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Estimating Technological Systems Reliability Using Software Applications

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Abstract

This paper presented the reliability problems specific to the technological systems, with a program (software application) that allows making certain applications simplifying the traditional mathematics device and getting closer quickly to solution taking into consideration its economic aspect in the working conditions. Also, there are presented some general considerations regarding the method followed by an example that used the estimation of the drilling bit reliability modeled like a parallel technological system.

Key words: *reliability, software application, technological system, drilling bits, data processing.*

Introduction

Following carefully the statistics and also from case studies solution on drilling bits used in exploitation, there was realized a centralization of the number of used equipments depending on their dimension. The data were collected in an interval of seven years and they are the object of a data base concerning the use of the tricone drilling bits during the hydrocarbon drilling process in the country and abroad and they were interpreted and centralized having as a direct result the graphic from the fig. 1.

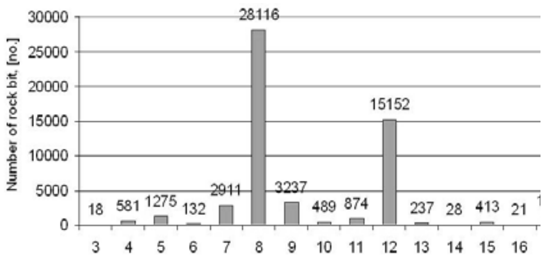


Fig. 1. Number of drilling bits used in production depending on their dimension

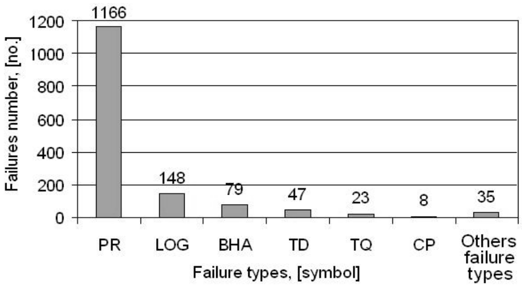


Fig. 2. Types of failures presented in the drilling pipes out of production
PR - penetration rate; LOG - run logs; BHA - change BHA; TD - Total depth/casing depth; TQ - torque; CP - core point.

Also, from a study made to the extraction of the drilling bits used in the production process, there were been established the main ways of their failure and there were presented synthetically with the help of the figure 2.

The main cause of drilling bits failure is the decreasing of the advance speed because of the tooth, bearing wear and hydraulic losses. Further there was presented in percents the packing, tooth degree and hydraulic losses of the used drilling bits which are the object of the study.

The packing degree of the bearings for the used studied drilling bits (see figure 3):
1. E - presents the packing;
2. H - the packing cannot be appreciated;
3. F - missed sealing up gasket.

The tooth degree for the used studied drilling bits (see figure 4):
1. A - bearings wear over 80%;
2. B - bearings wear between 50-80%;
3. C - bearings wear between 20-50%;
4. D - bearings wear under 20%.

The hydraulics losses (a parallel system with mechanic one) for the used studied drilling bits (see figure 5):
1. I - hydraulic system performance (included presence of all nozzles) over 75%;
2. J - hydraulic system performance (one or two nozzles are losses at bottom of the hole) over between 20-75%;
3. K - hydraulic system performance (all nozzles are losses at bottom of the hole) under 20%;

Taking into account the influence of the damage ways of the studied drilling bits found out to their extraction from the drilling process, there was been conceived a complex (mixed - with serial and parallel reliability blocks) reliability model (fig. 6), built from blocks for which the will be presented a special software conceived for the study of the industrial equipments (systems).

