

SEED GERMINATION WITH USE OF ACOUSTIC - CAVITATION TECHNOLOGIES

Evgeniy G. Ivanov

Nizhny Novgorod State Agricultural Academy, Russia

ngsha-kancel-1@bk.ru

Abstract. Acoustic-cavitation effect on soaked seeds is created by generating sound waves of certain intensity in water. Passing the vacuum phase of the wave, water is torn forming cavities. Passing the manometric phase of the wave, these cavities collapse with a total speed of the counter walls of $3000 \text{ m}\cdot\text{s}^{-1}$. At the point of collapse high energy density is created. This increases the temperature of the treated water, shock waves are created, their interference occurs, and so on. As a result, this causes deformation and mixing of water, as well as changing its properties. When low-quality seeds are soaked in this water their germination increases (up to 90 %), the germination time decreases (in 3 times) compared with the control germination. Seed processing in the passive zone of the cavitator and then their soaking in treated water increases germination up to 97 %, or reduces germination time from 3 days to 6 hours compared to the original (control) process. A series of devices for various methods of cavitator seed treatment are created, both for crop growing and for preparation of highly enriched feed in animal husbandry: liquid whistle of vortex type (vortex cavitator), liquid whistle of vortex type with the resonator placed in an external holder, liquid whistle of vortex type with the rotating resonator, liquid whistle of vortex type with the correcting device and several resonators, liquid whistle of multiple-jet type, the liquid siren combined with the network pump.

Keywords: seeds, sprouting, vitamins, feed, cavitation, germinating ability, time period.

Introduction

Acoustic-cavitation effect on soaked seeds is created by generating of sound waves of certain intensity in water. Passing the vacuum phase of the wave, water is torn forming cavities. Passing the manometric phase of the wave, these cavities collapse with a total speed of the counter walls of $3000 \text{ m}\cdot\text{s}^{-1}$. At the point of collapse high energy density is created, Fig. 1.

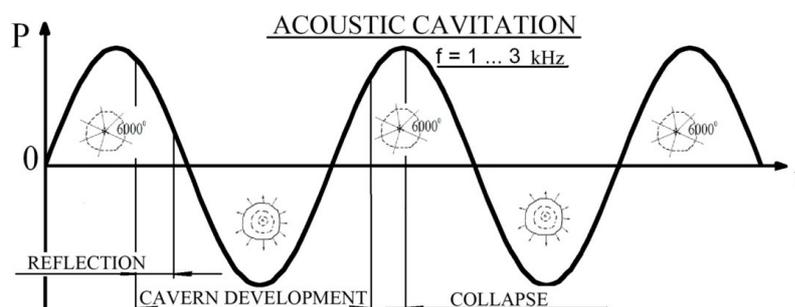


Fig. 1. Mechanism of acoustic cavitation

This increases the temperature of the treated water, shock waves are created, their interference occurs from different sources, and so alternate apparition and desparation of free surface in the cavities, their influence on the margins of rigid bodies, ionizing impulse radiation take place. Everything mentioned above takes place in the whole processing volume with the frequency near 3000 per second etc.

When the seeds find in the area acoustic waves passing they perceive this group of effects first of all as a massage from near collapses. The cell membranes become more penetrating. The metabolism increases with the seed awakening.

Secondly, multidirectional in volume water deformation in the molecular level creates accurate mixture, equal allocation of the admixture (useful microelements) concentration, the exception of admixture clot with harmful concentrations.

As a result, the common concentration level of useful substances becomes increased and equal in all the water volume, the concentration gradient in all the cell surfaces increases and it has as consequences the metabolism increase, accelerated development of each of seeds because of increased diffusion.

Thirdly, the increased temperature till 6000 degrees, more exactly its gradient, little in time but ultrahigh, on the one hand, creates a stress for the biological object. On the other hand, it creates the increase of the common thermal level and it awakens the fruit and creates favorable conditions for its development.

Fourthly, during near collapses the complexes of water molecules (crystallohydrates) destroy, but instantly they reappear as new short term local crystalloid structures. Besides, the crystal lattices from these local structures may be diverse and in some cavitation regimes most favorable structures for the living organism may be created. It is proved with many experiments.

At the same time, the molecules of useful gases (e.g., oxygen) may be placed (hidden) in the space between the lattice sites. The detailed and constant cavitation may provide a more compact filling of these spaces and consequently the increase of its quantity going to the seed cell. In this case water is a delivery device of carbon, oxygen, hydrogen, dissolved nitrogen.

