теорологічним прогнозом. Методичні рекомендації / [А. М. Рокочинський, Я. Я. Зубик, Л. В. Зубик, Є. І. Покладньов ; за участю спеціалістів Держводгоспу України В. А. Сташук, В. Д. Крученюк]. — Рівне : НУВГП, 2005. — 53 с.
2. Системна оптимізація водокористування при зрошенні : монографія / [П. Ковальчук, Н. Пендак, В. Ковальчук, М. Волошин]. — Рівне : НУВГП, 2008. — 204 с.
3. Леоненков А. Нечёткое моделирование в среде Matlab и fuzzyTech / А. Леоненков. — СПб. : БХВ-Петербург, 2005. — 719 с.
4. Jang J.-Sh. R. Neuro-Fuzzy and Soft Computing / J.-Sh. R. Jang, Ch.-T. Sun, E. Mizutani. — Upper Saddle River, NJ : Prentice Hall, 1997. — 514 p.

In this work the task of forecasting of non-saturated part of soil's moisture on the control module of land-reclamation double-sided action system with underground moistening by means of neo-fuzzy neural networks is resolved.

Key words: *soil, agricultural cultures, moisture, sucking soil's pressure, neural network, falls, deficit of air's moisture, groundwater level.*

Отримано: 12.03.2012

UDC 621.182.56+519.711.2+519.832.3

V. V. Romanuke, c. t. s.,
S. S. Kovalchuk, c. t. s.
Khmelnitskiy National University, Khmelnitskiy

A REMOVING UNCERTAINTY FRAMEWORK FOR APPROXIMATING THE PROBABILISTIC DISTRIBUTION OVER ABRASIVE-ADHESIVE-DIFFUSIVE WEAR EVALUATION MODELS OFF MOST-PRECAUTIOUS DISTRIBUTION PATTERN

There are considered single-parameter output models of tool wear evaluation, grounded on abrasion, adhesion, and diffusion phenomena. A mathematical framework of removing such three-model uncertainty, using the multi-lap-measurement-approximated probabilistic distribution off most-precautious distribution pattern, is stated.

Key words: *tool wear evaluation, abrasive model, adhesive model, diffusive model, model uncertainty, probabilistic distribution, matrix game, investigator optimal strategy.*

A problem statement. In cutting and processing metals or their workfaces there extensively are four specific features, being focused on to get considered the complex tool wear mechanism quantitatively: abrasion, adhesion, diffusion and oxidization [1; 2]. The last one stands out to be deeply complicated, and so mostly there are three mathematical models of tool wear evaluation (TWE), grounded on abrasive-adhesive-diffusive phenomena separately, slightly included oxidizing effect. The matter is to form an adequate probabilistic distribution (PD) over these abrasive-adhesive-diffusive wear evaluation models (AADWEM) for obtaining the single tool wear value.

References analysis. As the being started for consideration mathematical models have the single-parameter output (tool wear value), then naturally that the prime PD over three values of the parameter with unknown expectation and variance could have been laid uniform [3]. But taking here probabilities

$$\begin{bmatrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \end{bmatrix} \quad (1)$$

over AADWEM would have meant those models have identical influences, what is unobvious and initially unacceptable in consequence of that [4]. Due to the just said here cannot be used the simple average for removing uncertainty with AADWEM, though it is pretty often used in solving non-sophisticated well-defined decision-making problems [5; 6].

Data-out pre-notation. Having explicitly or implicitly those three AADWEM, suppose that there

$$w_i(x, t) \text{ by } i = \overline{1, 3} \quad (2)$$

is TWE in the moment $t \in [0; T]$ on the location $x \in [0; L]$ from the i-th model, where T is the observation interval duration, L is the tool wearing curve length.

An aim of the mathematical framework. The being developed paper direction aim is to state a framework for approximating PD over AADWEM, giving wear values (2), starting off the most-precautious distribution pattern. The developed framework will allow to remove uncertainty

$$\left\{ \left\{ \left\{ w_i(x, t) \right\}_{i=1}^{3} \right\}_{x \in [0; L]} \right\}_{t \in [0; T]} \quad (3)$$

into

$$\left\{ \left\{ w(x, t) \right\}_{x \in [0; L]} \right\}_{t \in [0; T]}, \quad (4)$$

using the approximated PD.

