THE STRENGTH MONITORING OF HEN EGGS BY THE ACOUSTIC EMISSION METHOD

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Abstract: The article deals with monitoring of hen eggshells strength by the acoustic emission method. The subject of this research is diffusion and formation of micro fissures. These egg´s micro fissures rise by weighting of eggshells samples through the use of compression force between two platens. The main purpose is focused on the possibilities of the acoustic emission usage for maximal eggshells strength prediction. Furthermore, the experimental measurement is focused on suitable placement and gripping of acoustic emission sensor.

Key Words: Acoustic Emission, Eggs, Eggshell

INTRODUCTION

The production of hen´s eggs reached up to 61 million of tons in 2010. The scientists suppose the production should rise nearly 70 million of tons in 2015. Eggs with lover eggshells quality means for consumption production sizable economical wastes, we can talk about 6–8% of consumption eggs in the global average and even 15% of wastes in the Czech Republic. The eggshell is nature barrier to eggs' cores protection from surface micro-organisms. Fissured eggs can mean one of the hygienic risks that we should avoid to. The second economic reasons can be inapplicableness of fissured eggs for breeding selection (Nedomova 2011).

We can take note of impulse effects, e.g. by the eggs movement in cages, involving dynamical forced results connected with transporting, sorting and packing. These mentioned factors can cause a damage of eggshells such as fissures and breakages (Strnkova et al. 2014).

The eggshell strength is determinated by material qualities and eggshell constructions and all these factors we have contemplate by the description of forces results. The material qualities generally depends on inside structure of eggshell and they are defined by Young's modul E, Poisson's constant v and pressure intensity, during that pressure are formed fissures (Bain 1992).

The strengthis affected by eggshell thickness, proportions and forms, proportions of crystals and their crystallography orientation. The crystals border can be one of the most important factors for spreading fissured (Severa et al. 2010).

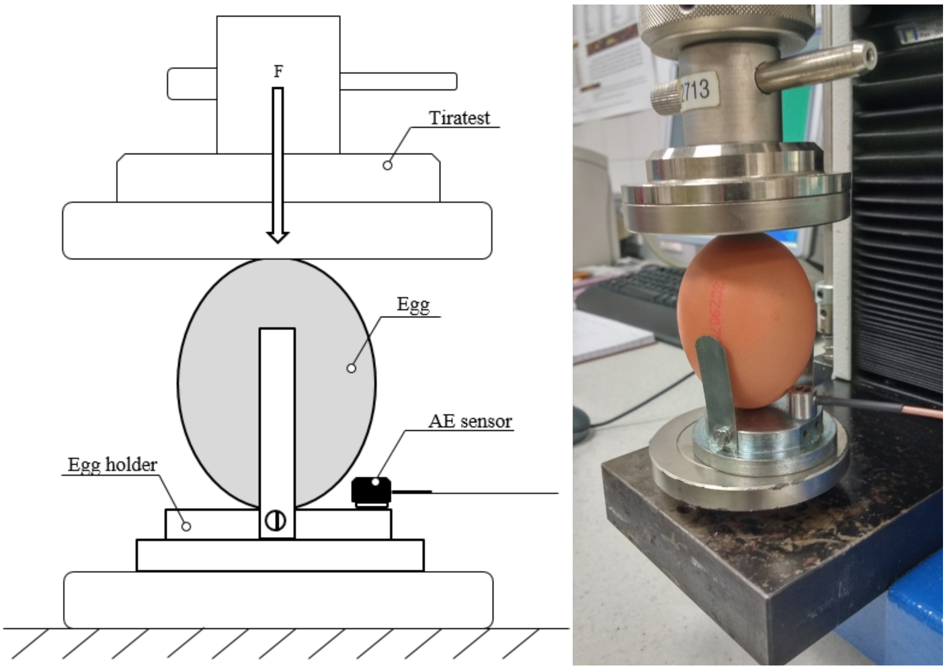
The eggshell structure situation is affected also by calcium content, age of hens, structure of mamilar layer and many others. We can define the eggshell as the bio-ceramic composite compound of 5% organic and 95% inorganic substances (Nedomova 2011).

