LIVESTOCK EAR TAG'S LASER PRINT RESISTANCE IN CONDITIONS OF MONGOLIA CLIMATE

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Abstract

Identification of animal in central region of Mongolia made under project number 17/Mze/B/07-09 with total number of 602.474 cattle and 2 973.561 sheep/goat to be tagged www.vetnaadam.org. Provider of ear tags is company MAVE Boretice Ltd. from Czech Republic. All ear tags are made under certificate of quality number 472101174 of polyurethan. Only chemical standards of basic material e.g. plastic granules are tested with focus to chemical and biological hazards. It was decided to make a research in detail because of knowledge and observations gained during research were made in Mongolia and the specific climate of very low –40°C temperatures of winter, summer's temperatures deviations + 35°C/0°C and frequent sandstorm as no EU country has similar conditions.

Key words: polyurethan, hardness, erosion, hardness, cattle

INTRODUCTION

The basic objectives on the identification of bovine animals are: the localisation and tracing of animals for veterinary purposes, which is of crucial importance for the control of infectious diseases, the traceability of beef for public health reasons and, the management and supervision of livestock premiums as part of the common organisation of the meat market.

According to Council Directive 90/425/EEC (EUR-Lex 2009) of 26 June 1990 concerning veterinary and zootechnical checks applicable in intra-Community trade in certain live animals and products with a view to the completion of the internal market, animals must be identified in accordance with Community rules and be registered in such a way that the original or transit holding, centre or organisation can be traced.

The system for the identification and registration of bovine animals in European Union (EU) includes the elements "double eartag", "holding register", "cattle-passport" and "computerised database". Testing ear tag and history of ear tag in Czech Republic and EU has been published (Novakova, 2009). The main areas of succeptible level of damage of ear tag in Mongolia were specified at the laser print so the numbering is essential for herders and national register of livestock.

Aim of the paper is to support of electronic ear tag introduction in Mongolia under project EuropeAid/123489/C/SER/MN "Animal Health and Livestock, Marketing Project". Current requirements are laid down in Commission Regulation (EC) No 911/2004 (EUR-Lex 2009) of 29 April 2004 implementing Regulation (EC) No 1760/2000 (EUR-Lex 2009) of the European Parliament. The aim of carried out experiment research was to find out the information about the ear tags produced by the company MAVE Boretice Ltd. on the base of knowledge of the target destination "Mongolia" simultaneously with the impact to ensuring their lifetime and functionality under extreme climate conditions. The integral aim was an experimental programme simulation issuing from the international technical standards comprising the change influence of properties and behaviour of ear tags coming from the specific conditions of Mongolia getting from the literary environment and personal experince. The resistance ability to erosive wear, the hardness changes and the surface texture changes were tested.

MATERIALS AND METHODS

Ear tag testing was made during July and September of 2009 with supply of ear tag by company MAVE Boretice Ltd. Three hundreds of ear tag were divided by series of ten prepared for testing. Measures of all series were done in 5–15 seconds interval.

Hardness of ear tag

Hardness is a property which shows the material´s resistance to the penetration of a specified indenter, which is forced into the material under specified conditions. Hardness measurement methods for plastic were made after the standard (CSN EN ISO 868 2003).

Commonly used hardness indentation measurement methods measure the degree of penetration into the material, which is inversely related to the hardness values. This means that for a hardness value of 0 total penetration is needed, whereas in the case of a maximum hardness value of 100 there is no penetration.

The method used was hardness Shore A scale up to 90 (soft materials) and hardness Shore D (soft and medium hard materials). Cattle ear tag: blocks were made from 6 tags, 9.2 mm thick block cut to square size (6 × 1.5 mm).

Measurements were divided in three groups of temperatures –35°C, +22°C and +40°C. On each reference block, ten measurements uniformly distributed over the test surface were carried out. The test was made in accordance with CSN EN ISO 868.

Abrasion of ear tag

In this study, were simulated in the laboratory the effect of grain blasting on the hardness of ear tag. The varying parameters are the different impact angles between 30°, 60°, 90° and short durations up to 25 min. These durations are smaller than the saturation time shown in a previous work to be greater than 25 min (Bitter, 1963). There is formation of a plastic imprint with radial cracks and some scaling caused by the development of lateral cracks that extend and curve up to the surface. From the expression of the damage rate as defined in the literature, were introduced a function relating the impact angles and the grain blasting durations.