Procedure of deducing PD over AADWEM. The precaution in starting to approximate PD over AADWEM lies in minimizing distances

$$k_{ij}(x, t) = \left| w_i(x, t) - w_j(x, t) \right| \text{ by } i = \overline{1, 3} \text{ and } j = \overline{1, 3}, \quad (5)$$

where $w_j(x, t)$ is an investigator decision to accept the j-th model in the moment $t \in [0; T]$ on the location $x \in [0; L]$, though in actual fact within that time-location the i-th model prevails. The values (5) are united into the matrix

$$\mathbf{K}(x,\, t) = \left[k_{ij}(x,\, t) \right]_{3\times 3} \tag{6}$$

for the game

$$\left\langle \{m_i\}_{i=1}^{3},\, \{s_j\}_{j=1}^{3},\, \mathbf{K}(x,\, t) \right\rangle =$$
$$= \left\langle \{m_i\}_{i=1}^{3},\, \{s_j\}_{j=1}^{3},\, \begin{bmatrix} 0 & k_{12}(x,\, t) & k_{13}(x,\, t) \\ k_{12}(x,\, t) & 0 & k_{23}(x,\, t) \\ k_{13}(x,\, t) & k_{23}(x,\, t) & 0 \end{bmatrix} \right\rangle, \tag{7}$$

in which the pure strategy m_i means the i-th wear model from AADWEM actually prevails within time-location $\{x,\, t\}$ and the investigator practically selects the j-th model with its pure strategy s_j. In the game (7) the investigator has its optimal strategy

$$\breve{\mathbf{Q}}(x,t) = \left[\breve{q}_1(x,t)\; \breve{q}_2(x,t)\; \breve{q}_3(x,t) \right] \in \breve{\mathcal{Q}}(x,t) \subset$$
$$\subset \mathcal{Q} = \left\{ \mathbf{Q} = \left[q_1\;\, q_2\;\, q_3 \right] \in \mathbb{R}^3 : q_j \in [0;1]\, \forall\, j = \overline{1,3},\; \sum_{j=1}^{3} q_j = 1 \right\} \tag{8}$$

belonging to the set of all optimal strategies

$$\breve{\mathcal{Q}}(x,t) = \arg \min_{\mathbf{Q}\in\mathcal{Q}} \max_{\mathbf{P}\in\mathcal{P}} \left(\mathbf{P} \cdot \mathbf{K}(x,t) \cdot \mathbf{Q}^{\mathrm{T}} \right) \tag{9}$$

for the set

$$\mathcal{P} = \left\{ \mathbf{P} = \left[p_1\;\, p_2\;\, p_3 \right] \in \mathbb{R}^3 : \sum_{i=1}^{3} p_i = 1 \right\} \tag{10}$$

of all possible PD over AADWEM, but conditions of generating these distributions cannot be structured or systematized.

Having minimized the distances (5) over the two-dimensional fundamental simplex (equilateral triangle space) $\mathcal{Q}$ under the worst situation (adverse conditions) as the maximized distances (5) over the two-dimensional fundamental simplex (10), the components of the optimal strategy (8) may be used to determine the most-precautious expectation

$$\tilde{w}^{\langle 0\rangle}(x,\, t) = \sum_{j=1}^{3} w_j(x,\, t)\, \breve{q}_j(x,\, t) \tag{11}$$

of TWE. But naturally that wear forecasting is tightly linked to measuring wear. So, may on the u-th lap of measuring wear within time-location $\{x_l,\, t_n\}$ there be the tool wear sample (TWS) $w^{\langle u\rangle}(x_l,\, t_n)$, where

$$l = \overline{0,\, M}\,,\; x_0 = 0\,,\; x_M = L\,,\; n = \overline{1,\, N}\,,\; t_1 > 0\,,\; t_N = T\,,$$
$$\{x_l\}_{l=0}^{M} \subset [0;\, L]\,,\; \{t_n\}_{n=1}^{N} \subset [0;\, T]\,, \tag{12}$$

$$u = \overline{1, U}\ ,\ M \geq 2,\ N \geq 2,\ U \geq 2.$$

And with the carried out measurements of TWS through U laps

$$\left\{ \left\{ w^{\langle u \rangle}\left(x_l,\, t_n\right) \right\}_{l=0}^{M} \right\}_{n=1}^{N} \text{ for } u = \overline{1, U} \tag{13}$$