MATERIAL AND METHODS

Samples of hen eggs came from hybrid ISA Brown layers. Layers were kept in cage technology and fed by completed feed mixture. Eggs were warehoused in unwavering temperature 6°C and relative humidity 70–75 %.

The universal instrument was used for measuring the physical parameters TIRATEST 27025 (see Figure 1). The instrument provide for measuring different materials throughout tension, compression and bending. As the main method was chosen layers compression. The egg was compressed until the point of eggshell disruption. The parameters of measuring are displayed in Table 1.

Figure 1 Scheme of Tiratest



The assessment of eggshell strength during the process of compression between two straight layers.

The egg is vertically places (blunt part) between two straight layers. The lower layer is firm fixed. Upper layer is moving by given speed generally by 1–1000 mm·m^{-1} and is connected with dynamometer, that provide temporal subservience of the force F which is affecting eggshell (Nedomova 2011).

Table 1 Parameters of measuring

Load capacity:	200 N
Test type:	Pressure
Crosshead velocity:	10 mm·min^{-1}
End threshold:	Decrease in strength 40 %

Legend: Load Capacity – The maximum load for which the equipment is designed by the manufacturer. Test type – The type of testing is tensile or compressive. Crosshead velocity – The crosshead velocity is defined as change of displacement per time interval. End threshold – Test is terminated when force decreases to value entered (40%).

The pressure force is rising during weighting until the point of eggshell disruption. The pressure force F depends on displacement of x mainly in linear direction until the point of eggshell disruption. The value of force – Fc, the point of eggshell disruption, models fracture force and accordant the displacement x_c. Except absolute value of this deformation is used also measuring fracture force (Braga et al. 1999).

Acoustic emission system

The acoustic emission means physical effect during that is possible to observe acoustic signals broadcasted by the mechanical, heat or chemical subjected by the solid and it also includes diagnostic method based on this effect. The acoustic emission is performed in the source of acoustic emission during the energy disengaging caused by inner and outer powers. The acoustic emission formation is generated by nonreversible dislocated and degradation processes in the material microstructure and macrostructure, also by cavity processes in the hydro dynamical systems, by the turbulence during the pipeline liquid fading, dielectric degeneration etc. Energy is transformed to the mechanical tension impulse. This impulse is dilating throw the material such as elastic tension longitudinal or transverse wave (Dostal et al. 2012).

The sensor IDK-09 was used in this research. The reason is the suitable sensitivity of it. It is common to place the sensor on the top of the tested sample during the monitoring of quality defined samples. The acoustic emission sensor was fixed by the specific elastic rubber rings on egg holder. Suitable setting of the acoustic emission for measuring hen eggshells is displayed in Table 2.

The specific egg holder was used to implementation of the measurement and the acoustic emission sensor and was used as the waveguide for acoustic emission signals (see Figure 1).

Table 2 Optimal setting of the acoustic emission for measuring hen eggshells

Amplifier:	48 dB
Count 1:	400
Count 2:	600
HW measuring interval:	7 ms

For this measurement with using the specific sensor IDK-09 and amplifying 48dB was necessary to use HW measuring interval 7 ms. This was set by the software and could not be less. System does not allow to decrease it. This interval is the lowest suitable value what can be chosen for those purpose in described setting. The reason is that the system was made for different purpose.

