OPTIONS FOR USING HYDRODYNAMIC CAVITATOR TO SPEED UP SEED GERMINATION

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ВАРИАНТЫ ИСПОЛЬЗОВАНИЯ ГИДРОДИНАМИЧЕСКОГО КАВИТАТОРА ДЛЯ УСКОРЕННОГО ПРОРАЩИВАНИЯ СЕМЯН

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Abstract: *Acoustic cavitation in water causes water's break in vacuum phase of passing of sound wave and then collapse of this break in manometric phase. These processes are taking place 3000 times a second all over the functional volume of cavitator. This leads to seeds' awakening and massaging, improves metabolism and stimulates their development and functioning. There are four technology areas in cavitator: 1) internal functional space, 2) central part of space, 3) passive space from the outside of resonator (housing), 4) external heat space around cavitator.*

The Academy conducted study on seed treatment in each of these areas. Moreover, in passive area and in external space experiments were performed both in wet and dry options. Analysis of experimental results showed: first, all kinds of treatment in all zones of cavitator have advantages over conventional soaking seeds; secondly, each of the processing forms has its own advantages: 1) dry processing is characterized by thermal and vibrational effects on seeds, it requires their direct contact with the resonator, 2) wet processing in passive zone is characterized by additional water exposure and transmission of vibration effects from resonator over long distances, that enables to increase size of functional area and pre-processing performance, 3) processing in central part of the active zone provides essential decrease of exposure time from tens of minutes to 3-5, that allows using this method in industrial agriculture, 4)processing in turbulent flow of active zone damages seeds and is suitable only for solid seeds and seeds difficult to germinate. Using cavitator improves seed germination by tens of percent when shortened processing time. This reduces the labor intensity, improves pre-processing performance and leads to higher yields.

Keywords: *ACOUSTIC CAVITATION, WATER STRUCTURE, SEEDS, HYDRODYNAMIC CAVITATOR, ACTIVE ZONE, RESONATOR, PASSIVE ZONE, WET PROCESSING, DRY PROCESSING.*

1. Introduction

An important task in agricultural production is to increase and accelerate the germination of seed and forage grains. In plant growing pre-sowing treatment provides higher yields in the same proportion. In fodder production, when germinating forage grains for the preparation of vitaminized fodders, the increase of germination improves feed quality due to the increased content of proteins, carotenes, vitamins. This process is also important for bakery production.

The improvement of germination technology is also of great importance, since acceleration of this process reduces production costs, production space, equipment and maintenance costs, labor intensity. Very often the cost of the operation determines usefulness of germination.

2. Preconditions and means to solve the problem

The following traditionally known methods of stimulating wakening and development of seeds can be called: heat treatment, soaking, bubbling, which can be used both individually and in combination, but their effectiveness is low - germination time is several days, germination rate increases slightly.

A necessary condition for accelerating development of the industry is using for both existing and promising technological processes new physical operation and physical effects. The following new methods for seed evocation can be called: seed treatment by electric fields in the range of ultrahigh frequencies, radioactive and X-rays, explosive effect, etc. However, these methods, firstly, can be harmful to the plants and to the operators; secondly, their effectiveness is insignificant in comparison with traditional methods. Most interesting is acoustocavitational treatment of seeds which provides balanced multi-component effect on the seeds.

3. Solution of the problem

The essence of acoustic cavitation is that when sound waves are emitted in aqueous medium, in each of its nucleus (irregularity) with frequency f = 3000 times per second, the pressure changes from the vacuum magnitudes (values) breaking the medium, to the manometric ones that ensure the collapse of each of these ruptures. In this case, the phase of formation of rupture cavity provides pumping elastic energy into it, and the collapse phase ensures the compaction of this energy, both in space and in time (fig.1).

