RELIABILITY ANALYSIS OF CUT-OFF PLATE (VIR) FROM HPP TILEAGD USING MONTE CARLO SIMULATION

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***Abstract** – The reliability level of hydro mechanical equipments can have a major impact on the operational reliability of HPP (Hydro Power Plants). In consequence, there are justified the concerns regarding the predictive reliability of them. In this paper, these studies of hydro mechanical equipments reliability is made using the Monte Carlo simulation.*

Keywords: **reliability, hydro mechanical equipement, Monte Carlo simulation**

1. Introduction

In every hydro energetic arrangement, the water approaches, in differently construction elements and trough them, are equipped with valves. These valves assure the normal functioning of equipments, respectively there operatively insulation in case of failures or repairs.

The accomplished studies [3, 4], indicate that some valves type are more performant under the reliability aspects than other equipments (hydraulic turbines). In succession, on the reliability studies, the valves are treated as bivalent elements (Functioning; Faulting).

The reliability analysis of hydro mechanical equipments it has been made using the Monte Carlo simulation [2].

2. Case study. Reliability analysis of cut-off plate (VIR) from HPP Tileagd using the simulation program

The cut-off plate from HPP Tileagd (VIR 4,0x5,1/23), is a complex ensemble used to protect the hydraulic turbine (KVB 9,4-23,2) against the over speed. The VIR belong to the automation system, for protection. The closing of water admittance to the hydraulic turbine is made with guiding apparatus.

During the reliability analysis, the cut-off plate (VIR) from HPP Tileagd, it has been regarded like a system compound of following subsystems (fig. 1):

- the rolling and guiding subsystem (RGS);
- the closing or obstructing subsystem (CSS);
- the sealing subsystem (SSS);
- the control subsystem (NSS);
- the operate subsystem (OSS);
- the protection subsystem (PSS).

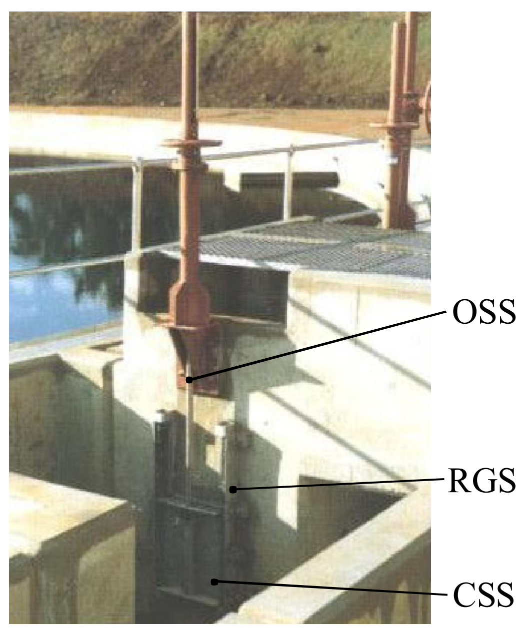

Fig. 1 - The VIR structure and subsystems.

According to previously specifications (for the simplified reliability analysis) VIR it has been treated as a system compound of six subsystems. In consequence, it can represent the simplified equivalent diagram (fig. 2), who reflects the necessity that, all the subsystems to be in work for satisfied all the cut-off plate functions.

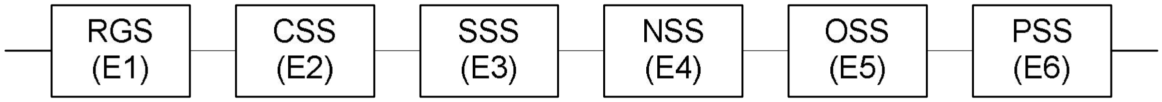

Fig. 2. – The equivalent diagram of VIR

Based on data obtained from monitoring the operations of cut-off plate (VIR) in the HPP Tileagd can assess the subsystems reliability indicators R_i, F_i, μ_i, M_i, [3] obtained values are given in table 1.