Grain blasting is made of Al_2O_3 and corundum responsible for grain scale. Pressure is 7 bars. In our case, the air blow velocity was measured using an anemometer and was found to be 16.6 $m.s^{-1}$ which represents a mean velocity of grain casting. It is evident that the flux velocity obtained by the anemometer does not correspond to the grain particles velocity.

According to Davies (Davies, 1972), a circular flow emerging from a cylindrical nozzle with a diameter d presents a divergent cone whose apex angle is given by experience as being between 25 and 30°C. The cone can be divided into four distinctives zones whose lengths depend on the nozzle diameter d. On the basis of this assumption, the distance between the pipe nozzle and the specimens was adjusted to 24 cm (Sparks et al., 1991).

For the ear tag surface evaluation the roughness parameters are important which are in direct interaction with the erosive wear values. The surface roughnesses were measured according to the ISO Standards CSN EN ISO 4287, CSN EN ISO 4288.

The surface roughness measurements were made with a surface profilmeter "Surftest 301". The optical transmission measurements were carried out on washed and dried specimens using a stereoscopic microscope equiped by digital camera Artcam 300 M. The surface roughness and the transmission values obtained in this work represent mean values of five measurements. During the tests, the impact angle 30°, 60°, 90° corresponds to sample position perpendicular to the air flow. The measuring methodology uses knowledge gained from the long-term research of the interaction of the erosive wearing on the specific surfaces together with the surface hardness evaluation (Muller et al., 2009; Muller, 2007).

The samples were prepared from a ear tag sheet of local production. The dimensions used were 6 × 1.5 mm.

The grain size varies between approximately 212 and 180 µm shows a sample of the grain used in this study. We can observe that the shape of the particles is very irregular. There are rounded and angular grains with different sizes. We can also notice that there is a predominance of sharp grains with different sharp angles which could be simulated by sharp indenters (Vickers or Knoop indenters). Microhardness scattering is probably due to the chemical nature of the grains which contain different amounts of oxides (Poorna et al., 2009).

Decision was made to test ear tags at the different temperature conditions of Mongolia. Measurements were distributed in three groups of temperatures (–35°C, +22°C, +40°C) multiplied by angles (30°, 60°, 90°). Temperatures were measured by contact thermometer on the surface.

The numeried and statistical variables were used for the objektive evaluation of laboratory experiments and for reaching other information about the measured data fines. The relation between the varioables has to be perfectly described and analyzed that means to hit off the dependence course (the function change trend) when expressing the measured values in the grapt which is the aim of the regressive analysis. The function type was derived from the correlation field shape which is created

Tab. 1: Hardness of cattle ear tags

Groups of temperatures	Place of temperature measurement	Temperature (°C)	Hardness shore A	Hardness shore D
–35°C	t/surface	0 ± 1	94.9 ± 1.3*	69.1 ± 2.8
	t/environment	–35 ± 2		
+22°C	t/surface	+22 ± 0	91.6 ± 1.6	60.7 ± 1.6
	t/environment	+22 ± 0		
+40°C	t/surface	+26.5 ± 0.5	90.9 ± 0.5	55.7 ± 1.5
	t/environment	+40 ± 2		

*Statement of measured values (arithmetical mean ± standard deviation)

by the points in the intersection of dependent and independent variable. Points in 2D graph are the aritmetical means of given file values at which the maximum and minimum value of observed characteristic is stated too (mistake abscisa). Stated 3D graphs were created by means of the programme STATISTICA which uses the least squares metod.

RESULTS AND DISCUSSION

Hardness

The indenters used for Shore A are a truncated cone, for Shore D a cone with a tip rounding. Accordingly the uncertainty of the indenter geometry must be determined in different ways. For the cone angle the uncertainty of the determination of the indenter geometry is calculated.

By direct verification with hardness reference blocks, the overall function of the hardness testing equipment is checked and the repeatability as well as the deviation of the hardness testing instrument from the real hardness value is determined.

The uncertainty of measurement of the indirect verification of the hardness testing instrument follows from the configuration.

Table 1 shows the experimentally set results of the hardness Shore A nad Shore D and corresponding environment and surface temperatures.