One more merit of the studied process is bacterium eradication, i.e. disinfection at that without any chemical reagent and in not higher temperature except protein degradation. After such treatment smut generation and must covering etc. cease. As a result, the quantity of grown seeds increases essentially and their development accelerates [1-3].

Materials and methods

Different technical facilities (e.g., magnetostrictional or piezoelectric) may be used for creation of the acoustic field in water. However, the use of crystals as radiators is restricted with the little power value, no more than 1kW. Such power value presumes little productivity of the equipment. It cannot reach the required speed of work in the pretreatment period, which is short.

Liquid whistles, which power may reach dozens and even hundreds kW, have got the development and use for this purpose in recent years, Fig. 2.



Fig. 2. Appearance of vortex cavitator with water jacket

At that this device can be characterized by its active volume and internal volume 3 and external space 6 with sparing effect, Fig. 3.

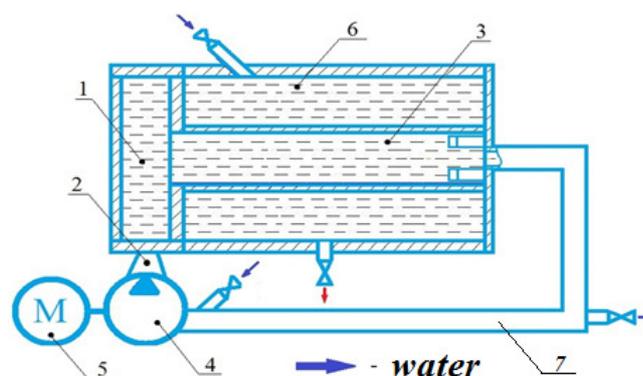


Fig. 3. Principal scheme of vortex cavitator with water jacket: 1 – cyclone; 2 – nozzle; 3 – resonator; 4 – pump; 5 – driving engine; 6 – water jacket; 7 – return line

The job of the vortex cavitator occurs in the following way: the pump 4 makes a pressure flow, which goes to the cyclone 1 through the nozzle 2. The cyclone 1 presents a scroll with a tangential inlet. The input stream making nearly complete revolution in peripheral circle interacts with its input component and makes a sound signal, which distributes to the resonator 3 and then reverberating from the entering end makes a standing acoustic wave. The cavitation processes cited above in Fig. 1 take place in the antinodes of this wave. The stream of the working fluid- water goes from the cyclone 1 to the resonator 3 and then goes to the pump 4 by the return line 7.

The variant of seed treatment in the sparing exterior space in the water jacket 6, Fig. 2, was considered in the first phase of the research program. The intensity of cavitation influence and the duration of its influence were considered as variable factors of the determined experiment.

The influence intensity characterizes by the average number of cycles in the contour: pump – cyclone – resonator – return line – pump of each part of water particulate. As that, the quantity of the cycles depends on the flow rate of the transfer stream by the cavitator. If the flow rate is maximal the quantity of the cycles is minimal and if the flow rate is minimal the quantity of the cycles is maximal. If the transfer stream is absent the quantity of the cycles is unlimited.

It should be noted that the quantity of the spin cycle of each water particle in the contour cited above creates its proper temperature rate of the working fluid in the working process as other analogues of this device are often used as heat-generators. Therefore, the temperature of the working fluid was presented as intensity of cavitation influence.

At the same time the product of the influence intensity and its duration (exposition) determines the quantity of acoustic influence and its rate is proper for the proper crop. So, the correlation between the intensity and exposition may be represented as a matrix diagonal formed with these two factors. However, only some crops have such structure of factor interaction. Moreover, in the most cases it is a tendency. In the whole, the correlation of these factors is more difficult.

Results and discussion

One of the peculiarities is that the germination rate by the factor of exposition duration may be periodically stable so that may be statistically proved. It is caused by the abundance of the influence on the living processes in speed, which have not yet awoken. Fig. 4.