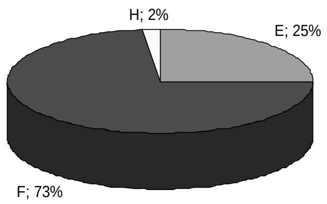


Fig. 3. Bearings degree to the drilling bits out of use

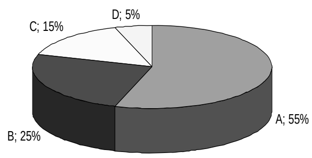


Fig. 4. Tooth degree to the drilling bits out of use

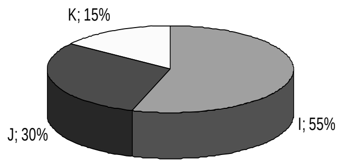


Fig. 5. Hydraulic system performance to the drilling bits out of use

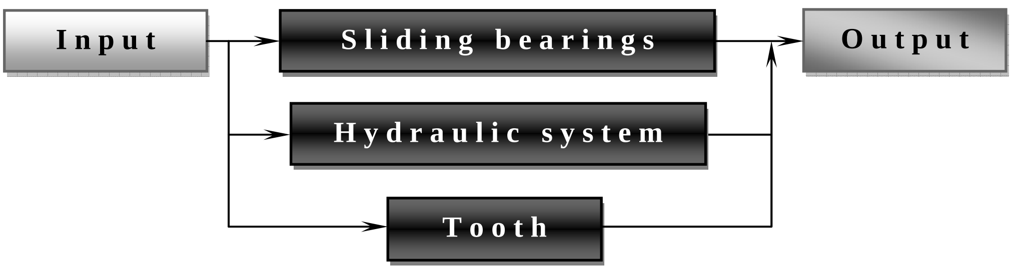


Fig. 6. Paralel reliability model realized in blocks

Presentation of the Systems Reliability Software Application v 1.0

The application window, the interface (see figure 7) is composed of 5 (five) work zones thus:
1. Work left zone for realizing the model composed of equipments' subsystems (blocks of reliability characterized by a certain level) and the connection between them;

2. Right up zone for the allocation of the reliability block label and of the value corresponding to the reliability level;
3. Right down zone for defining the ways (connections) between the reliability blocks and the display of the value corresponding to the respective way;
4. The display zone of the subsystems coordinates that compose the reliability way on two directions x and y;
5. The display zone of the final result - the reliability level of the subsystem the most pessimistic way that takes into consideration the connection between the system elements (serial system, parallel system and mixed system).

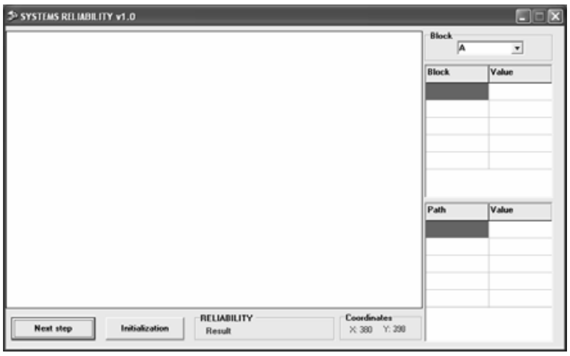


Fig. 7. Graphic interface of the application SYSTEMS RELIABILITY v1.0

Also, the application zone contains the buttons associated to the commands ″Next step″ and ″Initialization″. The first command is necessary to cover the steps necessary for the application and the second for resetting an application that rules and the initiation of a new one. For understanding the soft there was exemplified by solving the model afferent to the figure 6.
The user as we mentioned has the model composed of blocks established with the each characteristic reliability values (calculated with the help of any reliability law presented in this chapter without any restrictions or recommendations on its use especially of any of these), for the system to which it is calculated the total reliability value. There has to be mentioned that it is also applied a calculus algorithm to the reliability systems composed of blocks that are found in different relations (besides the presented complex type relation) thus the reliability systems with elements (blocks): in parallel, serial and mixed.
For solving the model there is preceded the following step succession:
Step 1. After the ″V1.0 SYSTEMS RELIABILITY″ application initialization by ruling the folder ″Systems reliability.exe″, the user meets the interface (window) afferent to it (see figure 7) that was presented upper.