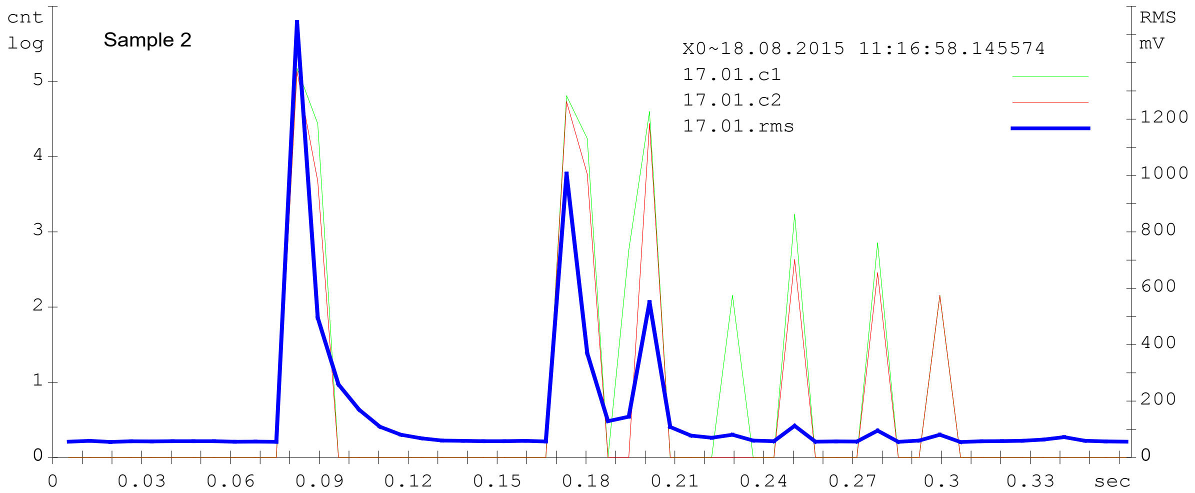
All tested samples were attentively documented. The documentation was focused on these parameters: weight of egg, egg weight loss during storage, length, width, shape index, albumen high, albumen length, albumen width, yolk width, yolk length, the colour of yolk, yolk weight, weight of eggshell and eggshell percentage.

The measurement was realised by 40 samples divided into two groups. The first group was formed by 30 samples with the corresponding parameters.The second group of left 10 egg samples was marked by letter Z. These samples were different in given parameters.

RESULTS AND DISCUSSION

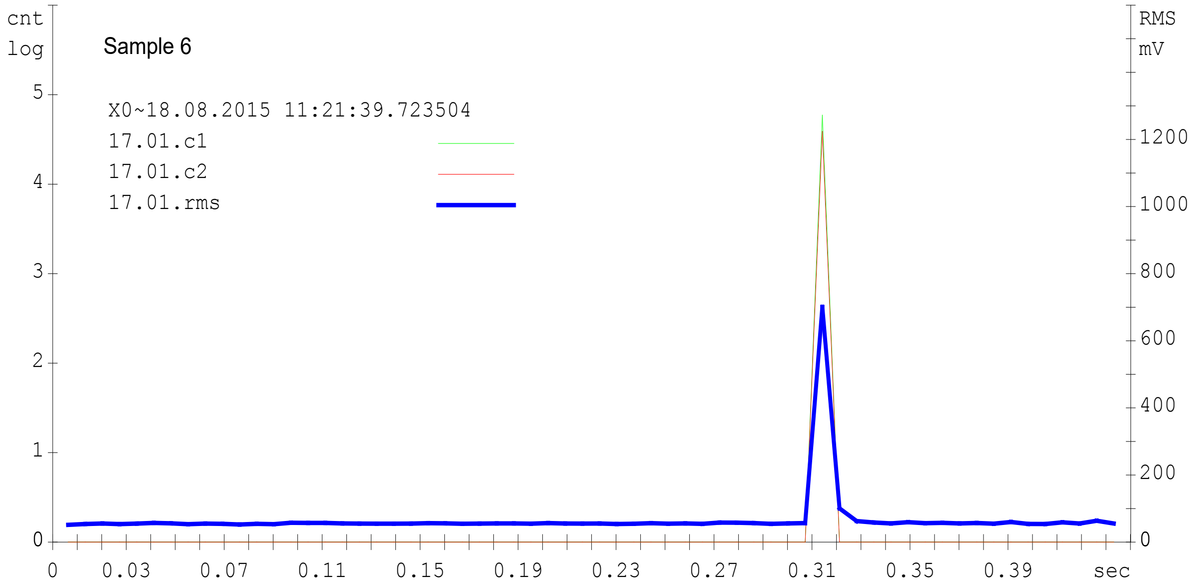
There were 40 verification measures within the experimental measuring. Each of the measuring included continual acoustic emission scanning see in enclosed literature (Dostal et al. 2012). Gained data were tested by regressive analysis. The conclusions of analysis demonstrate the dependence of signal force and process on egg width and eggshell thickness. There was no dependence among other measured parameters.

