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STOCHASTIC PROCESSES USED FOR LABORATORY OF PHYSICS AND MECHANICS TESTS

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Abstract: This paper deals with the stochastic processes with application in the tests laboratory. We designed a stochastic process with discreet times and for that one we made some calculation using real data observed in several physics and mechanics tests. At the same time, we made some remarks concerning the obtained results and we indicated the suitable manner to adapt our approach in a practical case. Also, we prove that our results can improve the process of estimate of the expense required in the laboratory work.

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1. Introduction

The stochastic processes were designed especially for that processes which depends, in a strong manner, of a parameter like time or space (see [1], [2]). So, a peculiar process that passes from several stages together with time passing can be appropriate modelled using the stochastic processes theory. The physics and mechanics laboratory tests for allied and high allied steel are ones of these aleatory processes ([3], [4], [5]). To decide if a certain product made in a steel enterprise is in accord with quality standards the enterprise has to make some laboratory trials like: traction trial, bending at shock trial, Brinele hardness trial, Rockwell hardness trial, Vickers hardness trial or Yominy temper trial

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or bend trial. The traction trial for example is composed of four transforming stages: the retailing, the milling, the lathering and the rectification. A sample of the steel bar passes through these stages consecutive and in the end is labelled as good (corresponding) or reject. Is important to emphasize that at end of each stage, the sample of steel bar can pass in the next stage, can taking again the processing or can be labelled as reject.

In the next section we design the stochastic process with discreet times suitable for the traction trial of a allied steel bar. For our calculation we used the pass probabilities computed using real laboratory data.

2. Traction Trial for the Allied Steel

For our design we consider a stochastic process with discreet times $\{X(t), t \in T\}$ where $(t) = stage_i$. The stages space is : $S = \{stage_i\}$ with $i \in \{1, 2, 3, 4, 5, 6\}$.

In the traction trial the transforming stages are:

$stage_1$: The sample of steel bar is at the end of the retailing process;

$stage_2$: The sample of steel bar is at the end of the milling process;

$stage_3$: The sample of steel bar is at the end of the lathering process;

$stage_4$: The sample of steel bar is at the end of the rectification process;

$stage_5$: The sample of steel bar is labelled as corresponding;

$stage_6$: The sample of steel bar is labelled as reject.

Using the laboratory real data we computed the pass probabilities: For the retailing process the units that must taking again the processing (that have to be retailed again) are in proportion of $0,5\%$ and those which are reject are in proportion of $0,2\%$.These results lead to the following probabilities: The unit taking again the retailing with probability $q_1 = 0,005$; the unit is labelled as reject with probability $r_1 = 0,002$ and the unit pass in the next stage with the probability $p_1 = 0,993$.

For the milling process the corresponding proportions are: $0,5\%$ and $0,3\%$. The probabilities are: $q_2 = 0,005$, $r_2 = 0,003$ and $p_2 = 0,992$.

For the lathering process we have the proportions: $0,4\%$ and $0,3\%$ and the probabilities: $q_3 = 0,004$, $r_3 = 0,003$ and $p_3 = 0,993$.

For the rectification process we have: $0,3\%$ and $0,2\%$ and the probabilities: $q_4 = 0,003$, $r_4 = 0,002$ and $p_4 = 0,995$.

To describe the stochastic process evolution we use the pass probabilities matrix and the pass probabilities graph. The pass probabilities matrix is the stochastic matrix: $P = (p_{ij})_{i,j=1,6}$ where the pass probabilities are the conditioned probabilities (see [1]): $p_{ij} = P(X(t+1) = stage_j | X(t) = stage_i)$. For example the probability : $p_{11} = P(X(t+1) = stage_1 | X(t) = stage_1)$ represent the probability that a unit will be in the future moment of time in the stage 1, if we know that at the present moment of time the unit is in the stage 1. Using our data we obtain that: $p_{11} = q_1 = 0,005$. The next two matrix gives all pass probabilities:

$$\mathbf{P} = \begin{pmatrix} q_1 & p_1 & 0 & 0 & 0 & r_1 \\ 0 & q_2 & p_2 & 0 & 0 & r_2 \\ 0 & 0 & q_3 & p_3 & 0 & r_3 \\ 0 & 0 & 0 & q_4 & p_4 & r_4 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix},$$

$$\mathbf{P} = \begin{pmatrix} 0,005 & 0,993 & 0 & 0 & 0 & 0,002 \\ 0 & 0,005 & 0,992 & 0 & 0 & 0,003 \\ 0 & 0 & 0,004 & 0,993 & 0 & 0,003 \\ 0 & 0 & 0 & 0,003 & 0,995 & 0,002 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}.$$

If the laboratory used N units for the traction trial and percents of the units that repeat, pass in the next stage or is labelled reject are these which are presented in the start of this section, we propose for compute the proportion of the reject labelled units the following formula:$N_G = N(1-r_1)(1-r_2)(1-r_3)(1-r_4)$, $N_R = N - N_G$. Where N_G is the number of the units that are labelled as good, N_R is the number of units that are labelled as rejected.

So, for our data we obtain: $N_G = N \times 0,998 \times 0,997 \times 0,997 \times 0,998 = N \times 0,99$ and $N_R = N - N \times 0,99 = N(1-0,99) = N \times 0,01$. The previous results conducts to the conclusion that units labelled as reject are in proportion of 1% from the total value of the units presented to the traction trials.

The pass probabilities graph (Fig. 1) is the oriented graph where the nods are corresponding to the six stages: four transforming stages and two absorbent stages (reject stage and corresponding stage). The arcs are according with the possible passing (those for that $p_{ij} \in (0,1]$).

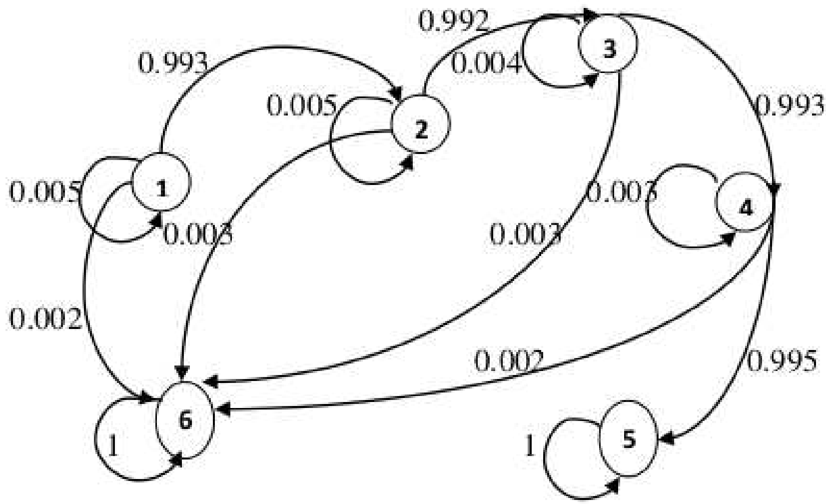

Figure 1: The probabilities graph for the traction trial of allied steel

3. Conclusions

Our design and computational calculus are made to be used in the laboratory work for estimation of the expense needed by the quality tests. The stochastic processes approach leads to rigorous and realistic evaluations of the total expenses.

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