GRAIN CROPS INJURIES AND DRYING MODES DURING SEEDS PREPARATION / *ТРАВМУВАННЯ ЗЕРНІВОК ТА РЕЖИМИ ПІДСУШУВАННЯ ПРИ ПІДГОТОВЛЕННІ НАСІННЯ*

Ph.D. Eng. Derevjnko D., **Ph.D. Eng. Sukmaniuk E, Stud. Derevjnko O.**
Zhytomyr National Agroecological University / Ukraine
E-mail: sukmanyukolena@gmail.com

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ABSTRACT

The article deals with the technological process of seed drying beginning with the bottom layer, where the heated air enters, which is quickly saturated with moisture from the grains. The higher the seed layers are placed, the less they are drying, which is the main cause of uneven quality for a certain time and can cause cracks, injury and deterioration of quality. In the work, the diagrams of forces' influence on grains are shown while moving along with the auger screw turns. The speed of the screw, the pressure of the seed to the body and the angle of the screw spiral, which influence the seeds injury, were studied. Optimal and proper drying conditions for seeds of different crops are established, which are the main factors in obtaining high quality seeds, especially of high energy and similarity.

РЕЗЮМЕ

В статті розглянуто технологічний процес підсушування насіння, який розпочинається з нижнього шару, куди надходить нагріте повітря, яке швидко насичується вологою від зернівок. Чим вище розміщені шари насіння, тим менше в них проходить підсушування, що буде основною причиною нерівномірної якості протягом певного часу і може викликати утворення тріщин, травмування та погіршення показників якості. В роботі показано схеми впливу сил на зернівку при переміщенні вздовж витків гвинта шнека. Досліджено частоту обертів гвинта, притиснення насіння до корпусу та кут нахилу спіралі гвинта, які впливають на травмування насіння. Встановлено оптимальні та правильні режими підсушування для насіння різних культур, які є головним чинником отримання високоякісного насіння, особливо високої енергії та схожості.

INTRODUCTION

For many decades, and especially in the second half of the last century, researchers, breeders, and manufacturers proved and substantiated that only high quality seeds, for all other similar opportunities, provide a significant part of the future harvest, so there is an urgent need for high-quality seeds that play a large role in the country food security.

Studies show that the improvement of the influence of technical means working elements in technological processes on reducing the seeds injury, contributes to a significant improvement in the quality of seeds and the growth of grain yields.

Injuries, damage and total destruction of grain crops are the result of mechanical loads effect of many elements of the technological process from harvesting to sowing.

Researchers (*Strona I.G., 1974; Derevianko D. A., 2015; Derevyanko D. A. et. al. 2012; Tarasenko A.P., 2003; Pugachev A.N., 1976; Chazov S.A. and Plaksin V.F. 1974; Chazov S.A. et. al. 1981; Fadeev L.V., 2015*) have proved that the grain crops injury during grinding reaches 20% and even more, and while finishing the grain pile, preparing the seeds and sowing, it significantly grows to 60-80%.

According to V. M. Drinch (*Drinch V.M., 2006*), the grain crops injury during threshing sometimes reaches 30-35%, and during the preparation of seeds, even more than 50%, depending on the moisture content and structure of the grain pile.

In recent years, considerable work has been carried out by L.V Fadeev (*Fadeev L.V., 2015*) on the development and introduction into the production of fundamentally new cleaning and calibration technical equipment and technical lines.

In creating the scientific foundation of the theory of interaction between the mechanisms' working surfaces and various materials, including grain mass, scientists such as P.M. Vasilenko (*Vasilenko P.M., 1960*), V.M. Drincha (*Drincha V. M. and Sukonin L. M., 1997*), V.V. Adamchuk (*Adamchuk V.V., 2010*), L.M. Tishchenko (*Tishchenko L.N. et. al., 2011*), A.P. Tarasenko (*Tarasenko A.P., 2003*), P.M. Zaika (*Zaika P.M., 2006*), and E. S. Goncharov (*Goncharov E.S., 1963*) had significant contribution.

Thus, a deep and comprehensive study of the physico-mechanical and biological characteristics of the seeds, the development of new technologies and the modernization of the working bodies that will provide the minimum amount of grain crops injury, is the basis for obtaining high quality seeds in accordance with the agro-technical requirements and state standards.

MATERIAL AND METHODS

Using the method of mathematical modeling of machines, working elements and technological processes, using calculated differential equations, transformations and graphic determinations based on the mechanical laws usage, we consider the processes of transportation and loading by screw, scraper, conveyor belts or other technical means, which leads to grain crops injury and their quality decrease.

It is important to study the influence of the angle of the turns' inclination on the force of seed pressure to the body of engagement, on the centrifugal force, grain crop weight and grain friction force of the seed with an auger.

The essence of the seed movement physical characteristics on the turns during the rotation of the screw shows that as the angle of spiral lifting increases, the forces of resistance to the seed movement increase, too.

