ORIGINAL PAPER

MARKOV CHAINS APPLIED FOR PHYSICAL AND MECHANICAL ALLIED STEEL LABORATORY TRIALS

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Manuscript received: 12.04.2014; Accepted paper: 30.05.2014;
Published online: 30.06.2014.

Abstract. *Our research intends to apply the stochastic processes theory in modelling of the high allied steel laboratory trials. How long the physics and mechanics allied steel tests are aleatory processes that depends of the time parameter is appropriate to design an absorbent Markov chain which can describes the stages by whom the process passes with time passing.*

Keywords: *Markov chains**,** laboratory trials, allied steel*

1. INTRODUCTION

Stochastic processes are a mathematical modeling of random phenomena [1]. These processes depend on space or time. They can be used in many areas. One of these areas is the physical and mechanical testing [2, 3]. Assessment and preparation of allied steels successfully use random processes of Markov chains. For preparation of test samples required some machining steps. These processing stages include two phases: declared reject samples, and declared corresponding samples. Therefore the role of stochastic processes is to appreciate the evaluative results. They are accurate estimations.

In the next section we will refer to the preparation of samples for tensile testing. This is an important test of the laboratory. These tests show toughness and performance allied steels. Factors that have influence in these stages are: human factor, sample processing machines, and quality of produced steel. We will use real data obtained in the laboratory after several tests.

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2. TENSILE TEST. PREPARATION OF SAMPLES

For a better understanding we give some definitions.

Definition 1: Stochastic process is called a family of random variables *X (t)*, where *X* is a random variable, *t* belongs to *R*, and the values of *X (t)* belong to *R* [1].

Definition 2: The set of all possible parameters *t* is denoted by *T* and is called the parameter space or space times [1].

Definition 3: The value of the random variable *X (t)* denoted by $x \in R$, is called the stage of the stochastic process at time t [1].

Definition 4: The set of all possible stages (the set of all stages) is called the stage space and is denoted by ***S*** [1].

Stochastic processes are of two types: discrete-time stochastic processes, and continuous-time stochastic processes.

For our application we use discrete-time stochastic processes which model the behavior of a product goes through several stages of transformation.

For example, tensile testing has six stages and two-phase transformation.

These are: S_1: The end of the first transforming stage; S_2: The end of the second transforming stage; S_3: The end of the third transforming stage; S_4: The end of the fourth transforming stage; S_5: The conformity; S_6: The rejection.

Then the space of stages is:

$$S = \{S_1, S_2, S_3, S_4, S_5, S_6\}$$

For the stochastic processes acquiring one of the points of interest is to find out which is the average times needed by the process to be absorbed if the process starts from a certain stage.

We denote with n_i the average of some random variables that measure the number of transitions needed to reach an absorbent stage when the process starts from the stage *i*.

We denote by ***S'*** the absorbent stage space and ***S''*** non-absorbent stage space.

The average times to absorption is determined by multiplying the average number of transitions until absorption with duration of one transition. The average number of transitions is determined by solving a system of mathematical equations like the one below (see [1]).

To calculate the absorbtion times we solve the following equations system:

$$\begin{cases} n_1 = 1 + \sum_{k \in \{1,2,3,4\}} p_{1k} \quad n_k = 1 + p_{11}n_1 + p_{12}n_2 + p_{13}n_3 + p_{14}n_4 \\ n_2 = 1 + \sum_{k \in \{1,2,3,4\}} p_{2k} \quad n_k = 1 + p_{21}n_1 + p_{22}n_2 + p_{23}n_3 + p_{24}n_4 \\ n_3 = 1 + \sum_{k \in \{1,2,3,4\}} p_{3k} \quad n_k = 1 + p_{31}n_1 + p_{32}n_2 + p_{33}n_3 + p_{34}n_4 \\ n_4 = 1 + \sum_{k \in \{1,2,3,4\}} p_{4k} \quad n_k = 1 + p_{41}n_1 + p_{42}n_2 + p_{43}n_3 + p_{44}n_4 \\ n_5 = 0 \\ n_6 = 0 \end{cases}$$

For the Markov chain that we designed for tensile test, the pass probabilities are the following:

For the first transforming stage: p_{11} =0,005, p_{12}=0,993 and p_{16}=0,002.

For the second transforming stage: p_{22} =0.005, p_{23} =0,992, p_{26}=0,003.

For the third transforming stage: p_{33} =0,004, p_{34} =993, p_{36} =0,003.

For the fourth transforming stage: p_{44} =0,003, p_{45} =0,995, p_{46} =0,002.

And for the absorbent stages we have: p_{55}=1 and p_{66}=1. The other pass probabilities are equal with zero.

With these probabilities we calculate the percentage of rejected samples and obtained the value 1% [4].

Then the equations system becomes:

$$\begin{cases} n_1 = 1 + 0{,}005 \bullet n_1 + 0{,}993 \bullet n_2 \\ n_2 = 1 + 0{,}005 \bullet n_2 + 0{,}993 \bullet n_3 \\ n_3 = 1 + 0{,}004 \bullet n_3 + 0{,}993 \bullet n_4 \\ n_4 = 1 + 0{,}003 \bullet n_4 \end{cases}$$

$$n_4 - 0{,}003 \bullet n_4 = 1 \Rightarrow 0{,}997 \bullet n_4 = 1 \Rightarrow n_4 = 1/0{,}997 = 1{,}003$$

$$n_3 - 0{,}004 \bullet n_3 = 1 + 0{,}995 \Rightarrow n_3 = 1{,}995 / 0{,}996 = 2{,}003$$

$$n_2 - 0{,}005 \bullet n_2 = 1 + 1{,}989 \Rightarrow n_2 = 2{,}989 / 0{,}995 = 3{,}004$$

$$n_1 - 0{,}005 \bullet n_1 = 1 + 2{,}983 \Rightarrow n_1 = 3{,}983 / 0{,}995 = 4{,}003$$

3. CONCLUSIONS

Our calculations were made for improving laboratory work and for estimate the costs for sample preparation. The values obtained are accurate estimate with a better precision. In the same time our stochastic design leeded to decreasing the number of the samples declared reject from the value 5-6% to the value 1% which represents an improvement of the production process.

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