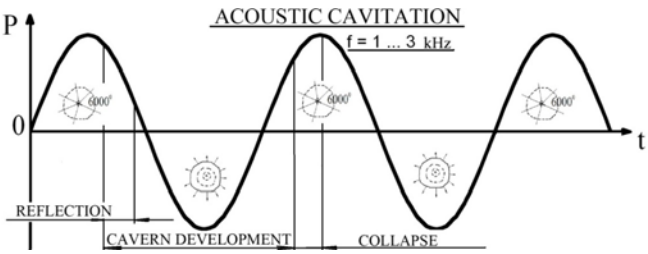

fig.1. *Mechanism of the acoustic cavitation*

High concentration of energy after collapsing provokes formation of electrodynamic, electrostatic processes, a number of chemical reactions, formation of secondary shock waves with high pressure gradient in their fronts, significant degree of deformation of liquid microparticles - clusters, followed by their destruction and formation of new ones, thorough grinding and mixing of foreign inclusions in water at the molecular level [1].

The listed (by far not all) processes affect the seeds placed in the cavitation area, causing their awakening, massage, volume deformation, create standing waves along each seed, change the properties of the medium, equally dissolve air and nutrients, bring them to the cell membranes, increase the permeability of these membranes.
As a result, the intensity of metabolic processes in the cells increases, seed evocation and development are activated [2].

Previously piezoelectric and magnetostrictive methods were used as a source of sound formation, but crystals-emitters of these methods can emit only limited power, above which they are destroyed.

More promising is the hydrodynamic method of generating acoustic waves [3], for example, interacting of circumferential (external) and input flows in the volute. In this case, sound signal is formed in the volute due to the competitive interaction of these multidirectional flows, and in the resonator which is made in the form of a cylindrical casing (body), this signal is amplified by almost two times (doubled) due to the formation of a standing wave (fig.2).

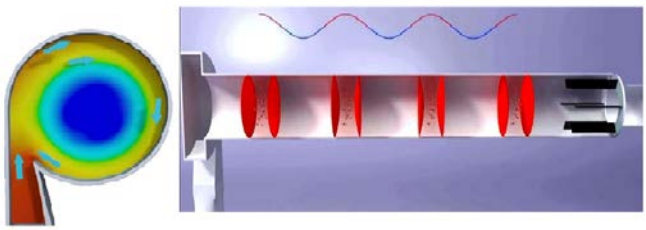

fig.2. *Cavitator emitter and cavitator body with a standing wave*

In the hydrodynamic cavitator (fig.3), it is possible to treat seeds with the following technological methods:

fig.3. *The appearance of vortex cavitator with water jacket.*

* **in the passive space from the outside of the casing, that is:**

- as "dry" treatment on the surface of the resonator;

- as "wet" treatment in the space of the body enclosing the resonator and filled with tap water;

- as "wet" treatment in the space of the casing filled with water treated in cavitator;

**** in the active (internal) space of the casing, that is:**

- in the central part of the active space;

- in the wall (peripheral) part of the active space of the fixed casing (body);

- in the wall (peripheral) part of the active space of the rotating body;

*** **in the outer space referred to the cavitator, that is:**

- in the form of dry (by heating) treatment over the cavitator;

- n the form of wet-heated treatment over the cavitator;

- in the form of soaking seeds in water, which has been treated on a cavitator.

Dry treatment when seeds (fig.4) come into contact with the outer surface of the resonator (*****) makes possible to increase germination of sunflower seeds from 82% to 96% due to the following factors: heating, possible low-intensity radiation, mechanical vibrations at frequencies of 50-3000 Hz.

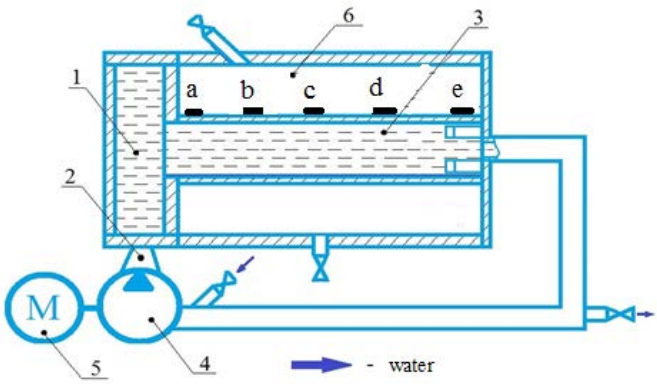

fig.4. *"Dry" treatment on the surface of the resonator*

The advantage of the situation in question is that the best results correspond to the middle part of the resonator (c, fig.4, fig.5), where the antinode of the standing wave is located, and to its end (e, fig.4, fig.5), where the local focus of acoustic cavitation formed from the vortex flow of the guiding device is located. That is, the zones of maximum intensity of acoustic cavitation have the most beneficial effect on the seed evocation and development.