Table 1 – The values of reliability indicators for the VIR subsystems

Subsystem	RGS (E1)	CSS (E2)	SSS (E3)	NSS (E4)	OSS (E5)	PSS (E6)
F_i x 10^4	15,2114	33,9333	40,9539	69,0367	842,482	167,326
μ_i [h^{-1}]	0,0038	0,005652	0,005756	0,004085	0,0055724	0,0045
M_i	0,2336	0,3267	0,3316	0,2487	0,3229	0,2705
R_i	0,998478	0,996606	0,995904	0,9930963	0,9157517	0,983267

These values will be input into the simulation program whose editing window is shown in figure 3.

Fig. 3 – The editing window of analyzed system

Following the steps from [2], it's obtained figures 4÷7, which refers to the characteristic equation, specifying the input data, the failure and repair rate values, also the saved and loading data windows of simulated system.

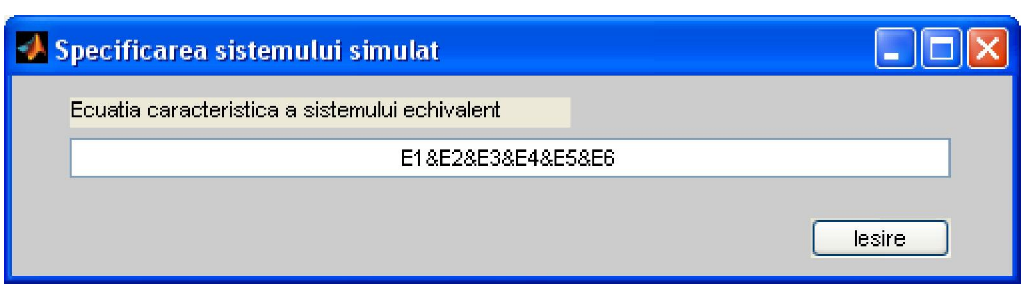

Fig. 4. – The characteristic equation of system

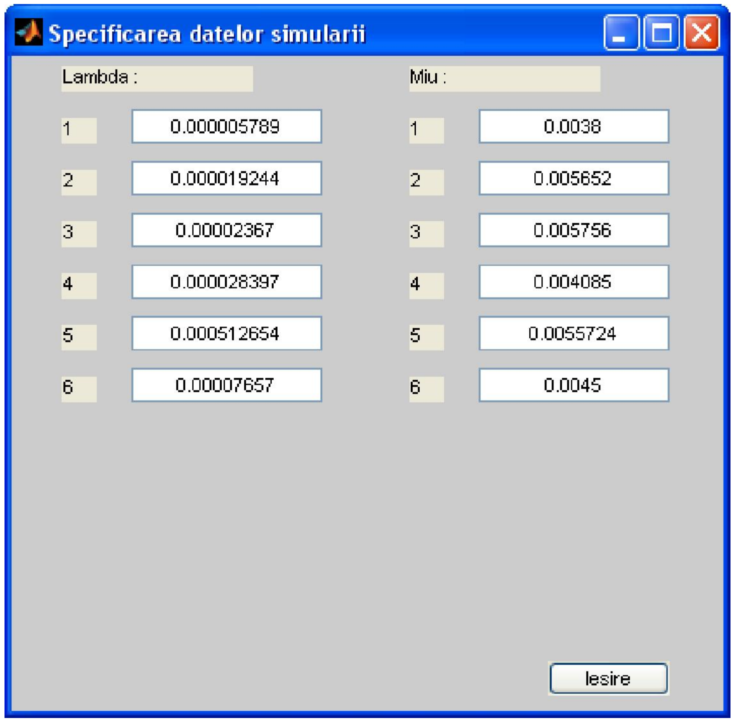

Fig. 5. – Specifying the simulation data of analyzed system

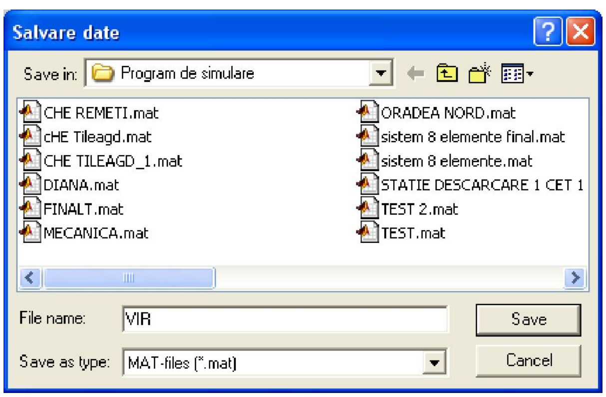

Fig. 6. –The saved data window for system analysis

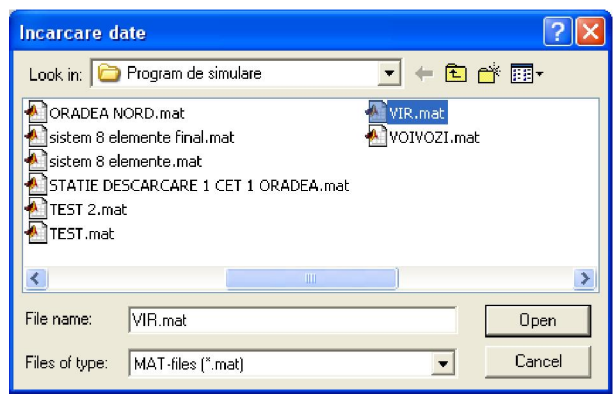

Fig. 7. – *The loading data window of analyzed system*

Figure 8 shows how to display the results for 10 years of analysis and 10.000 simulations, so that in figure 9 is presented the simulation results display window.

