Shock-absorbing technologies of seed treatment before sowing

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Abstract: In the conditions of agriculture biologization an urgent problem is to exclude the destruction of seeds and reduce their injury by the working bodies of machines. The advantages of using equipment with highly elastic working bodies in shock-absorbing technologies for preparing seeds for sowing are described. The process of interaction of seeds with reflective work surfaces was studied experimentally on a specially developed laboratory installation. Elastic working bodies of such devices provide a "gentle shock wave" mode, the impact of which on easily injured legume and potato seeds contributes to the development of positive dynamics of physiological processes in the seed, without injury and destruction of seeds. The impulse pressure is created by the shaking action of the elastic shell on the seeds. By adjusting the amplitude and frequency of vibrations of the elastic shell, it is possible to achieve the necessary value of the impact on the seeds, creating an impulse pressure on the seeds within the limits of those norms. The last, on the one hand, do not have a destructive effect on the seeds. On the other hand, contribute to increasing seed productivity. The developed shock-absorbing technology makes it possible to combine the use of both chemical and biological means of seed protection in large agricultural holdings, as well as in medium and small agricultural enterprises.

1. Introduction
Reducing injury and destruction of seeds by the working bodies of machines is an important task facing manufacturers of agricultural machinery. Damage to seeds by the working bodies of machines makes it economically unprofitable to use biological products in seed treatment technology before sowing to protect against pests and diseases. Moreover, at the present stage of the development of agricultural production, only "an organic farming system is capable of providing a real economically profitable transition to intensive production technologies, primarily grain" [1]. The transition to the biologization of crop production will make it possible to obtain a "science-intensive tool for increasing grain production with a simultaneous increase in the efficiency of an individual or collective agribusiness" [1, 2].

2. Materials and methods
Effective solution the problems of injury to seed and improve mixing efficiency, it is proposed to use shock-absorbing technologies based on the use of agricultural machines with highly elastic working bodies [3, 4].

Highly elastic materials, such as elastomers, must be used as the material of the working bodies of machines for performing technological operations in which it is required to exclude injury and damage to seeds [5, 6, 7].

In an elastic mixer-treater, the main working body is an elastic shell. Studies by many scientists have proven that the presence of internal mixing devices interfere with the free movement of particles and not only impede the mixing process but also injure the seeds [8, 9]. It is the highly elastic working bodies, due to their physical and mechanical properties and design features that best ensure the free chaotic movement of the components during mixing without damaging the seeds.

Let us consider the kinetics of the impact interaction of a particle with the surface of a working body made of a low-elastic and highly elastic polymer coating. There are many different definitions of impact in the scientific literature. The most accurate, in our opinion, is the formulation proposed by E.V. Aleksandrov and V.B. Sokolovsky in the monograph "Applied Theory and Calculations of Impact Systems". They note that "Mechanical shock is a phenomenon that occurs when bodies collide, accompanied by a complete or partial transition of the kinetic energy of bodies into the energy of their deformation" [10].

On impact, the forces of interaction between bodies are so high that all other consistently acting forces can be neglected. The force of impact arising from a collision with a rigid non-deformable surface is presented in the scientific literature as a sharp jump, a surge. With this interaction, the so-called "elastic shock" occurs, characterized by a sharp change in the trajectory, speed and acceleration of the point – curve 1 (Figure 1). If, for example, a rubber ball falls onto the surface, then after the collision, the ball bounces off the surface and regains its shape and size. The higher the coefficient of recovery, the more elastic properties of the surface and the ball. If a seed – a living organism – falls on the surface of the working bodies of agricultural machines, then such a collision does not pass without harm. The seed is injured and as a result of repeated falls and jumps can be destroyed, if the impact forces are significant, then the life of the seed will be significantly damaged. The higher the seed jumps, the more painful it is to fall again. However, what is sown is reaped. A weak seed means a bad harvest. Such a traumatic effect is exerted not only by the rigid steel surface of agricultural machines without polymer coating (curve 1, Figure 1) but also with a polymer coating (curve 2, Figure 1). The polymer coating softens but does not exclude the impact of the seed on a hard surface.

The surface on which the particles of the free-flowing body fall is deformed. If the surface deformation is insignificant, the higher is the impact force on the particle. It is known from the theory of mechanics of a deformable body that if the deformation of the surface exceeds the permissible values of the deformations of the elastic limit of the material, then they will become irreversible. That is, the material, when stretched, will not shrink but will remain in a stretched sagging state.

Consequently, the surface deformation must be both significant in order to soften, damp the impact force and elastic in order to withstand the impact force and not stretch beyond the limit values.

When a bulk body falls on a stretched highly elastic surface, the elastomer fibres stretch, accumulating potential deformation energy. Elastic interaction of the highly elastic working body and the bulk body occurs. When stretched, the fibres begin to contract (shrink) due to the elastic properties of the elastomer (curve 3, Figure 1). By contracting, the fibres transfer the deformation energy to the free-flowing body in the form of the kinetic energy of particle motion, prompting the particles to jump and bounce more intensively from the working surface.

