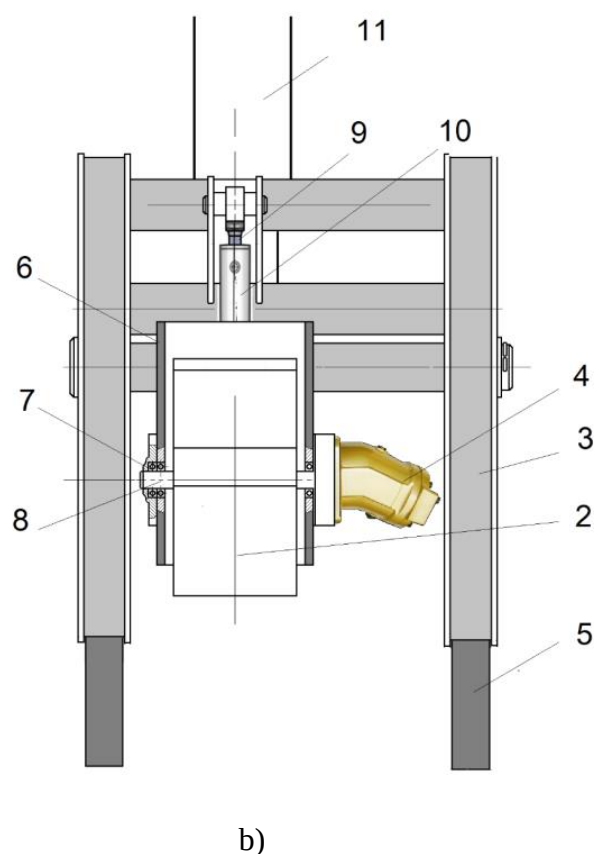
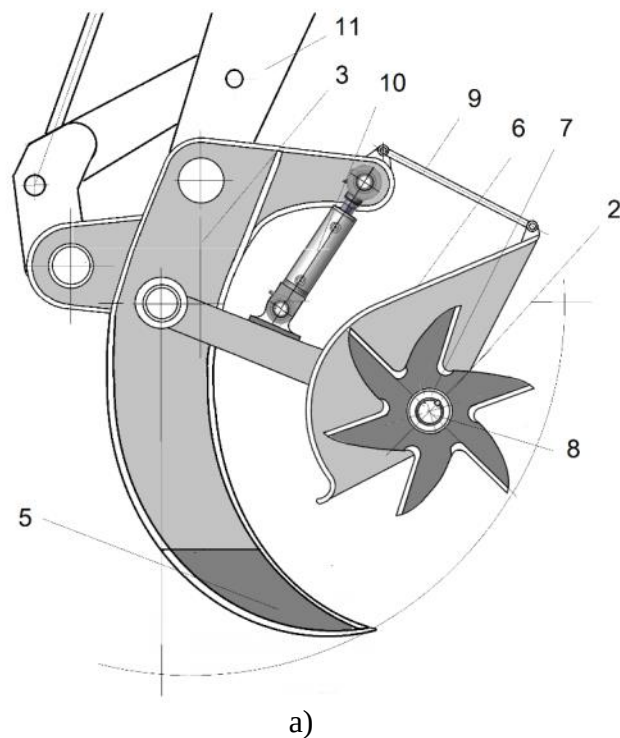


Fig. 4 General view of the firefighting soil-thrower: a - side view, b - front view.

Before starting work, with the help of the manipulator 11, the stops 5 are buried in the ground. U-shaped frame 3 is tilted forward until the working body 2 touches the ground. Then the hydraulic motor 4 and the hydraulic cylinder 10 are put into operation, while the working body 3 is introduced into the soil, due to which the cut volume of soil is separated and thrown

out of the device. At the same time, due to the thrust 9, the position of the casing 6 changes, due to which the distance of the soil departure from the device is regulated.

After processing the area ahead, the device can be rotated relative to the excavator, thereby circular processing can be performed. The excavator allows you to securely fix the soil-thrower in the soil, which increases the safety of working with it. After completion of work on the forest block, it is transferred to another, and the cycle repeats.

4 Discussion

According to many researchers in the field of fire extinguishing, soil has been and remains one of the most effective fire extinguishing agents. The use of soil for the direct fight against forest fires by throwing it with special soil throwers is a great prospect, since on dry soils, in flat conditions, there is always an unlimited amount of soil in the immediate vicinity of the edge of the fire.

There are a large number of designs of firefighting soil-thrower operating due to the operator's thrust [6, 7, 9]. The main disadvantages of which are high energy consumption, as well as low efficiency of the working body due to the lack of loosening of the forest floor, as well as the impossibility of overcoming obstacles, for example, in the form of tree roots due to the insufficient effort of the operator himself. These designs of fire ground throwers operating due to the operator's traction are effective only in cases where the roots and forest floor are first cut by a plow or in their absence (on sandy soils beyond the edge of the forest). Therefore, preference is given to self-propelled tractor firefighting soil-thrower.

Despite the fact that many well-known researchers have worked on this topic, the patent and literature search made it possible to conclude that similar developments in the field of fire extinguishing are relevant. The closest examples of such design solutions can be considered the designs proposed in the patents of Russian Federation [2, 3]. However, both designs of soil throwers have significant drawbacks compared to the proposed options. In particular, the following technical points can be attributed to the disadvantages of the design [2]:

1. The operation of the device is difficult in areas that have in their composition the roots of trees and shrubs and turf of herbaceous vegetation;
2. The device cannot be used for laying mineralized firebreaks;
3. The soil is fed into the fire zone together with the top cover, consisting of needle-foliage, which reduces the efficiency in extinguishing the fire and often contributes to its advancement.

The disadvantages of the design [3] is the insufficient effective removal of roots.

When using the new technical solutions proposed in the article for forest fire soil throwers, both the thickness of the separated soil shavings and the width of the mineralized strip are regulated. The thickness and width increase as the plowshares deepen into the ground in the first case and due to the deepening of the stops in the second case.

These structures make it possible to preliminarily loosen the soil and overcome obstacles in the form of tree roots due to their cutting by cutters-rippers and cutters-throwers.

CONCLUSION

The proposed designs of forest fire soil throwers make it possible to reduce the efforts to separate soil chips from the massif, to ensure the spreading of soil to various lengths and to overcome obstacles in the form of tree roots. Their use in forestry can significantly increase the efficiency of fighting forest fires in forest areas.

The technical features of the proposed structures are able to provide the possibility of their operation in conditions of not only light, but also heavy soils with an additional load from the surface root system of trees and shrubs. The designs provide the possibility of their installation on widespread types of tractors, both wheeled and caterpillar, which solves the problem of their widespread use in forestry enterprises when extinguishing forest fires. The options for technical modernization described in the article are not the final, but undoubtedly an important stage in the work of the team of authors. The next stage on the path of modernization of soil-throwers proposed by the authors should be the theoretical calculation and development of prototypes, their experimental verification in laboratory and production conditions, as well as an economic justification for the effectiveness of the proposed options for the modernization of constructions.

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