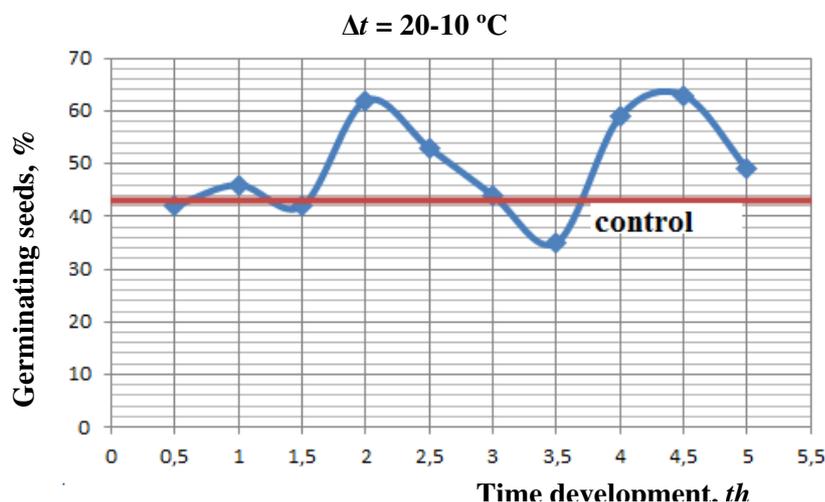


Fig. 4. Dependence of barley seed germination on exposition in regime $\Delta t = 20-10\text{ }^{\circ}\text{C}$

This abundance of influence depresses the development in seeds. As a result, germination gets down. However, this circumstance stimulates the immune system, which adapts the development process to the current condition, which creates stipulates for the next phase of the vital activity in the cavitator treatment on a higher level.

Such germination periodicity can be observed in the most cases by duration and exposition, Fig. 5.

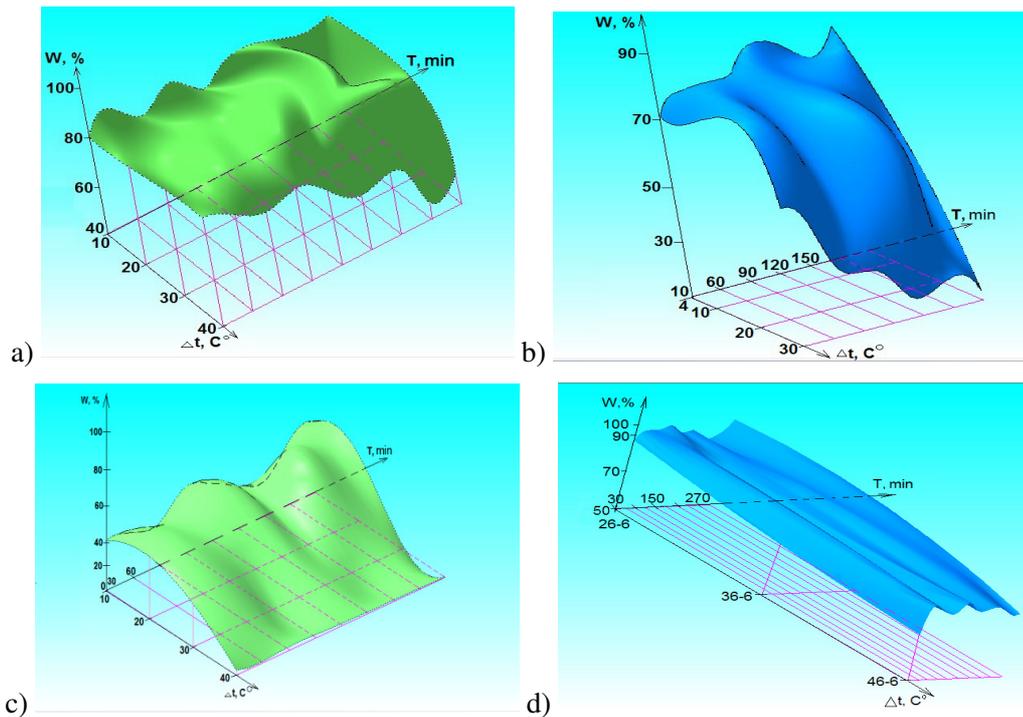


Fig. 5. Dependence of surface of reaction function in germination on intensity and duration of cavitation treatment of seeds of different crops: a – pine, b – wheat, c – barley, d – sunflower

Monotone or extreme dependence takes place in the most cases by the factor of the influence intensity, as the temperature increase with the increase of the influence intensity after the temperature rate $t = 40-45\text{ }^{\circ}\text{C}$ causes protein destroy and the seed vital activity finishes.

The result cited above characterizes [4; 5] the spare treatment of seeds in a cavitator. Its peculiarity is the long treatment term $\tau = 1-5$ hours, though it is advantageous in comparison with steep, barbotage etc. Besides, the treatment result gives advantages in control on several dozens of per cent, especially when the seeds are of bad quality.

The seed treatment is also made in the active zone 3, Fig. 3, of the vortex cavitator, Fig. 6, in the context of the experimental research program.