Figure 2 Sample 2, RMS 1550 mV



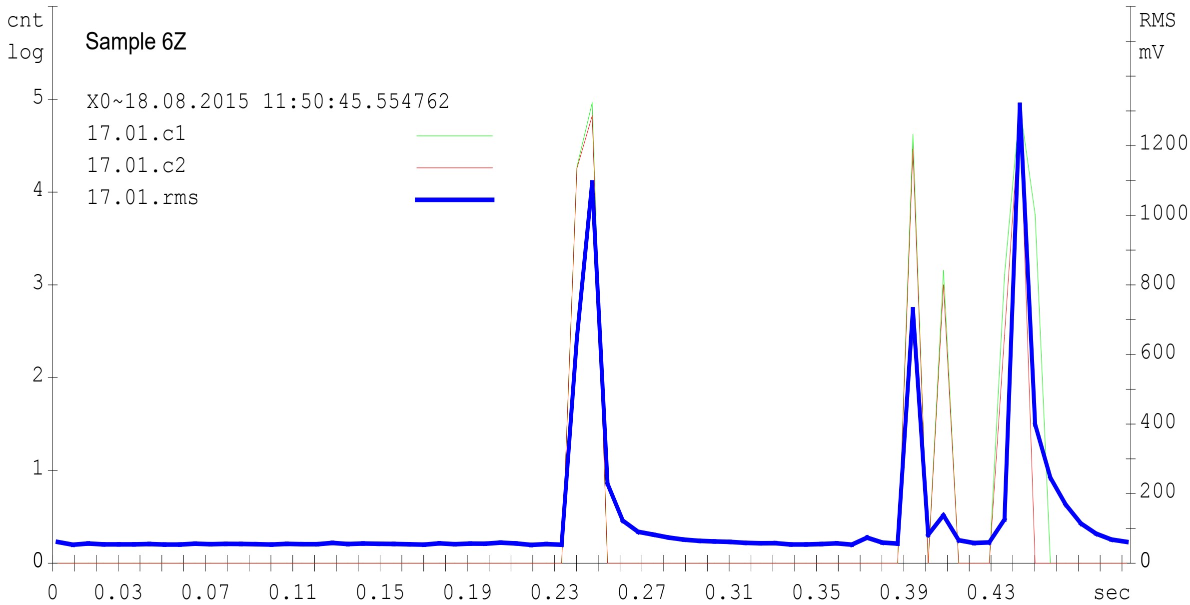
As is visible on the Figure 2, the acoustic emission manifested high-level intensity. The maximum RMS presents the value 1550 mV. The value RMS 1550 mV is the highest measured values during the whole measuring. We can also notice at the time line the rising of the RMS value in the point of 0.075 sec. which is the first record moment of the most expressive plastic eggshell deformation. There are no eggshell deformations from 0.120 to 0.165 sec. The next plastic eggshell deformations keep on time point 0.165 until 0.350 sec. that is the ending point pressure measuring.