When colliding with a highly elastic surface with high elongation within elastic deformations, the seeds will fall on the surface of the working body of the machine and cause it to stretch. The magnitude of this stretching will depend on the magnitude of the load from the seed material (bulk body) and the physical and mechanical properties of the material of the working body of the machine (curve 3, Figure 1). The highly elastic surface stretches by a significant amount, sufficient for damping (absorption) of the impact, but not exceeding the deformation of the elastic limit of the material. Since
the mass of a granular body in the volume of the shell has a finite value, the deformation of the shell material will also have a finite value, which, in turn, according to the above-described condition, should not exceed the elastic deformation of the shell material. Therefore, after stretching the surface under the weight of the bulk body, the highly elastic fibres of the working surface will begin to contract, releasing, like a spring, the accumulated deformation energy and transferring it to the bulk body in the form of the kinetic energy of motion of the particles of the bulk body.

Figure 1. Graphic representation of the impact of the working surfaces of various liquids

If the vibrations of the shell are forced, then this process will be cyclically repeated, and the seeds will be in a fluidized state. In this state, the bulk body is in suspension, and the particles of the bulk body move freely, changing their position in space relative to each other. It is known that the fluidized state of a bulk body is the best way to intensify the mixing process [11]. Moreover, the mixing process without destroying particles best meets the requirements of pre-sowing seed treatment with both chemical and biological preparations, dry or liquid.

The main advantages of using technology with highly elastic working bodies in mixing and seed treatment technologies before sowing include:
1. Elimination of mechanical damage and significant (10 or more times) reduction in the risk of injury to seeds by working bodies
2. Multifunctionality is the ability to use one device for the implementation of various methods, as well as a mixer to obtain multicomponent mixtures.
3. Environmental safety, ensured by the complete exclusion of contact of pesticides (pesticides) with the environment and service personnel.
4. The simplicity of construction and maintenance of the device.
5. The variety of used drive-stimulators to create a shaking vibrational effect of highly elastic working bodies.
6. Ensuring the preparation distribution uniformity on the seeds and the completeness of the coating with the dressing, as well as the mixing uniformity.
Shock-absorbing mixing technology based on the use of machines for processing seeds with highly elastic working bodies allows the use of sophisticated methods of processing by chemical, physical and biological methods.

The developed machines can be used for bio-incrustation of seeds, eliminating the risk of harmful effects of chemicals on the environment and humans [12, 13]. The obtained scientific results are aimed at creating high-tech and globally competitive agricultural machinery, strategically necessary for the agro-industrial complex of Russia, corresponding to the world level of development.

For an experimental study of the process of interaction of seeds with reflecting surfaces, a laboratory setup was made [14]. Figure 2 demonstrates this laboratory setup.

The following were used as reflective surfaces:
- steel plate;
- polymer-coated steel plate;
- highly elastic fabric (polyurethane).

The process of interaction of particles with reflecting surfaces was recorded using a high-speed video camera. The shooting results were processed using the Free Video to JPG Converter software for converting shooting frames.

Given the physical and mechanical characteristics of the shell material, it is possible to determine the value of the elastic force of the shell, at which detachment of particles of a granular body is possible without injury to its particles.

3. Results

The results of theoretical and experimental studies on the creation and the possibility of using devices with elastic working bodies in the technology of pre-sowing treatment of elite seeds and seeds of fragile crops (peas, soybeans, potatoes) are described in detail in [14]. Experimental studies made it possible to conclude that the force of the shock impact of rigid non-deformable working organs of agricultural machinery on the seeds of fragile crops is higher than the ultimate destructive load that the seed can withstand. Fragile crop seeds are elite seeds, legumes and potatoes and other crops.
Moreover, the force of impact of a particle on an elastically deformable elastic surface is hundreds of times less than the impact force on a rigid steel surface and much less than the destructive load that the seed can withstand [14].

4. Discussion

So, the shock effect of machines with rigid working bodies and impulse pressure devices can be excluded by using elastic working bodies as working bodies of machines. The elastic working organs of such devices provide a "gentle shock wave" mode, the effect of which on easily injured seeds of legumes and potatoes contributes to the development of positive dynamics of physiological processes in the seed, without injury and destruction of seeds. The impulse pressure is created by the shaking effect of the elastic shell on the seeds.

Adjustment of the amplitude and frequency of vibrations of the elastic shell led to achieving the required impact on the seeds. This shock effect creates an impulse pressure on the seeds within the limits of those norms, which, on the one hand, do not have a destructive effect on the seeds, and on the other hand, contribute to an increase in seed productivity.

Therefore, it is necessary to use elastic-elastic materials - elastomers - as the material of the working bodies of devices for pre-sowing seed treatment and all other technological operations. An essential task of pre-sowing seed treatment is to exclude injury and damage to seeds. Elastomers do not cause destruction and can significantly reduce and eliminate the risk of injury to seeds.

5. Conclusion

The developed shock-absorbing technology for mixing and treating seeds before sowing is essential for crop and seed production. The introduction of environmentally friendly technology for pre-sowing seed treatment based on devices that protect seeds from injury and destruction will improve the sowing quality, yield properties of seeds of grain and leguminous crops, and accelerate the transition to organic farming without losing yield. The developed shock-absorbing technology makes it possible to combine the use of both chemical and biological seed protection agents both in extensive agricultural holdings and in medium and small agricultural enterprises.

Acknowledgments

The study was carried out with the support of RFBR grants No. 19-01-00250.

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