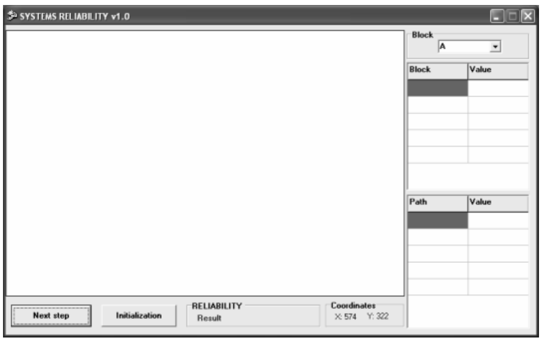
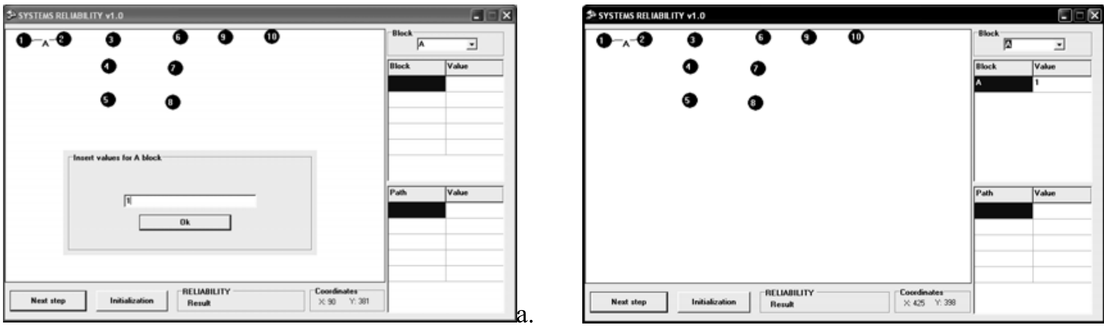


Fig. 8. Step 2: creation of the nodes that define the reliability blocks

Step 2. To this step there are located in the work zone the nodes that define the reliability blocks (see figure 8), by a single click on the left button of the mouse. The connection between the blocks is realized with the help of the nodes (the node from the last created block is practically

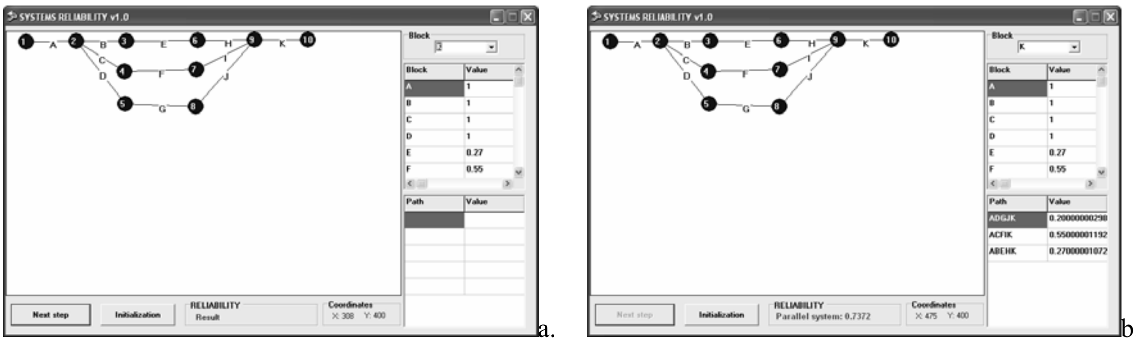
the first node that is created). After the nodes' creation it is pushed the button ″Next step″ for passing to the next step.
Step 3. Within the step 3 there are realized the connections between the created nodes (see figure 9), these connections having the blocks' signification from which it is composed the studied system, there are assigned labels, capital letters form the Latin alphabet (there has to mentioned that there must not use the same letter for defining two or more reliability blocks) and the reliability values characteristic to each element (see figure 9.a). The blocks' labels are selected form the ″Block″ zone of each main window by through the mouse from the selection element type combo-box. After realizing the connections and the assignation of the reliability values (see figure 10.a) there is pushed the button ″Next step″ passing thus to the step 4.
Step 4. Visualization of the obtained result (fig. 10.b) in the zone 5 and of the reliability possible ways (connections) with values calculated in the step 4.



a. b.

Fig. 9. Step 3: realization of the connections (reliability blocks) with assignation of characteristic labels and characteristic reliability values

It may be mentioned also the fact that for the reliability blocks that are practically functional (the reliability function having value 1) in the selection element type combo-box there is the option 1 and instead the label with capital letter it will appear the number ″1″ specific to the reliability value.



a. b.

Fig. 10. Step 4: visualization of the model and of the result made by the application

The result is verified applying the reliability formula for the parallel systems presented in the next paragraphs.
In this case, the functioning of the entire system is based on the functioning of its every component elements.
It is considered that in terms of reliability, a system "S" consisting of "n" is a structural component in parallel, failure if an item does not lead to system failure, in which case the operation is ensured by the failure last component. In this case the logical layout of the reliability is published in fig. 11.