Figure 3 Sample 6, RMS 700 mV



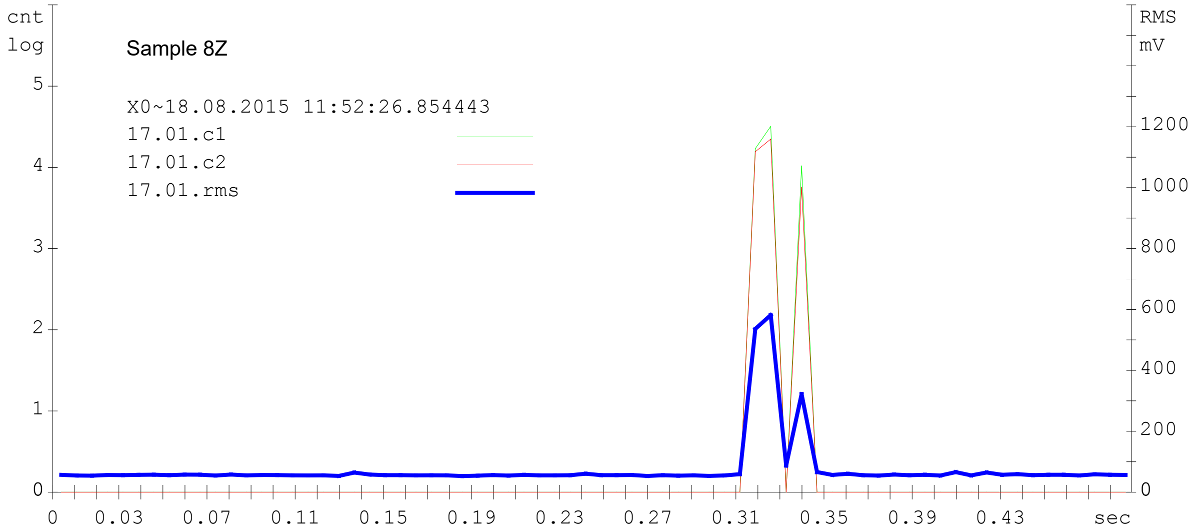
The Figure 3 of sample 6 pictured the maximal value RMS 700 mV. The first and also the last plastic deformation is noticed on time line in point from 0.310 to 0.320 sec. because of slip on the egg surface.

Figure 4 Sample 6Z, RMS 1320 mV



The Figure 4 of sample 6Z shows the maximum value RMS 1320. The RMS spline process is similar as the sample 2. The difference is that the plastic deformation in time 0.230 to 0.255 sec. did not achieve the maximum RMS.

Figure 5 Sample 8Z, RMS 580 mV



The Figure 5 of sample 8Z presents the maximum value RMS 580 mV witch is the lowest reached value for whole measuring. The reason is that the sample 8Z is the smallest sample of all. We can compare it with the quail egg. The first recorded plastic deformation in the point of time 0.31–0.33 sec. achieved maximum RMS and that is why this deformation is so specific by the process.

One of the defined claims was to predict the moment of creation eggshell micro fissures during the weighting with the aid of the acoustic emission apparat. The micro fissures prediction must be exempted because of constitution and structure of hen eggshell. The acoustic emission question linked to egg shells was also solved by (Wang et al. 2006) and (Sinha et al. 1992).

CONCLUSION

There was described the use of acoustic emission during testing quality of eggshell in this paper. By means of this non-destructive testing method was visualized the signal for better understanding of degradation process of eggshell by pressure. There was described the basic research in this work. The system of assessment of degradation was made for engineering applications. Some parameters have to be changed to this type of measurement and use of small type of acoustic sensor. In this case some problems occurred, for example the HW measuring interval. It was set on 7ms because of using this setting of whole system. In next research it will be necessary to use different type of sensor, change setting of system and set lower measuring interval for better signal. The weak signal is caused also by minimal comprehension tension response to the eggshell. The period between micro fissure creation and major fissure is highly short, regular several tens milliseconds.

The eggshell strength is one of the most important factors affecting the quality off egg. The technological process needs a feedback for quality control, grading, manipulation, storing and transporting. Hen eggs succumb to irreversible degradation processes and to inception of micro fissures by all these factors and that used to be dangerous to health. It is very important to monitor lifecycle of groceries by different ways and instruments.

This experiment was used to configure the methodology and preparation for application of acoustic emission and applied this process for the monitoring of hen eggshell strength. It is obvious that submitted methodology can be applied as the one of the measurable parameters for evaluating of different agricultural products strength consistence.

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