Development of a manual garden shovel with the ability to quickly clean the working surface

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Abstract. Manual garden shovels have various shapes and sizes, are used to perform a large number of works with soil. A common problem for all garden shovels is the sticking of soil on the working part – the blade. Constant sticking of soil on the blade reduces labor productivity, requires considerable effort and time for cleaning, even the presence of special devices. There are constant attempts to solve the problem of quick cleaning of the blade of manual shovels. Many technical solutions to this problem are patented and are actively used in practice. The design of the self-cleaning shovel consists of a handle and a metal blade with a sharpened cutting edge fixed at one end of the handle, a tubular clamp and footrests, as well as a cleaning plate that is fixed to the movable handle, and a compression spring located under the movable handle around the tubular clamp of the shovel. Cleaning of a metal blade is performed by the cleaning plate, which moves along the metal blade from the footrests to the cutting edge and back. To do this, the user moves the movable handle towards the metal blade, providing compression of the spring.

1. Introduction
Now and in the near future manual tools will be an important factor determining labor productivity in various areas of human activity [1]. The most famous and popular manual garden tools are shovels. They are used for digging, lifting, moving, and throwing tilled soil or loose building materials. A traditional shovel consists of a blade fixed to a handle by a tubular clamp (shank). The blade, stamped from a steel sheet, usually contains footrests and a fold, serve as stiffeners (figure 1).

![Figure 1. The design of a traditional shovel.](image)

The handle of the shovel, which is usually 0.7 to 1.27 cm long, may contain a grip. The angle between the handle axis and the blade plane is called a lift and provides the tool with an additional lever force [1].
Agro-technical processes of manual tillage should be performed with a quality convenient tool that provides high-quality preparation of land or ground [2,3,4].

Digging is an important basic mechanical soil processing activity, during which soil layers are lifted to the surface and partially crushed [5]. During the soil processing, plant residues and fertilizers are incorporated, a favorable thermal and water-air regime is created, i.e. the structure of the plowing layer changes. At the same time, weeds, pests and plant pathogens are destroyed, and the nutrient status of the soil is improved [2].

When digging with a shovel, a significant part of the effort is spent not only to lift and turn over a layer or clod of earth, but also to clean the blade from the stuck layer of soil.

When the blade is stuck with soil, the user's actions are limited not only to the pushing of the tool blade into the ground, lifting the soil to a small height, turning the blade over, and breaking clods. Cleaning of the shovel blade from the stuck soil, especially on heavy clay soils, is possible only when the end part of the shovel hits hard surfaces or when using additional tools. This is an energy-intensive process, which increases the pressure on user’s arms and back [2]. Intense flexion of the back and wrists can cause injuries, the treatment of which is usually very expensive [6].

If earlier users, including agriculturists and farmers, used the simplest tools and devices, nowadays most of them are convinced that under market conditions it is possible to achieve high profitability only by using modern and more advanced tools [7]. The creation of comfortable working conditions and the use of ergonomic tools are already important factors in improving labor productivity.

This increases the relevance of the processes of improving manual tools used in various fields of activity, including when performing agricultural processes.

2. Methods

For the first time from a scientific point of view, the effect of using a shovel on labor productivity was studied by F. W. Taylor in the United States at the end of the 19th century. Since then, many researchers have analyzed various aspects of shoveling [1].

Despite the rather significant difference in the studied aspects, the data of most researchers clearly reflect an increase in efficiency with an increase in the speed of shoveling, as well as an improvement in its ergonomic characteristics [1,8,9].

The basic bayonet-type design has the most popular and mass-produced dacha shovel [10, 11], made of a metal blade, which is plain-bent along the axis at the side of its front surface, the lower part of which has a sharpened cutting edge. On the upper part along the axis of the blade there is a tubular clamp, made for fixing a wooden handle in it. On the blade, to the left and to the right of the tubular clamp, there are footrests folded toward the front surface of the blade.