At Figure 1 below it can be seen that under low temperatures hardness and brittleness of material is increasing and under high temperatures hardness and brittleness of material is deacreasing.

After the standard CSN EN ISO 868 direct measuring of D Shore was made at 5–15 sec. intervals with focus to DIN 53505. The difference between –35 ± 2ºC and +40 ± 2ºC of hardness Shore D value was going nearly to 80%.

Hardness measuring instruments were verified for each scale with ten reference blocks. The blocks shall be selected from the hardness ranges. Only Shore A, D are suitable for plastics.

Figure 1: Hardness chart of cattle ear tags under temperatures 22 ± 2ºC, –35 ± 2ºC and +40 ± 2ºC

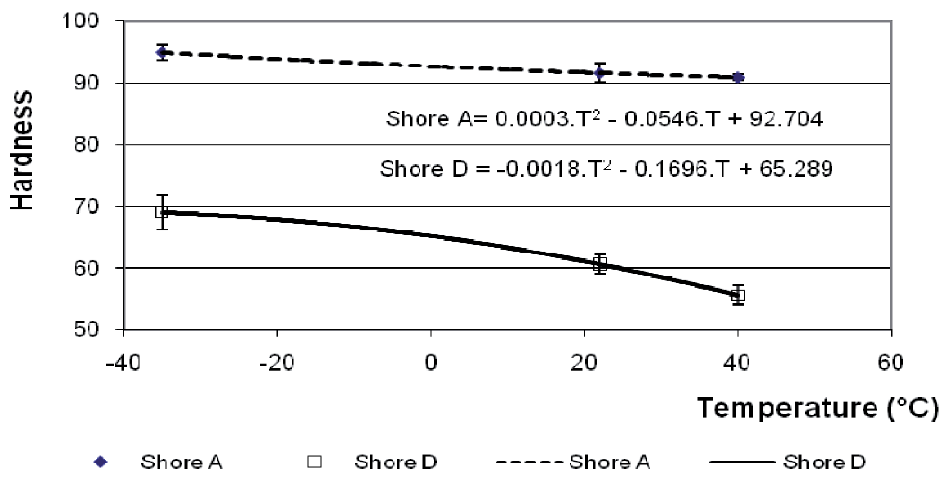
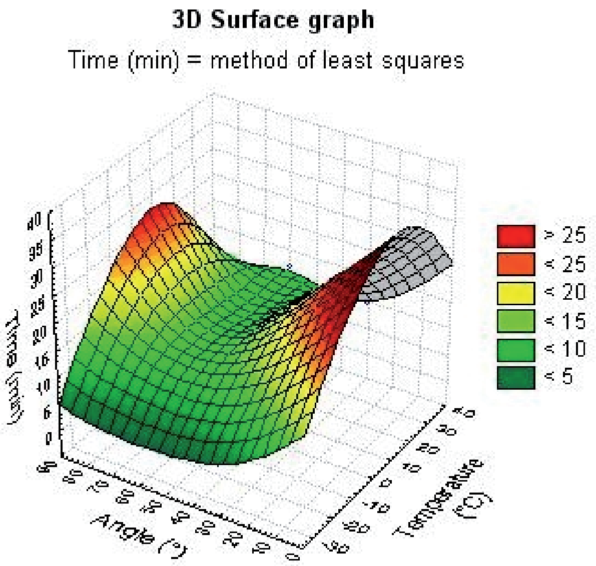


Figure 2: Erosion of ear tags 3D chart under temperatures 22 ± 2ºC, –35 ± 2ºC and +40 ± 2ºC and 30º, 60º, 90º angles



Before making these indentations at least one preliminary indentation shall be made to ensure that the instrument is working freely and that the reference block and the anvil are seated correctly. The result of this preliminary indentation shall be ignored.

For each reference block, the values of the measured hardness let are arranged in increasing order of magnitude.

The combined relative standard uncertainty of the test force calibration is calculated according to the following action (Kang et al., 1995). The environment temperature proved significantly at the hardness shore D. We can conclude from the results that with increasing minus temperature the hardness shore D increases. It causes higher brittleness which secondary influences the wearing speed which can be seen from the Figure 2.

Erosion

In order to simulate the effects of the grainstorm durations and the impact angles on the properties of an ear tag surface, a grain blower apparatus was employed. The erosion tests were carried out with a stationary sample impacted by grain particles accelerated in an air stream by a ventilator. We have used a nozzle diameter d = 4 mm. The grain feed during the erosion tests was fixed constant at about 1.58 $g.s^{-1}$ (Lancaster, 1990).

