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RELIABILITY ANALYSIS OF SPHERICAL VALVE (VS) FROM HPP REMEȚI USING MONTE CARLO SIMULATION

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ABSTRACT: 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. Also, 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 are made using the Monte Carlo simulation.
KEYWORDS: reliability, hydro mechanical equipment, Monte Carlo simulation

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 [4, 5], indicate that some valves type are more performing 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, 6, 7].

RELIABILITY ANALYSIS OF SPHERICAL VALVE (VS) FROM HPP REMEȚI USING SIMULATION PROGRAM

The spherical valve equipment, SV 150-500, is a complex ensemble who attended the hydraulic turbine FVM 52-320. It is located upstream of turbine and downstream of distributor. The spherical valve performed one's functions namely, the safety device for turbine.

The valve control its automatic realize, in the hydro generator on-off process. During a several distinctly operations the spherical valve it has manual control, from the local panel.

During the reliability analyses, the spherical valve (SV) from HPP Remeti, it has been regarded like a system compound of following subsystems (figure 1):

- The closing subsystem (CSS);
- The sealing subsystem (SSS);
- The control subsystem (NSS);
- The operate subsystem (OSS);
- The protection subsystem (PSS).

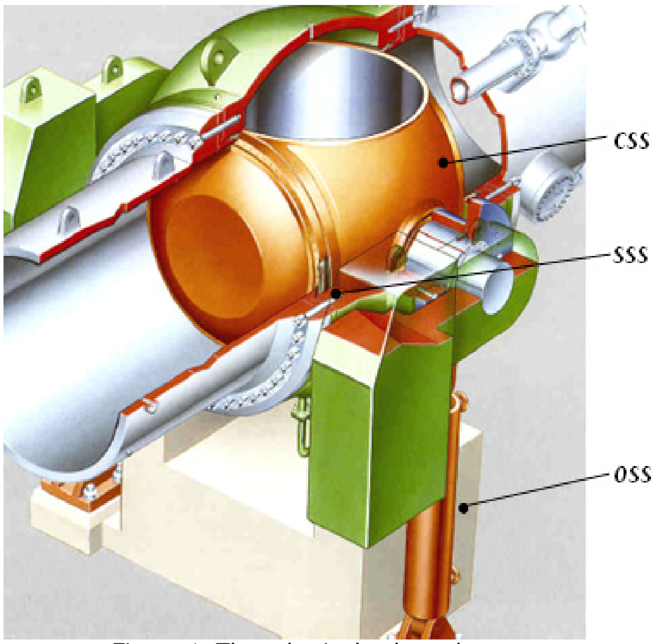

Figure 1. The spherical valve subsystems

According to previously specifications (for the simplified reliability analyses) SV it has been treated as a system compound of five subsystems. In consequence, it can represent the simplified equivalent diagram, who reflects the necessity that, all the subsystems to be in work for satisfied all the spherical valve functions.

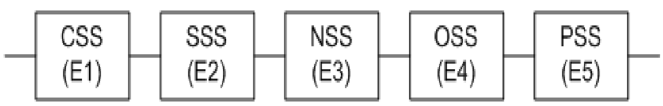

Figure 2. The equivalent diagram of SV

Depend on results obtained from the operational reliability studies [4,5], it can estimate the subsystems reliability indicators [R_i, Fi, μ_i, M_i].

The calculus relations are:

$$F_{SV} = \frac{\lambda}{\lambda + \mu};\ F_i = \frac{v_i[\%]}{100} F_{SV};$$
$$\mu_i = \frac{v_i[\%]}{\beta_i[\%]}\mu;\ M_i = 1 - e^{-\mu_i\ t_r} \quad (1)$$

where: λ, μ - the SV reliability indicators;
F_{SV} - failure probability of SV;
v_i, β_i - the weight of number failures and failures time, of the (i) subsystems from the total value of these indicators at the level of SV.

The maintainability values (M_i) are determined using condition that the maintenance corrective operations must finished in MTM = 42 h [4].
The values are represented in table 1.

Table 1 - The values of reliability indicators for the VS subsystems

Subsystem	CSS (E1)	SSS(E2)	NSS (E3)
$F_i \times 10^3$	3.9355	27.7062	9.2878
$\mu_i\,[h^{-1}]$	0.00625	0.00855	0.006
M_i	0.23087	0.30169	0.22282
R_i	0.9960645	0.9722938	0.9907122
$\lambda_i\,[h^{-1}]$	0.000024694	0.00024363	0.000056249
Subsystem	OSS (E4)	PSS (E5)	
$F_i \times 10^3$	101.852	14.6402	
$\mu_i\,[h^{-1}]$	0.006908	0.007159	
M_i	0.2518381	0.2596838	
R_i	0.898148	0.9853598	

