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FATIGUE STRENGTH OF WHEAT GRAINS. PART 2. THE FATIGUE STRENGTH INDEX FOR WHEAT GRAIN*

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A b s t r a c t. In the presented research, fatigue tests were conducted in which a load was applied in the from of a mechanic impact. In the authors opinion, it is the best method to simulate natural conditions, where grains are subjected to multiple stress during the entire technological cycle.

Significant emphasis in relation to the quality of sowing material requires the application of precise methods for the assessment of changes in biological quality (usually estimated through the strength and energy of germination) in the course of technological processes. However, such analysis requires a number of germination tests. The presented research results are a continuation of the scholarly search aimed at defining an objective, rapid method for assessing the fatigue resistance of wheat grain.

The fatigue measurements conformed to the methods proposed in part one. The statistical analysis was made to define the correlation between resistance indicators and corresponding values of germination capacity and energy. The above revealed that the index, calculated following the 5^{th} impact, best describes grain behavior - from the viewpoint of fatigue resistance.

K e y w o r d s: multiple loads, grain deformation

INTRODUCTION

The materials presented in the paper constitute the second phase of research aimed at developing an objective and rapid assessment method of the fatigue strength of wheat grain. The analysis of reaction force and deformation of grain following impact, allowed us to suggest a grain elasticity index. This index is defined as the ratio of maximum reaction force to the corresponding deformation value in the course of single deformation. In further analysis, the proposed index was tested from the viewpoint of selecting a fatigue strength indicator, which would reliably determine the decrease in grain resistance related to multiple impacts.

MATERIALS AND METHODS

Research was planned according to the diagram shown in Fig. 1. The measurements were made on four varieties of wheat: *Henika, Eta, Almari, Astron.* The grains were periodically moistened or dried, in order to obtain an appropriate humidity level.

Form the mass of grain, for each humidity level, a laboratory sample was collected, and, then, a representative sample consisting of thirty grains was selected. Each grain was collated, groove downward, on adhesive tape, and marked with successive numbers: 1 to 30. Next, particular grains were placed on a bench (groove downwards) and beaten. The maximum number of impacts during the research cycle was defined experimentally at a level of 30, i.e., until the appearance of the first microcrack. The single research cycle was subdivided into seven zones. At the borders of such zones, the registration of grain reaction force

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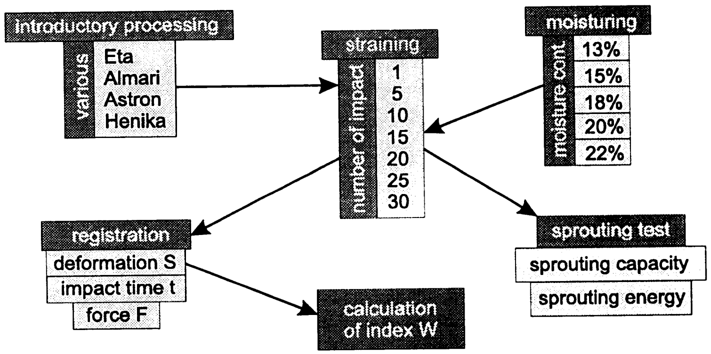

Fig. 1. The diagram of the experiment.

was effected, as well as its deformation and impact time. In this way, for each grain, at every humidity level, seven characteristics were obtained - for: 1, 5, 10, 15, 20, 25, and 30th impact.

A specially designed mechanic impact apparatus (using spring energy) was used for the simulation of real-life strains. The unit was built of a cast steel body, the weight of which isolated the system from possible disturbances caused by vibrations occurring during the test. Subsystems were subsequently mounted on it - such as a beating mandrel with an tensometric head, a lever-and-spring mechanism, a mobile measurement bench. The mechanic system was supplied with a measurement set connected to a computer. This provided the possibility of registering the shift (deformation) and the value of force [1].

In order to assess the change in sprouting capacity of the grain under the influence of multiple strains, the sprouting tests were effected for given combinations of experimental conditions.

RESULTS AND DISCUSSION

After calculating the elasticity coefficient W for all variants of the experiment, variance analysis was made in double classification. This showed the influence of moisture content and number of impacts upon the value of W index. Table 1 shows the results of the Duncan test conducted on the basis of above procedure. In the case of the moisture content factor, two homogeneous groups were identified: moisture content level 20% and 22%, as well as 13%, 15% and 18%. In the former group the values of W index are statistically lower by 50% compared to the latter group. This significant difference between both groups leads to the conclusion about material property transformation. Above the humidity level of 20% - in effect of increased water content in grains - its resistance is significantly reduced and the grain becomes susceptible to all sorts of permanent deformations under the influence of strain. Assuming that each such deformation results in the permanent destruction of intercellular links (which had not yet been

Table 1. Duncan test results

Factor: impact			Factor: moisture content		
Number of impact	Mean value index W	Homogenous groups	Moisture content (%)	Mean value index W	Homogenous groups
1	0.130	X	22	0.142	X
25	0.181	X	20	0.162	X
30	0.183	X	15	0.206	X
20	0.195	XX	18	0.211	X
15	0.204	XX	13	0.227	X
10	0.207	XX			
5	0.226	X			

fully proven in research), rather than the mere change in mutual positioning (as in the case with liquids), the recommendation should be to harvest and process grain at moisture content levels lower than 18%.