In most applications, the ear tag surface is exposed to a variety of external agressive conditions such as corrosion, chemical reactions and mechanical damage. The erosion of brittle materials by particle impacts is caused by localised cracking. The intersection of cracks with each other and with the surface leads to material removal. It is known that erosion of materials depends strongly on the impact angle.

Measurements were distributed in three groups of temperatures multiplied by angles: 22 ± 2ºC, –35 ± 2ºC and +40 ± 2ºC by 30º, 60º, 90º. Arithmetical averages and uncertainty of measurements are described only.

Table 2 shows experimentally set results of erosive wear of information prints on the ear tags surface when respecting the impact angle of erosive particles, environment temperature and the surface roughness Ra.

The results of measurements were applied at Figure 2. Material erosion under angles and environment temperatures is clearly visible. Grain blasting is made of Al_2O_3 corundum and F80 responsible for grain scale. Pressure is 7 bars. The applied abrasive Al_2O_3 of a granularity F80 has a fraction measuring dimension of 212–180 µm.

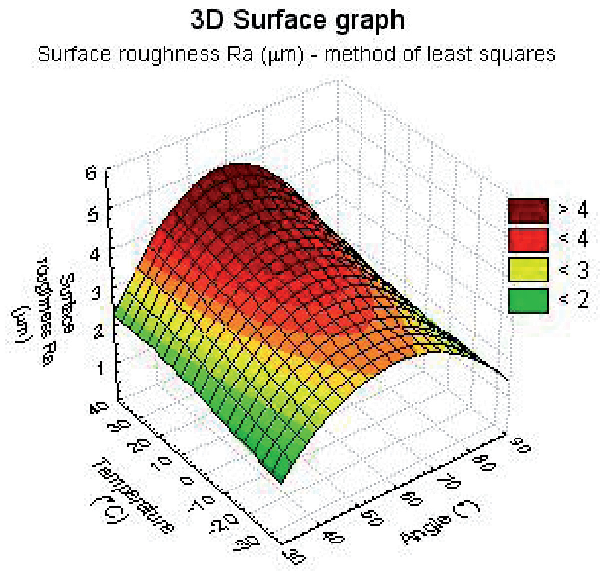
A characterization of a different intensity of various angle and temperature in dependence on time can be seen from the 3D graph (Figure 2) created by means of the least squares method.

Tab. 2: Erosive wear results of ear tags surface

Groups of angles (°)	Groups of temperatures (°C)	Time of erosion (min)	Surface roughness Ra (µm)
	t/surface = 0 ± 1, t/environment = –35 ± 2	5.0 ± 0.0*	1.62 ± 0.15
30	t/surface = +22 ± 2, t/environment = +22 ± 2	13.3 ± 6.2	2.31 ± 0.22
	t/surface = +26.5 ± 0.5, t/environment = +40 ± 2	8.0 ± 2.4	2.26 ± 0.10
	t/surface = 0 ± 1, t/environment = –35 ± 2	3.0 ± 0.0	3.30 ± 0.31
60	t/surface = +22 ± 2, t/environment = +22 ± 2	7.5 ± 2.5	4.35 ± 0.34
	t/surface = +26.5 ± 0.5, t/environment = +40 ± 2	8.0 ± 3.1	4.97 ± 0.36
	t/surface = 0 ± 1, t/environment = –35 ± 2	5.0 ± 0.0	1.44 ± 0.17
90	t/surface = +22 ± 2, t/environment = +22 ± 2	15.0 ± 7.1	1.42 ± 0.10
	t/surface = +26.5 ± 0.5, t/environment = +40 ± 2	8.0 ± 2.4	1.55 ± 0.22

*Statement of measured values (arithmetical mean ± standard deviation)

Figure 3: Surface hardness in dependence to environment temperature and grinding angle



In general, the highest impact under erosion of ear tag has temperature and after that angle of impact of particles.