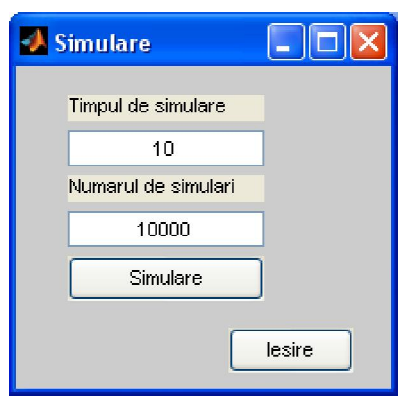

Fig. 8. – The simulation module for 10 years and 10 000 simulations

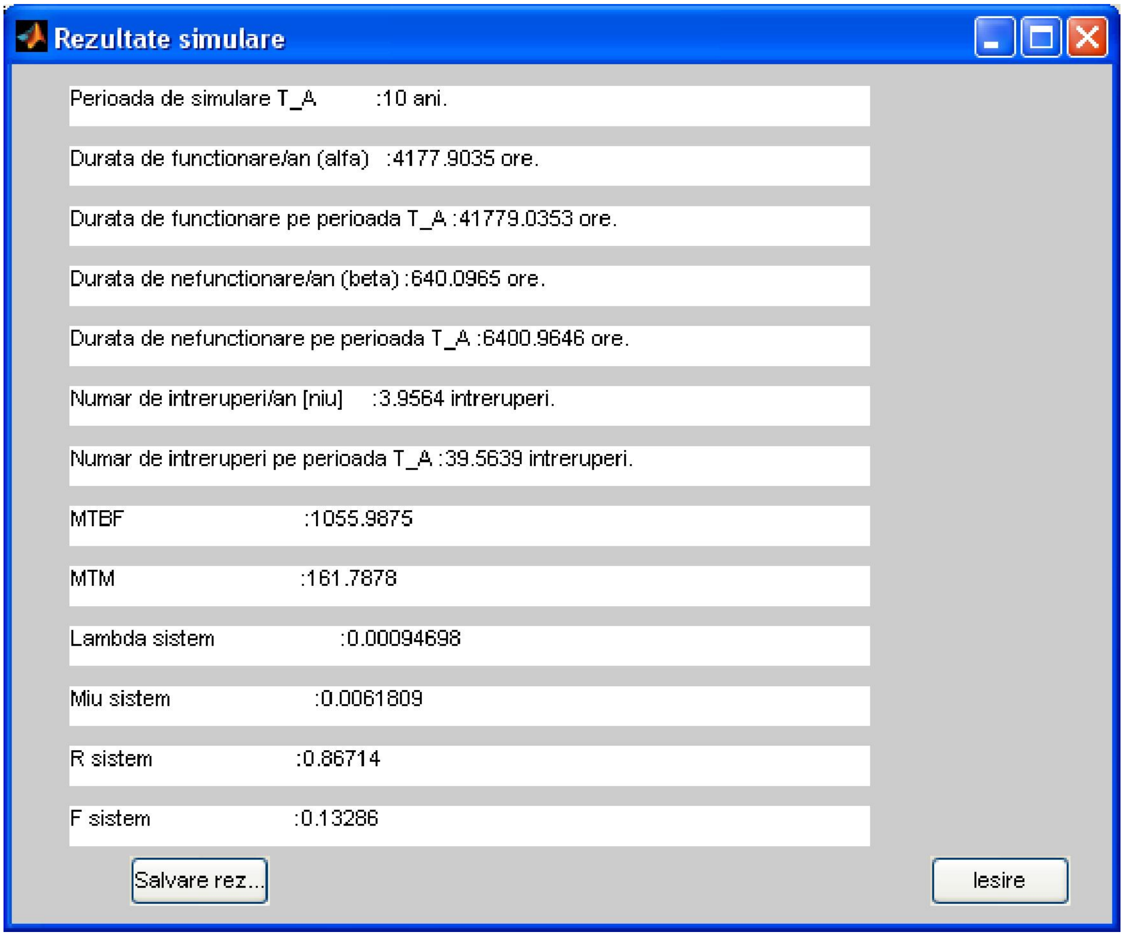

Fig. 9. - The simulation results display window

Figure 10 shows the display module of operating diagrams and diagram in figure 11 presents the corresponding data input module. It is noted the existence of defects over time at both component and system level. This, and the simulation results are due to the elements in series of analyzed system.