will construct a procedure of approximating PD over AADWEM to

$$\tilde{\mathbf{Q}}\left(x_l,\, t_n\right) = \left[\tilde{q}_1\left(x_l,\, t_n\right) \quad \tilde{q}_2\left(x_l,\, t_n\right) \quad \tilde{q}_3\left(x_l,\, t_n\right) \right], \tag{14}$$

where

$$\tilde{q}_j\left(x_l,\, t_n\right) \in [0;\, 1] \text{ by } \sum_{j=1}^{3} \tilde{q}_j\left(x_l,\, t_n\right) = 1\,, \tag{15}$$

starting off the most-precautious distribution pattern in (8). For this there is the j_*-th probability to be corrected as

$$\tilde{q}_{j_*}^{\langle u \rangle}\left(x_l,\, t_n\right) = \alpha \tilde{q}_{j_*}^{\langle u-1 \rangle}\left(x_l,\, t_n\right) \text{ at } j_* \in \left\{\overline{1, 3}\right\} \tag{16}$$

with some coefficient

$$\alpha \in \left(1;\, \frac{1}{\tilde{q}_{j_*}^{\langle u-1 \rangle}\left(x_l,\, t_n\right)} \right], \tag{17}$$

whereupon other probabilities

$$\tilde{q}_j^{\langle u \rangle}\left(x_l,\, t_n\right) = \beta \tilde{q}_j^{\langle u-1 \rangle}\left(x_l,\, t_n\right) \text{ for } j \in \left\{\overline{1, 3}\right\} \setminus \left\{j_*\right\} \tag{18}$$

are corrected with the coefficient

$$\beta = \frac{1 - \alpha \tilde{q}_{j_*}^{\langle u-1 \rangle}\left(x_l,\, t_n\right)}{\sum\limits_{j \in \left\{\overline{1, 3}\right\} \setminus \left\{j_*\right\}} \tilde{q}_j^{\langle u-1 \rangle}\left(x_l,\, t_n\right)}, \tag{19}$$

using a classification rule

$$j_* \in \arg \min_{j=\overline{1, 3}} \left| w^{\langle u \rangle}\left(x_l,\, t_n\right) - w_j\left(x_l,\, t_n\right) \right| \tag{20}$$

with the calculated TWE

$$\tilde{w}^{\langle u-1 \rangle}\left(x_l,\, t_n\right) = \sum_{j=1}^{3} w_j\left(x_l,\, t_n\right) \tilde{q}_j^{\langle u-1 \rangle}\left(x_l,\, t_n\right) \tag{21}$$

after the $(u-1)$-th lap correction, by

$$\tilde{q}_j^{\langle 0 \rangle}\left(x_l,\, t_n\right) = \breve{q}_j\left(x_l,\, t_n\right) \quad \forall\ j = \overline{1, 3} \tag{22}$$

for start-off with (11). It is clear that correction coefficient (17) should be chosen due to the distance between TWS $w^{\langle u \rangle}\left(x_l,\, t_n\right)$ and TWE (21), being a nondecreasing function

$$\alpha = \alpha\left(\left| w^{\langle u \rangle}\left(x_l,\, t_n\right) - \tilde{w}^{\langle u-1 \rangle}\left(x_l,\, t_n\right) \right| \right), \tag{23}$$

that is

$$\alpha\left(z_1\right) \le \alpha\left(z_2\right) \text{ for } z_1 < z_2 \tag{24}$$

by any element from (13) and any (21). Finally, the probabilities

$$\tilde{q}_j\left(x_l,\, t_n\right) = \tilde{q}_j^{\langle U \rangle}\left(x_l,\, t_n\right) \;\; \forall \;\; j = \overline{1,\, 3} \text{ for } l = \overline{0,\, M} \text{ and } n = \overline{1,\, N} \tag{25}$$

constitute the U -lapped-measurement PD (14) for (15) over AADWEM with (2), what gives the single tool wear value

$$\tilde{w}\left(x_l,\, t_n\right) = \sum_{j=1}^{3} w_j\left(x_l,\, t_n\right) \tilde{q}_j\left(x_l,\, t_n\right) \tag{26}$$

and removes uncertainty (3) into (4) as $w\left(x_l,\, t_n\right) = \tilde{w}\left(x_l,\, t_n\right)$.