The erosive wearing of ear tags led to the decrease/lost of their identification. Secondary, it came to the surface texture change. The surface roughness of the original ear tags ranged in the "plastic" area Ra = 2.73 ± 0.13 µm and in the area of the laser identification printing Ra = 4.04 ± 0.27 µm. Figure 3 shows the influence of the surface roughness in dependence to the environment temperature and the grinding angle. A characterization of a different intensity of various angle and temperature in dependence on the surface roughness Ra can be seen from the 3D graph (Figure 3) created by means of the least squares method.

The surface texture change visible from the Figure 3 depends mainly on the grinding angle. The surface hardness at the angle 30° and 90° ranged in the interval Ra = 1.77 ± 0.2 µm. On the contrary, at the angle 60° Ra reached 4.21 ± 0.35 µm. This means that the ear tags surface has higher peaks and pits than the original ear tags without laser print and wearing.

According to literature, it is well established that erosion of brittle materials by hard particles results from elastic–plastic fracture. This fracture is characterised from the contact area between the impacting particle and target. In the case of sharp particles, there is subsurface lateral cracks propagating outward from the base of the contact zone on planes nearly parallel to the surface, and radial cracks propagating from the contact zone normal to the surface. The lateral cracks are considered to be responsible for material removal and the radial cracks are the main source of strength degradation.

Erosive degradation is typical for cases of mechanical changes by sand grinding. Mechanism of erosive degradation is very similar to abrasive (strains and cutting of plastic). Wang et al. (2009) reported serious losses in industrial branch. Bitter (1963) explains erosion, heavy mass attack of grid flow at high speed. Wang et al. (2009) made the calculation of erosion rate of simple particle weight and total plastic weight. It is has been known maximum effect of grinding is equal to the angle of fallen particle. After many experiments it was proved not only plastic but all of materials are dependable on angle at constant speed of grinding (sand blasting). Plastic deformation rate at 90º is higher than at 30º but loss of material is lower. At this situation micro-erosion is responsible for particles impact. Means low angle affects great loss of material however particles damage surface of plastic slightly only which cause low rate of hardness.

All the tests were evaluated at stereoscopic microscope. The resistance of laser print and plastic (charts of hardness and erosion) is easily recognized by areas of rapid degradation of polymer significantly at low/high temperatures.

The future vision of that type of ear tag is to increase depth of laser printing or the perforation because of lowest lifetime of ear tag was measured at –35ºC and it is five time shorter than at the temperature of +22 ± 2ºC. There is also an option to exchange type of thickener to manipulate the hardness of plastic material during polymerization.

CONCLUSION

The paper deals with the problem of the interaction of the hardness, surface texture, environment, time and erosive wearing to the changes of ear tags surface leading to the lost of their identification function.

The experiments confirmed the logically proposed result of increased negative environment influence on the ear tags function retaining.

Laser print hardness of surface tests were made under temperatures –35 ± 2ºC, +22 ± 2ºC, and +40 ± 2ºC in reference groups of ten in accordance with CSN EN ISO 868 conditions. The difference between –35 ± 2ºC and +40 ± 2ºC of hardness Shore D value is going to 80%.

The grinding of ear tags were under temperatures 22 ± 2ºC, –35 ± 2ºC, +40 ± 2ºC and angles 30°, 60°, 90° till non-visibility of laser print. Rezistance of ear tag laser print measured at –35 ºC and is five time shorter than at the temperature of +22 ± 2ºC.

The highest impact under erosion of ear tag has temperature and after that angle of impact of particles.

The interaction of the erosive wearing time (seen from the Figure 2) and the surface roughness (seen from the

Figure 3) shows the negative influence at the angle 60°. The angle 60° manifested the highest hardness values and it also means the increase of ear tags surface wearing. The environment temperature proved significantly at the hardness shore D. We can conclude from the results that with increasing minus temperature the hardness shore D increases. It causes higher brittleness which secondary influences the wearing speed which can be seen from the Figure 2.

A contour graph was created from reached data in the programme STATISTICA from which wider application limits could be set.

The experiments results can be summarized as following:

- the Shore hardness of polyurethan ear tag increases with decreasing temperature,
- the erosive wear reaches the critical values at the impact angle 60°,
- the erosive wear reaches the critical values in negative temperature, in experiment –35°C,
- the surface texture (roughness Ra) decreases with decreasing temperature, the Ra values culminates at the impact angle 60°.

The negative influence of the negative temperature and the erosive wear ranging around the impact angle 60° to the ear tags surface and their function is evident from the carried out experiments.

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