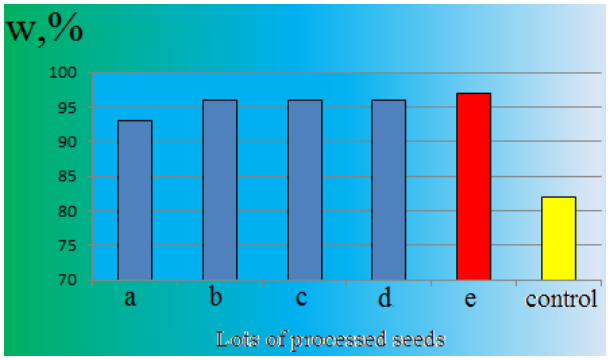

fig.5. *Results of "dry" treatment on the surface of the resonator*

Filling the enclosure with just tap water expands the means of action on each seed, firstly, due to the fact that body vibrations are transmitted not only to the internal space, but also to the outer space (fig.6).

Although the external elastic vibration is characterized by divergent directions, and because of this its intensity decreases, nevertheless, in the outside wall area of the casing cavitation processes are likely to occur [4].

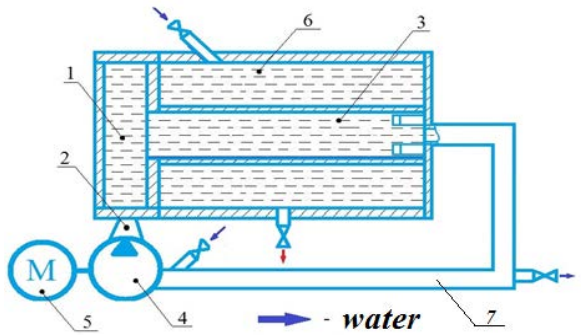

fig.6. *Principal scheme of vortex cavitator with water casing : 1- cyclone; 2 – nozzle; 3 – resonator; 4 – pump; 5 – driving engine; 6 – water casing; 7 - return line*

Secondly, in this case presence of water combines processes of seed evocation and soaking. Water ensures delivery of nutrients, oxygen and other vital components to the seed cells. Thirdly, due to cavitation processes (although limited), water gets additional positive qualities due to its structure change [5]. As a result, germination of low-quality wheat seeds increases from 44% to 88% (fig.7).

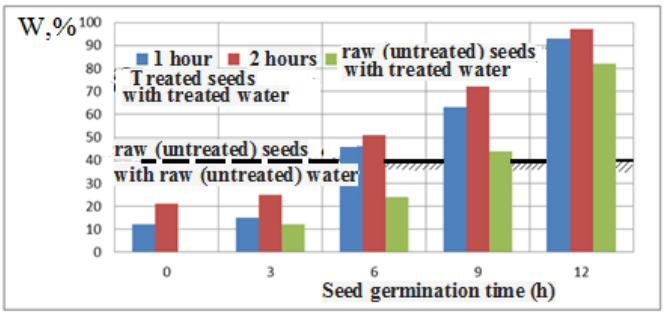

fig.7. *Germination of wheat seeds after different treatments on a cavitator in comparison with traditional soaking*

The efficiency of seed germination increases significantly, if during wet seed treatment in the casing space, the usual tap water is replaced with water treated in active zone of the cavitator (fig.8).