Conclusion. The essence of the stated procedure of deducing PD over AADWEM off the most-precautious distribution pattern in (8) from the set (9) is in lap-by-lap correcting probabilities (16) and (18) with coefficients (17) and (19), using a classification rule (20), and running it through U laps with measurements of TWS (13) on (12). This forms the impartial PD (14) over AADWEM with data-out (2) for obtaining (26) without groundless PD (1), starting off probabilities (22) and deducing on probabilities (25). The nondecreasing function (23) as (24) should be identified also numerically, although it is a further-work problem.

References:

1. Andersson S. A random wear model for the interaction between a rough and a smooth surface / S. Andersson, A. Sцderberg, U. Olofsson // Wear. — 2008. — Vol. 264, Issues 9–10. — P. 763–769.
2. Jankauskas V. Analysis of abrasive wear performance of arc welded hard layers / V. Jankauskas, R. Kreivaitis, D. Milčius, A. Baltušnikas // Wear. — 2008. — Vol. 265, Issues 11–12. — P. 1626–1632.
3. Черноруцкий И. Г. Методы принятия решений / И. Г. Черноруцкий. — СПб. : БХВ-Петербург, 2005. — 416 с. : ил.
4. Inseok Park. A Bayesian approach for quantification of model uncertainty / Inseok Park, Hemanth K. Amarchinta, Ramana V. Grandhi // Reliability Engineering & System Safety. — 2010. — Vol. 95, Issue 7. — P. 777–785.
5. Jacques J. Sensitivity analysis in presence of model uncertainty and correlated inputs / J. Jacques, C. Lavergne, N. Devictor // Reliability Engineering & System Safety. — 2006. — Vol. 91, Issues 10–11. — P. 1126–1134.
6. Трухаев Р. И. Модели принятия решений в условиях неопределённости / Р. И. Трухаев. — М. : Наука, 1981. — 258 с.

Розглядаються моделі оцінювання зношування інструмента з одно-параметричним виходом, засновані на явищах стирання, адгезії та дифузії. Викладається математична основа для усунення такої тримодельної невизначеності, де використовується апроксимований за багаторазовими вимірювання імовірнісний розподіл, починаючи зі зразк найобережнішого розподілу.

Ключові слова: *оцінювання зносу інструмента, абразивна модель, адгезійна модель, дифузійна модель, модельна невизначеність, імовірнісний розподіл, матрична гра, оптимальна стратегія дослідника.*

Отримано: 13.03.2012

УДК 681.51.09

М. Ф. Сопель, канд. техн. наук

Институт электродинамики НАН Украины, г. Киев

АНАЛИЗ ТОПОЛОГИЧЕСКИХ СТРУКТУР КОМПЬЮТЕРНЫХ СЕТЕЙ СИСТЕМ МОНИТОРИНГА В ЭНЕРГЕТИКЕ С УЧЁТОМ ФОРМИРОВАНИЯ СРЕДСТВ ЗАЩИТЫ ИНФОРМАЦИИ

В статье рассмотрены различные виды топологических структур компьютерных сетей, ориентированные на использование в системах мониторинга в энергетике. Проводится анализ структур и выбор наиболее целесообразной из условий оптимизации сети с обеспечением возможности реализации средств защиты информации.

Ключевые слова: *топология сети, информационная безопасность, дерево-гиперкубическая сеть, кольцевая топология.*

Задачи синтеза и защиты информации компьютерных сетей систем мониторинга в энергетике. Компьютерные сети систем мониторинга в энергетике и объектов в процессе своего развития превращаются в сложные, высококритичные среды, состоящие из множества серверов различных типов, а также многочисленных рабочих групп, нуждающихся в связи друг с другом. В такой среде неоптимальность структуры топологии и отсутствие или слабость средств защиты информации (СЗИ) несут в себе угрозу снижения производительности, уменьшения надежности и ухудшения безопасности систем энергетики.

Рабочие станции систем мониторинга в энергетике взаимодействуют между собой в основном посредством локальных серверов гораздо чаще, чем с внешними серверами Web, поэтому имеет смысл оптимизировать топологию сети, в частности сегментировать сеть в соответствии с рабочими группами, в которых большая часть трафика не выходит за пределы локального сегмента. Кроме того, оптимизация и сегментирование структуры сети позволяют легко организовать гибкие СЗИ.

Оптимизация топологии сети и вопросы синтеза сети с оптимальной топологией описаны во многих источниках, так например, в работах [1, 2] эти проблемы изложены обстоятельно. В работе [3] приведен полный и обоснованный анализ вопросов построения математической