Fig. 6. Charging of seed batch in active zone of experimental vortex cavitator

The result of the research of active treatment showed that in that case it is possible to reduce the treatment time from several hours to several minutes, so that is decisive for the production. The laws of germination change from the same variables, are analogic to the spare zone treatment, the rates are comparable, Fig. 7.

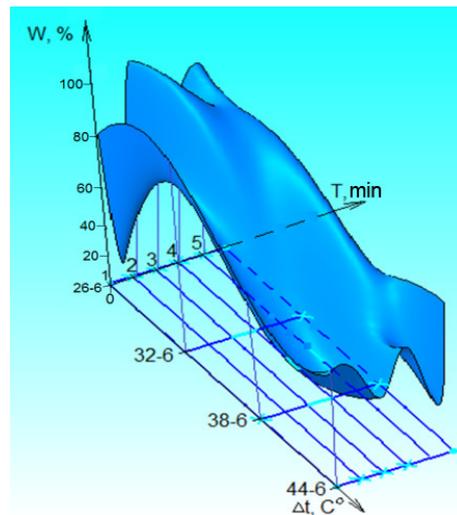


Fig.7. Result of sunflower seed treatment in active zone of vortex cavitator

In this case the gain in efficiency of the treatment may be explained by the fact that all the factors cited at the beginning of this article play a role in the treatment in the active zone of the cavitator. And as for the treatment in the spare zone, to be exact in the water jacket of the resonator, some factors do not influence upon seeds. These factors are the acoustic cavitation itself, microcavitational processes, high turbulent stream, gases taking part in the process etc.

It should be noted that acceleration of germination takes place together with its increase after this kind of presowing treatment, Fig. 8.

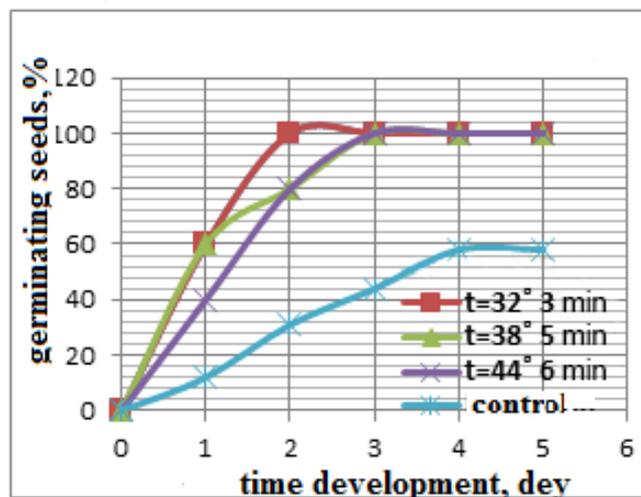


Fig. 8. Rule of sunflower germination by time factor

The described above circumstances let to adopt this kind of treatment in two ways:

- to increase the germination rate with high productivity. It is important from the agronomical point of view,
- to shorten the germination time (from several days to several hours). It is important for preparing of high-vitaminized forage from germinated grain in animal breeding.

A series of devices for various methods of cavitator seed treatment are created, both for crop growing and for preparation of highly enriched feed in animal husbandry [6]:

- liquid whistle of vortex type (vortex cavitator);
- liquid whistle of vortex type with the resonator placed in an external holder;
- liquid whistle of vortex type with the rotating resonator;
- liquid whistle of vortex type with the correcting device and several resonators;
- liquid whistle of multiple-jet type;

- liquid siren combined with the network pump.

Conclusions

1. The cavitation components make a stimulating influence on the seed germinating ability and further development. It presumes amelioration of forage quality or increasing of crop capacity of the fields.
2. The quality if the influence is stipulated for its quantity may be determined as the product of intensity and duration.
3. When the factor exposition changes the germinating ability regularity is periodical.
4. When the factor intensity changes the germinating ability regularity may be extreme or it goes down because of intensity increase.
5. The cavitation influence on seeds in the active zone of the cavitator makes it possible to shorten the time of treatment from several hours to 3-5 minutes.
6. The system of facilities for highly productive cavitation treatment in the active zone of the cavitator is proposed.
7. The increase of the intensity of seed treatment makes it possible to shot the sprouting time. It gives the possibility
 - to reduce the prime cost of the process,
 - to reduce the production space: to intensify the movement of circulating assets in an enterprise making sprouting.
8. Cavitational processing becomes convenient for improvement of the quality of seeds.
9. Cavitational processing of seeds can be combined with other preseeding and sowing operations.

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