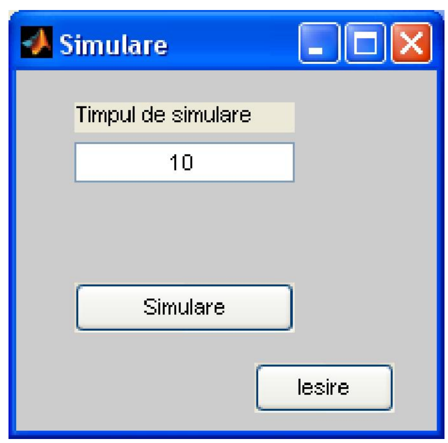

Fig. 10. - The window display module of operating diagram for analysis system

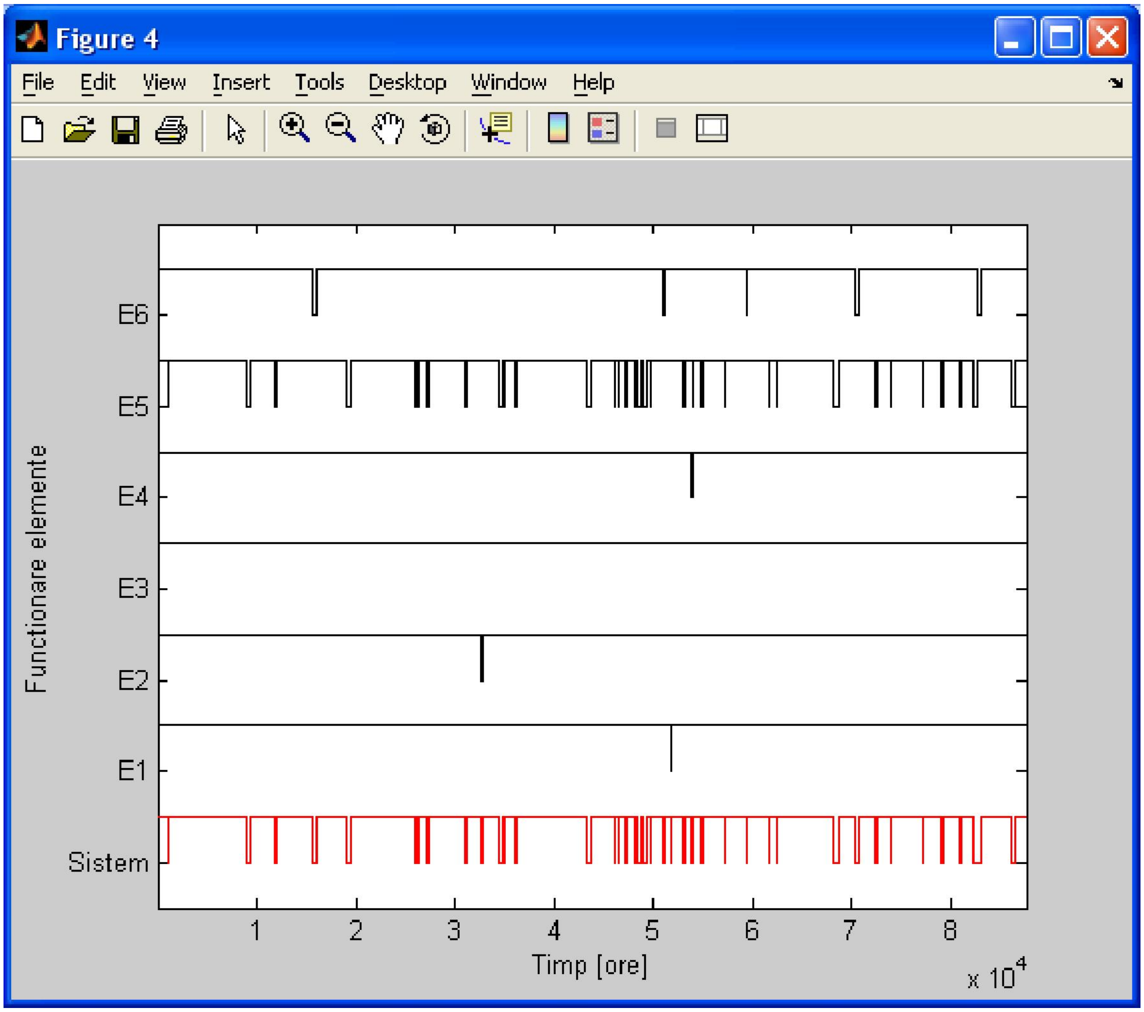

Fig. 11. – The operating diagram of analized system

To be convinced of the usefulness and accuracy of the reliability simulation program will be a comparison of the results obtained by simulation and those obtained by analytical calcuus - DEF method - [3], on reliability.

The analytical calculus of system reliability is $R_{sis} = 0{,}8671761$, comparable to that obtained in the simulation, which was: $R_{sis} = 0{,}86714$.

Must be made clear that the simulation results are influenced by the system evolution in time, taking into account the defects that occur during the analysis.

It is found that the differences that arise in calculating the reliability by Monte Carlo and analytical methods are very small, they appeared only in the fifth decimal place, which gives the judge that Monte Carlo simulation method can be applied in reliability analysis of hydraulic equipment.

The differences are due to the number of simulations that are working. Matlab working memory with 14 decimal places, even if fewer show differences that are within an acceptable calculation errors.

Conclusions:

1. In the reliability analysis will consider the cut-off plate (VIR) as a complex system consists of six subsystems connected in series.

2. For complex systems, the program presented in [2] and run for VIR is considered very effective, allowing reliability calculus, drawing of operating diagrams for all elements and system in record time.

3. The assessments made by this program are accurate, these results derived comparing the reliability by Monte Carlo simulation, or directly through DEF.

System	MONTE CARLO 10000 simulations	DEF
VIR	$R_{sis} = 0{,}86714$	$R_{sis} = 0{,}8671761$

4. The Monte Carlo method remains one of the successful methods in various energy analysis.

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