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

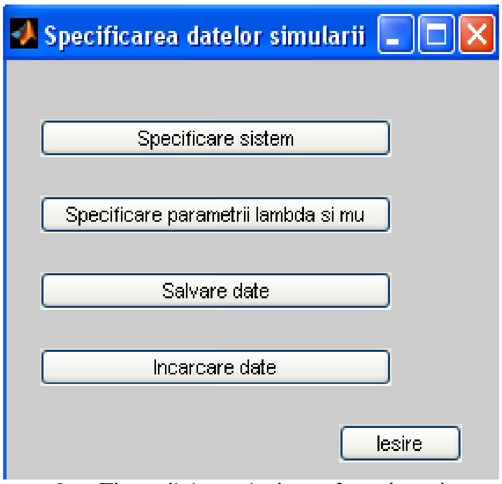

Figure 3. - The editing window of analyzed system

Following the steps from [2, 3], 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.

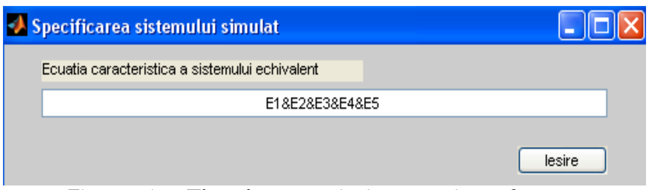

Figure 4. - The characteristic equation of system

Figure 5. - Specifying the simulation data of analyzed system

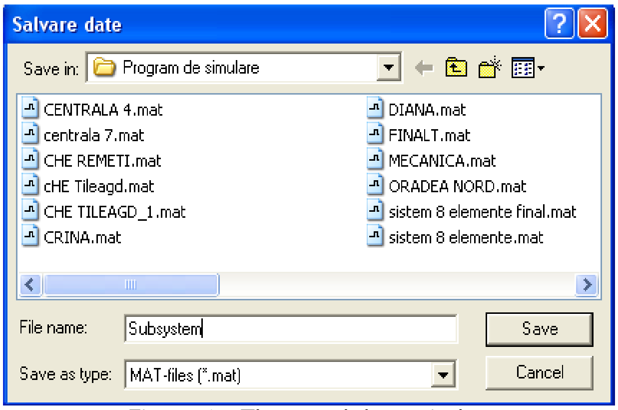

Figure 6. -The saved data window for system analysis

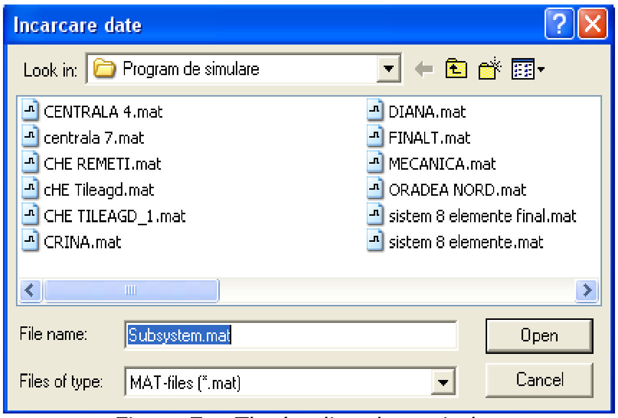

Figure 7. - The loading data window of analyzed system

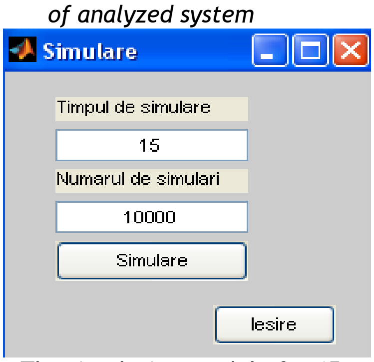

Figure 8. - The simulation module for 15 years and 10 000 simulations

Figure 8 shows how to display the results for 15 years of analysis and 10.000 simulations, so that in figure 9 is presented the simulation results display window.