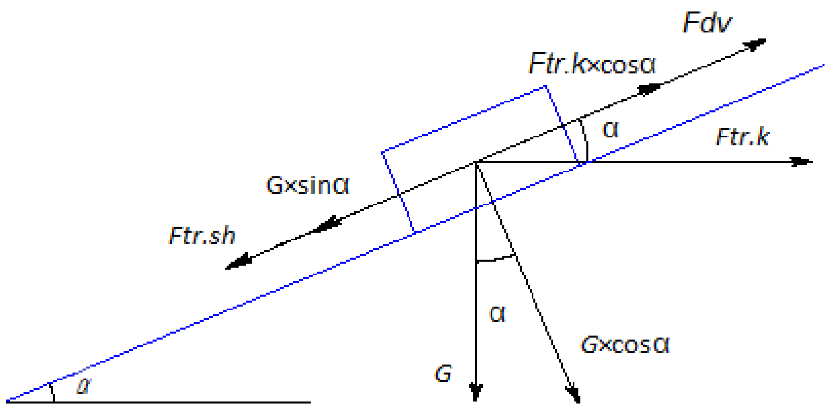

Fig. 1 – Scheme of the force effect on the corn grain when moving along the turns of the screw

From this scheme of forces acting on a certain number of seeds between the rods along the screw (fig. 1) it is evident that the force that promotes the movement of the seeds upwards the coils of the screw is the friction with the casing $F_{tr}k$, but counteract this frictional force with the rotation of the screw $Ftr.sh$ and weight force $G \times \sin\alpha$. So, the difference between the first and the sum of the two others allows you to determine the force that drives the seeds by turning the screw up:

$$F_r = m \cdot \left[\omega_{sh}^2 R \cos\alpha \cdot f_k - g(\sin\alpha + \cos\alpha \cdot f_{sh})\right] \quad (1)$$

Where $\omega_ш$ – the angle of the auger speed;

R – auger radius;

α – the angle of auger lifting;

f_k – friction coefficient of the seed with the body;

$f_ш$ – friction coefficient of the seed with the auger.

The analysis of the change in the intensity of the motion force, depending on the turn lifting angle, indicates that this indicator is a variable quantity and the smallest intensity is in the range $\alpha = 5-10°$, and starting with $\alpha = 15°$, the intensity increases in proportion to the angle of lifting the turns of the screw.

RESULTS

The following factors, such as the value of the screw spiral inclination angle, the pressure of the seed to the body, the critical speed of the screw, etc., affect the corn seed injury when the technological processes are carried out by screw conveyors during their inclined or vertical placement.

Studies show that the seed volume between the turns has a linear dependence on the area of the screw cross section, so the analytical dependence for the calculation of seed volume will be:

$$V_n = \mathrm{K}_{ob} \cdot D \cdot n_{sh} \tag{2}$$

Where K_{ob} – the coefficient, which depends on the density of the seed and the distance between the turns, that is a step;

D – auger diameter, [m].

n_{sh} – auger speed [r/min.].

These studies suggest that not only the friction force but also the centrifugal force F_c acting on the seed during the rotation of the screw affects the damage of the corn grains (fig. 2).

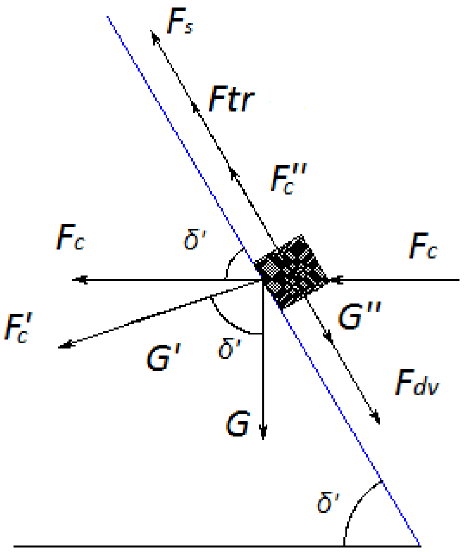

Fig. 2 – Scheme of the influence of forces on the corn grain at the rotation of the auger screw

If we show the forces of action on the corn grains, as the product of pressure on the area, we obtain an equation of the general case that describes the movement of the seed layer in a vertical screw conveyor, taking into account the angular velocity.

On the basis of the forces scheme analysis acting on the corn grains across the turn, we obtain the dependence on the calculation of the effort of pressing the seed to the working surface of the screw and the possibility of its injury (fig. 3).

$$F_{pr} = m \times [\omega_{sh}^2 \times p(\cos\gamma + \sin\gamma \times f_{sh}) + g(\sin\gamma - \cos\gamma \times f_{sh})] \tag{3}$$

Where γ – the angle of inclination of the spindle to the auger axis;

p – the resistivity.

Calculations according to the expression (3) show that the turns inclined from the axis to the periphery of the auger, the growth of the seeds to the body pressing force, compared with the variant, where the turns in the cross section of the auger are horizontal, is 5–38%, depending on the auger speed.

Thus, the expression (3) allows determining analytically the dependence of the angle γ on the friction coefficient of grains with the auger.