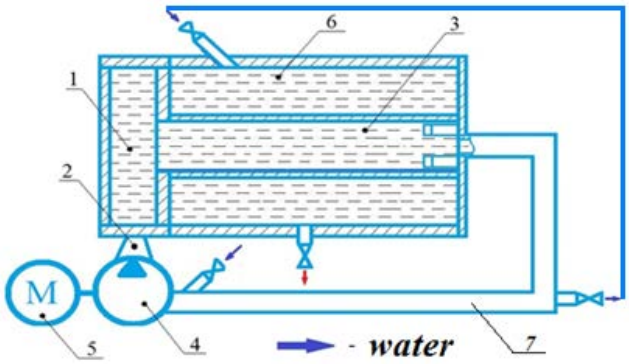

fig.8. *Scheme of water supply from the cavitator in the cover*

This happens because water changes the structure of clusters, obtains additional properties, and gets biologically active. Thus, it is possible to further increase germination to 96% and to shorten times of treatment from several days (with conventional soaking) to several hours [5]. In this case, germination dependence on the cavitator working mode and on the seed treatment time can be represented as a surface that increases with increasing holding time and decreases with increasing treatment temperature, especially in the range 45^0 – 70^0, which is due to partial destruction of protein (fig.9).

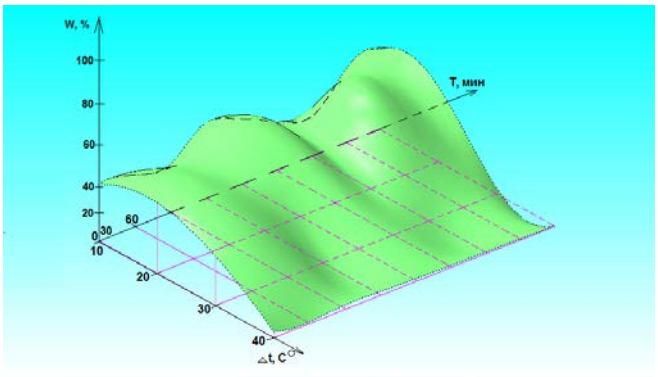

fig.9. *The surface of barley germination as function of cavitator operating mode and treatment exposure*

The seed treatment in the central part of the active space **(**)** of the body 3 (fig.4.) is accompanied by high turbulence of water flow rotating at speed of 30 m / s, by intense exposure of ordinary and acoustic cavitation, by impacts of free surfaces of air and vapor cavities with each seed, by thermal action, ionizing action of low intensity, high gradient fronts of shock waves arising from collapse of cavitation caverns, etc [6].

In this case, the necessary time for seed treatment is reduced from a few hours to 2 - 5 minutes (fig.10.), that allows to use this treatment method as an industrial one and combine sowing and pre-sowing seed treatment in one operation.

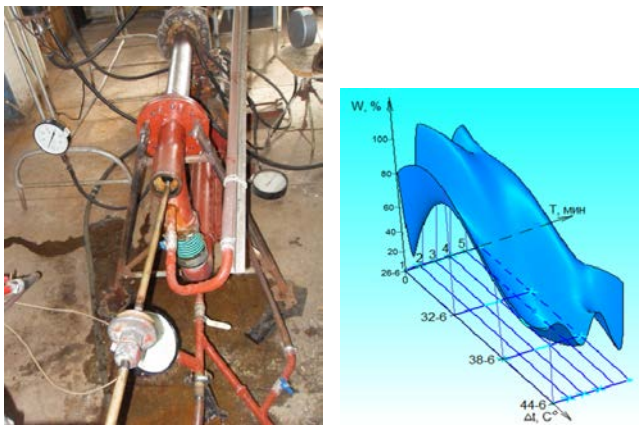

fig.10. *Processing of sunflower seeds in the active zone of the cavitator and its results*

The placement of seeds in the peripheral part of the casing 3 provokes their relative movement with speed ≈ 30 m / s, high friction, shell destruction and, at excessive treatment time, mechanical seed failure. Therefore, this kind of treatment is recommended only for seeds with extremely strong and thick shells at small and accurate exposures. To exclude the processes of destruction, it is advisable to make a casing or an underlying layer (for example, in the form of a grid) rotating at the speed of seed rotation (fig.11).