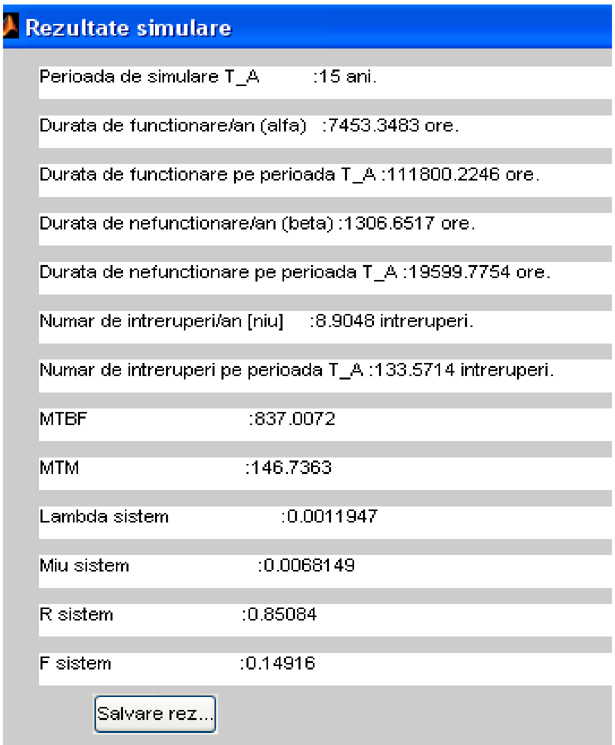

Figure 9. - The simulation results display window

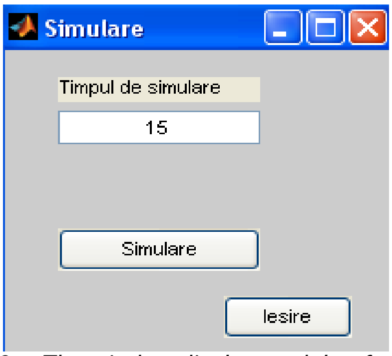

Figure 10. - The window display module of operating diagram for analysis system

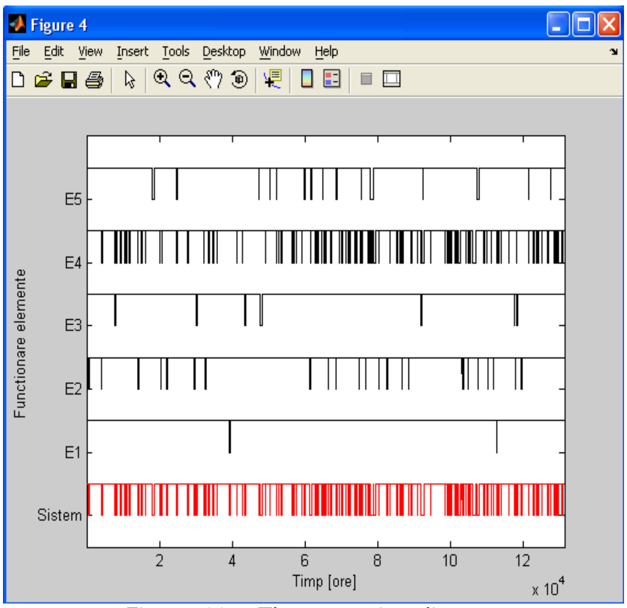

Figure 11. - The operating diagram of analyzed system for 15 years

Figure 10 shows the display module of operating diagrams and diagram in figure 11, 12 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.

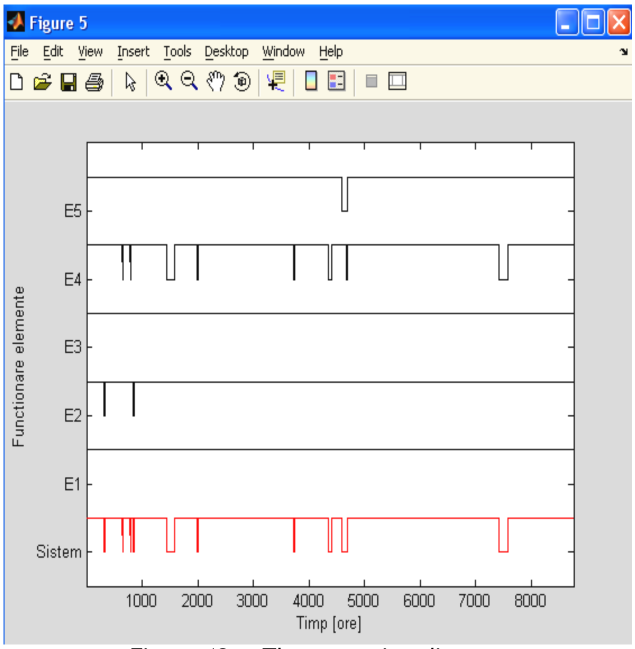

Figure 12. - The operating diagram of analized system for 1 year

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 calculus - DEF method - [4,5], on reliability.

The analytical calculus of system reliability is R_{sis} *= 0.849132, comparable to that obtained in the simulation, which was:* R_{sis} *= 0.85084.*

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 observed that defects are the most common at element 4 which has the lowest reliability. Frequent defects of 4 element, serially connected to the other element, leading to overall system failure, so to decrease system reliability.

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

CONCLUSIONS

1. *In the reliability analysis will consider the spherical valve (VS) as a complex system consists of five subsystems connected in series.*
2. *For complex systems, the program presented in [2] and run for VS 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
VS	R_{sis} = 0.849132	R_{sis} = 0.85084

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

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