The Duncan tests for the mechanic impact factor showed the existence of three homogeneous groups: impact 1, impact from 5 to 20th, and from 10 to 30th. The lowest elasticity index W occurs in the case of the first impact. Between the 1st and 5th impact, the index grows (which suggests the appearance of the so called "fatigue strengthening of material", mentioned in earlier analysis). Next, the value of W declines together with the growing number of impacts.

The described results is illustrated by the diagram plotted for mean values of W index, to be found in Fig. 2.

The analysis of available data leads to the conclusion that the elasticity index W_{05} calculated for the 5th impact of the mandrel is the most suitable to assess the fatigue strength of wheat grain.

The next stage of calculation consisted of testing whether a correlation exists between the index W_{05} and sprouting capacity and strength. The results are shown in Table 2. The conducted test indicated the existence of a correlation between W_{05} and sprouting capacity, which corroborates the correctness of the selection of fatigue strength index.

Figure 3 shows the changes in W_{05} depending on grain moisture content, for the studied varieties, as well as the approximation results for all obtained plots, by the third degree curve. The studied varieties of wheat reach the maximum value of W_{05} index (and therefore also the highest resilience) at a moisture content level of approx. 15%. Above a moisture content level of 18% the grain abruptly loses the elastic properties.

When the fatigue resistance index W_{05} is used, it is possible to run a comparative analysis of sowing material, and to evaluate the performance of technological lines for grain purification and sorting. In effect of "input" and "output" measurements of a given unit,

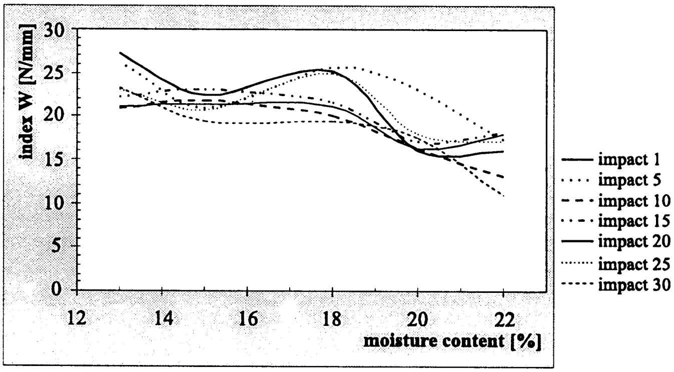

Fig. 2. The elasticity index of grain for various numbers of impacts.

T a b l e 2. Correlation coefficients

Variable	Moisture content	Number of impact	Index W_{05}	Sprouting energy	Sprouting capacity
Moisture content	1.00	0.00	-0.66**	-0.70**	-0.84**
Number of impact	0.00	1.00	0.02	-0.61**	-0.40**
Index W_{05}	-0.66**	0.02	1.00	0.35	0.46**
Sprouting energy	-0.70**	-0.61**	0.35	1.00	0.93**
Sprouting capacity	-0.84**	-0.40**	0.46**	0.93**	1.00

**The indicated correlation coefficients are significant at $p<0.05$.

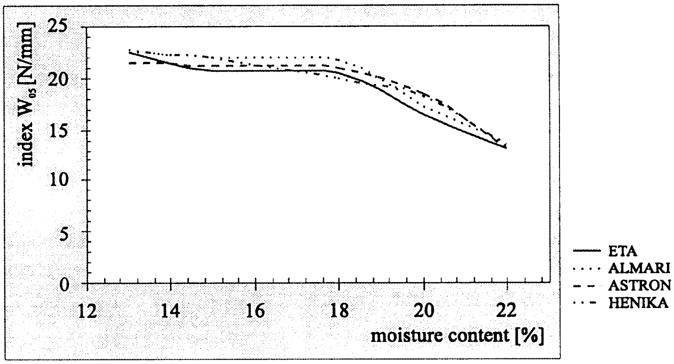

Fig. 3. The dependence of fatigue strength index W_{05} on moisture content.

system, or technological line, it is possible to define the decline in biological value of the processed material, and, next, optimize the technological process through introduction of proper regulations.

CONCLUSIONS

1. The research showns the significant influence of moisture content level and number of impacts upon the value of fatigue strength index W_{05}.

2. In relation to all the studied varieties of wheat, the highest value of W_{05} index was registered at a moisture content level of 15%.

3. The proposed fatigue strength index of wheat grain W_{05} is correlated to sprouting capacity.

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