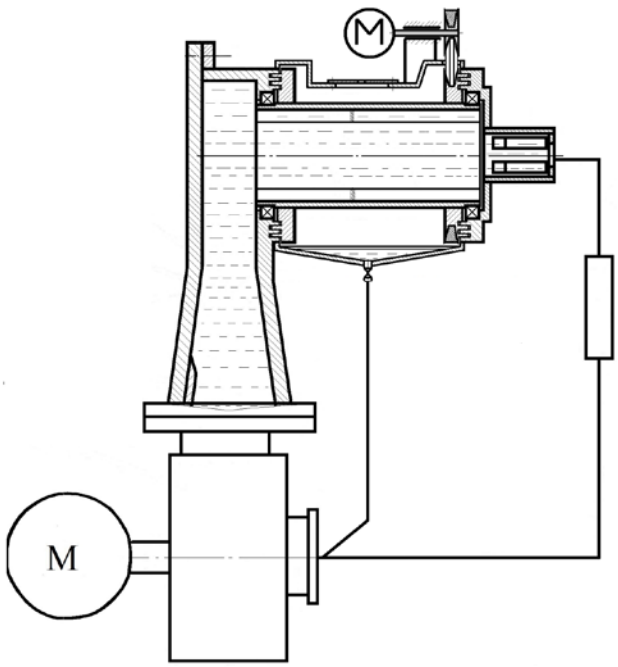

fig 11. *The cavitator project with a rotating body*

In this case, the effect of friction, macrocavitation, steam and air bubbles on the seeds will be eliminated, that will accurately dose the impact of the core on the seeds and at the same time select the most viable seeds, as the diseased seeds will rise to the axis of rotation [7].

When processing seeds in the external space of a cavitator (***) without water, functional factors are heat action and effect of fields of physical nature. At the same time, as the treatment period is increased in all modes of the cavitator operation, the germination increases to extreme values (W ≈ 93% ÷ 94%), after which there is an overabundance of influence and vital activity of seeds is inhibited (W ≈ 85% ÷ 88%). The transition to low-cost (high-temperature) regimes, firstly, shifts the extremum value to the region of smaller exposures (with τ = 7.5 hours at t = 30^0 to τ = 4.5 hours at t = 73^0), secondly, reduces the parameters of the treatment process - for example, the highest germination rate from 94% at t = 30^0 to 89% at t = 60^0, since in this case the cavitator operates in a non-optimal mode and therefore the amount of negative influence on the seeds increases and the share of positive influence decreases.

However, the rational use of heat at low-cost (high-temperature) modes of the cavitator operation can greatly stimulate seed evocation and development and thereby ensure comparability of the germination indicators with high consumption regimes, in this case the damage from insufficient influence of direct process of cavitation is compensated by thermal effect.

The process parameters also depend on the degree of seed removal from the cavitator - the most significant option is the placement of seeds in contact with the resonator (Fig.5).

It should be noted that the germination of seeds treated on a cavitator in all modes in the air exceeds the germination of control samples (W ≈ 85%).

4. Conclusions

1. All types of pre-sowing treatment with acoustic cavitation are more effective than the known ones:
   - soaking;
   - bubbling;
   - microwave treatment;
   - electrostatic treatment;
   - electromagnetic, etc.
2. The most significant cavitation zones are:
   - active internal space of the casing;
   - passive space of the enclosure around the body (casing).

   The external space of the cavitator is less significant area of the workspace.
3. The use of passive space for seed germination allows to increase the germination capacity and to accelerate significantly germination process. This fact makes it possible, due to the acceleration of germination, to increase the yield in plant growing, or to improve significantly quality of highly vitaminized animal feed in feed production. At the same time, due to the acceleration of germination process, the necessary production areas, equipment costs, labour intensity, production costs are reduced and flexibility of technological process is provided.
4. Using active zone of the casing for seed germination makes it possible to increase the productivity of the sprouting process tenfold and to combine this process with the technological operation of sowing.
5. The use of water treated in the cavitator makes it possible to accelerate seed germination by traditional methods - soaking, bubbling, etc. without direct application of cavitator itself.
6. The space above the cavitator is also favorable for germination and can be used when the cavitator performs another technological operation (heating, water treatment, etc.) when several processes are simultaneously combined.

5. Literature

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