Due to the fact that the first component of this formula practically does not depend on the angle γ at the permissible limit of 5°–20°, the increase in the force of pressing the seeds to the shell will be zero if $\sin\gamma = \cos\gamma \times f_{sh}$ we have:

$$\gamma = arctgf_{sh}. \quad (4)$$

When making an auger, the working surface of the screw is thoroughly treated, the coefficient of the corn grains friction with this surface in the majority will be 0.2–0.3, therefore the proposed inclination angle of the spindle relative to the auger axis will be within 10–15°.

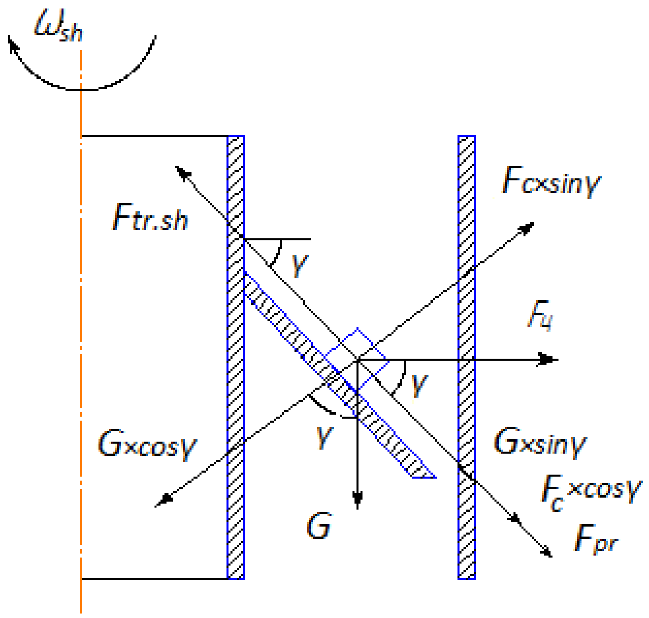

Fig. 3 – Scheme of forces acting on a corn grain on an inclined turn of a screw

As a result of thinning, the corn grain enters the stream in the presence of an under-mature seed, ventilated to accelerate the maturation process and increase the energy of germination and similarity, and in storage, this must be done to preserve the viability of the seed material.

With further movement of air, its ability to enrich with moisture decreases, relative humidity gradually increases and when the equilibrium with the grain is reached, the moisture passes through the rest of the grain mass and does not dry it, while in the upper layers it is possible even to leave the moisture. The grain moisture difference in the upper and lower layers can reach 15%.

Uneven drying of layers for a long time of operation is the main cause of cracks and deterioration of seed quality, which is manifested differently in different cultures. Thus, over-drying in the lower layers can lead to cracks while in the upper layers there will be mould and which generates self-warming, microorganism damage and quality degradation.

Drying of a small height grain layer is provided by heating the outside air with the temperature of the coolant up to 30–35 °C. A further increase in the temperature of the air may be dangerous, as there may be cracks. Consequently, to obtain high quality seeds it is inadmissible to obtain cracking corn grains, which means that overheating during drying cannot be achieved by maintaining the required air temperature parameters. Maximum permissible temperatures for air heating with active ventilation are given in table 1.

Table 1

Maximum allowable air temperature during seed drying

Culture	Temperature at the moisture content of the seeds,%	
	18	24
Barley, oats	56	52
Pea	36	32

This temperature mode in combination with the rate of air consumption to 1000–1500 m^3/h. per ton of grain with a thickness of 0.6-08 m for grain crops, 0.5-0.6 m for legumes and 0.3–0.5 m for corn grain should form the basis of the technology of drying seeds by active ventilation.

The supply of heated air stops when the average moisture content of the seeds reaches 12–14%, in this case the moisture content of the upper layer, which is dried, reaches 16–18%, while the bottom – 10-12%.

To avoid unwanted drying of grain in the lower layers during the process with the use of heated air, it is necessary to observe the parameters of the treatment layer thickness, the height of which should not exceed 100 cm.

During the drying of barley on the floor dryer, the number of cracks increased by 2–3 %, and the study of Canadians showed that the best quality of the seeds of barley is obtained at a low-temperature mode of drying in a thin layer. To study the temperature-humidity regime, drying of barley was carried out with a humidity of 17.0% at an air temperature of 7–38 °C, a relative humidity of 37–78 % and a velocity of 0.3–0.6 m/s. The results of the obtained data showed that the drying rate had the greatest influence on the temperature of the air, while the humidity of the air had a slight effect on this index.

CONCLUSIONS

To produce high-quality seeds, it is necessary to achieve uniform drying of seed mass layers during the entire technological process. Violation of this requirement will contribute to the formation of cracks, destruction and deterioration of quality indicators. The speed of the screw, pressing the seeds to the body and the angle of the screw spiral also affect the injury of the seed.

To determine the optimal drying conditions, it is necessary to correctly determine the height of the seed layer, the flow rate, air temperature and the corresponding amount of seeds for a certain period of time.

The application of special drying regimes, even longer in time, with a decrease in seeds moisture content of less than 6%, will negatively affect the quality of seeds, especially their similarity.

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