The disadvantage of the device is that in the case of soil sticking, cleaning the metal blade requires certain skills and considerable effort on the part of the user. The cleaning process reduces the productivity of using and operating the device, and may cause its breakage.

3. Results and discussion

The employee of the FSBEI of Higher Education “Pskov State University” has developed a self-cleaning shovel [12].

The utility model relates to agriculture, in particular to manual garden tools, and can be used for tillage and other types of agricultural and general construction works.

The technical task solved by the claimed device is to reduce the time and physical effort of the user when cleaning the metal blade of the shovel and, thus, to increase labor productivity, as well as to reduce the probability of breaking the device when cleaning it.

The technical task is achieved by the fact that the proposed device contains a handle and a metal blade fixed at one end of the handle. The lower part of the blade has a sharpened cutting edge. On the upper part along the axis of the blade there is a tubular clamp, made for fixing a handle in it. On the blade, to the left and to the right of the tubular clamp, there are footrests folded toward the front surface of the blade. The device contains a cleaning plate, which is formed with an opening, the profile of which
corresponds to a cross-section of the metal blade. The cleaning plate moves along the metal blade and is fixed to a movable handle that has lateral longitudinal grooves. These grooves allow the movable handle to move the cleaning plate along the metal blade from the footrests to the cutting edge and back. The compression spring, located under the movable handle around the tubular clamp, provides movement of the cleaning plate along the metal blade from the footrests to the cutting edge and back, and return of the cleaning plate to its original position.

The technical essence of the proposed device is explained by the drawings (figure 2, figure 3).

Figure 2. Plan view of the self-cleaning shovel (starting position (a) and working position (b)).

Figure 3. Sketch of the movable handle of the self-cleaning shovel as viewed from the metal blade.

The design of the self-cleaning shovel consists of a handle 1 and a metal blade 3 with a sharpened cutting edge fixed at one end of the handle, a tubular clamp 7 and footrests 2, as well as a cleaning plate 4 that is fixed to the movable handle 5, and a compression spring 6 located under the movable handle around the tubular clamp of the shovel. The movable handle 5 has lateral longitudinal grooves 8.

The movable handle provides movement of the cleaning plate relative to the tubular clamp and the handle, and, consequently, compression and releasing of the compression of the springs with two degrees of freedom. The overall dimensions of the proposed device are accepted according to the existing standards for such structures.

The principle of operation of the proposed device is - during the operation of the shovel, the cleaning plate is pressed against the footrests by a movable handle located on top of the uncompressed spring, which surrounds the tubular clamp of the shovel. Cleaning of the metal blade is performed by the cleaning plate, which moves along the metal blade from the footrests to the cutting edge and back. To do this, the user moves the movable handle towards the metal blade, providing compression of the spring. The metal blade with the footrests passes through the longitudinal grooves and serves as a one guide for the movable handle, and the handle serves as a second guide. The cleaning plate returns to its original state by releasing the spring after the user releases the movable handle.

The proposed change in the design of the traditional shovel reduces the intensity of flexion the user's back and wrists when cleaning the metal blade. The preliminary economical assessment shows that the
additional material and labor costs are relatively small compared to the medical costs of treating injuries caused by the use of traditional manual agricultural tools.

4. Conclusions

Shovels are still one of the most widely used manual tools. They are used for digging, lifting, moving, and throwing tilled soil or loose building materials.

Agro-technical processes of manual tillage and other works with soil should be performed with a quality convenient tool. The traditional design of the shovel has a significant disadvantage - in the case of soil sticking, cleaning the metal blade requires certain skills and considerable effort on the part of the user. The process of cleaning may require additional skills, reduce labor productivity, and may cause tool breakage. Cleaning of the shovel blade from the constant sticking of soil increases the pressure on user’s arms and back and may cause serious injuries.

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The technical task of the self-cleaning shovel is to improve the ergonomic characteristics, to reduce the time and physical effort of the user when cleaning the working part – the blade, and, consequently, to increase labor productivity.

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