If deemed event which consists of the proper functioning of the system and proper functioning of E1 component of the order 1, according to results contrary to the definition of the event:

$$E = \prod_{i=1}^{n} \overline{E}_i \tag{1}$$

with the likelihood that:

$$P\left(\overline{E}\right) = \prod_{i=1}^{n} P\left(\overline{E}_i\right) \tag{2}$$

Where events E and $\overline{E}$ form a comprehensive events namely:

$$P(E) + P\left(\overline{E}\right) = 1 \tag{3}$$

Noting with R_i= P(E_i) component reliability E_i, for parallel structure system reliability is:

$$R_s = 1 - \prod_{i=1}^{n} P\left(\overline{E}_i\right) = 1 - \prod_{i=1}^{n} \left[1 - P(E_i)\right] = 1 - \prod_{i=1}^{n} (1 - R_i) \tag{4}$$

where: R_s is the system reliability;
R_j probability as the element be operational.
Structural diagram of parallel system has n - parallel elements.
For example system reliability is given by formula:

$$R_s = 1 - \prod_{i=1}^{n} (1 - R_i) \tag{5}$$

For our considered system (fig. 6) reliability formula is:

$$R_s = 1 - (1 - R_T) \cdot (1 - R_{Hs}) \cdot (1 - R_{Sb}) \tag{6}$$

The function of non-reliability and the risk of failure are:

$$F_s = 1 - R_s = 1 - \left(1 - \prod_{i=1}^{n} (1 - R_i)\right) \tag{7}$$

The analogy with the complex circuits (electrical, mechanical etc.) is obvious. The system fails when there is no energy transfer; the components fail and/or work independently.

The scheme from the figure 11 represents a system with parallel components replaced with equivalent elements.

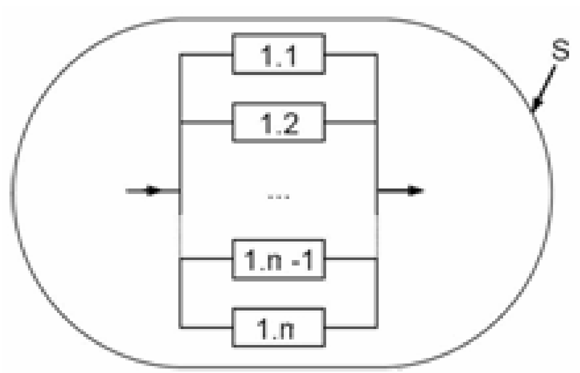


Fig. 11. Calculus of the reliability function for the parallel systems

To the replacement of the reliabilities corresponding to the elements (blocks) of the considered technological system there has been obtained the same result 0,7372 so it may be traced the conclusion that the software responds correctly to the data introduction.

Conclusions

There were identified the main causes of the rolling drilling bits failures generally and of those with sliding bearings packed especially by the analysis of an important lot of drilling bits used in exploitation. By an attentive evaluation of the wear of the drilling bit every elements there were emphasized that the main causes of the packed sliding bearings drilling bits out of order are the loss of the packing and the catastrophic wear of the tooth.

The presented software, conceived by the authors of the article is an independent instrument of the used operation system within reach of the engineers from the industry and not also what is useful by the help that provides the calculus of the systems' reliability with minimal hardware resources.

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Estimarea fiabilităţii sistemelor tehnologice utilizând aplicaţii software

Rezumat

Articolul prezintă, în prima parte, principalele problemele ce influenţează fiabilitatea utilajelor (sistemelor tehnologice), pe care s-a efectuat studiul de caz, iar în partea a doua, cu ajutorul unui program (aplicaţie software), contribuţie proprie a autorilor, o metodă rapidă de estimare a fiabilităţii bazată pe sintetizarea datelor obţinute din utilizarea în procesul de lucru a acestor utilaje. Sunt prezentate unele consideraţii generale cu privire la această metodă, urmate de un exemplu concret de estimare a fiabilităţii sapelor de foraj, modelate ca sisteme tehnologice cu elemente conectate în paralel. Articolul se încheie cu principalele concluzii, dintre care cea mai importantă, este aceea că acest software este un instrument foarte util, şi mult mai rapid decât calculul matematic, pentru estimări ale fiabilităţii sistemelor tehnologice.