RELIABILITY ANALYSIS OF HYDRO - GENERATOR GROUPS USING MONTE CARLO SIMULATION

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Abstract: The reliability level of hydro generator subsystems can have a major impact on the 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 reliability will be made using Monte Carlo simulation for hydro generator groups from HPP Remeti.

1. INTRODUCTION

The hydro-generator groups can be interpreted as technical complex systems, composed from several subsystems. In the view of reliability evaluation it is necessary to know the technological structure till the level of subsystems and their components functioning, so as the energetic equipment, of their characteristic and schemes functioning.

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

2. CASE STUDY. RELIABILITY ANALYSIS OF HYDRO GENERATOR GROUPS FROM HPP REMEŢI USING MONTE CARLO SIMULATION

To evaluate the operational reliability indicators of the hydro-generator groups from HPP Remeţi, we detailed the analysis to the level of the next subsystems of these:

- The butterfly throttle (BT)
- The globe valve (GV)
- Hydraulic turbine (HT)
- Interacting automatic control system (governor + pressure oil group) (ACS)
- Hydro-generator (HG)
- Group transformer (GT)
- Evacuate substation (ES) (redactor, oil break switch, selector switch disconnector, current transformer).

According to previously specifications (for the simplified reliability analysis) hydro generator group it has been treated as a system compound of seven subsystems. In consequence, it can represent the simplified equivalent diagram (fig. 1), who reflects the necessity that, all the subsystems to be in work for satisfied all the hydro generator functions.

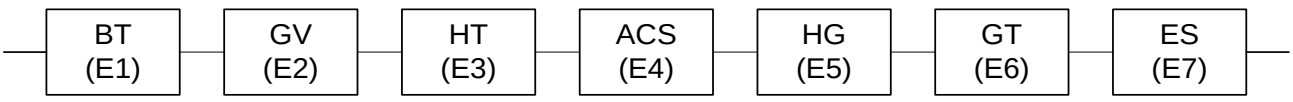

Fig. 1 - The equivalent diagram of hydro generator group

Based on data obtained from monitoring the operations of hydro generator group from HPP Remeţi can assess the subsystems reliability indicators R_i, F_i, μ_i, M_i, [3, 4] the obtained values are given in table 1.

Table 1 – The values of reliability indicators for the hydro generator subsystems

Subsystem	BT (E1)	GV (E2)	HT (E3)	ACS (E4)	HG (E5)	GT (E6)	ES (E7)
$\lambda_i \times 10^4$ [h^{-1}]	7,6221186	14,447103	11,900861	21,933805	11,639042	9,8041142	9,030347
$\mu_i \times 10^4$ [h^{-1}]	101,244	77,325987	129,094	220,806	290,398	271,348	183,448

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

Fig. 2 – The editing window of analyzed system

Following the steps from [2], it's obtained figures 3÷6, 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.

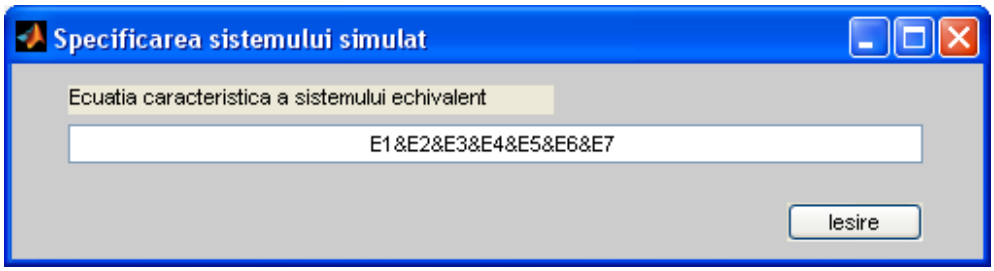

Fig. 3. – The characteristic equation of system

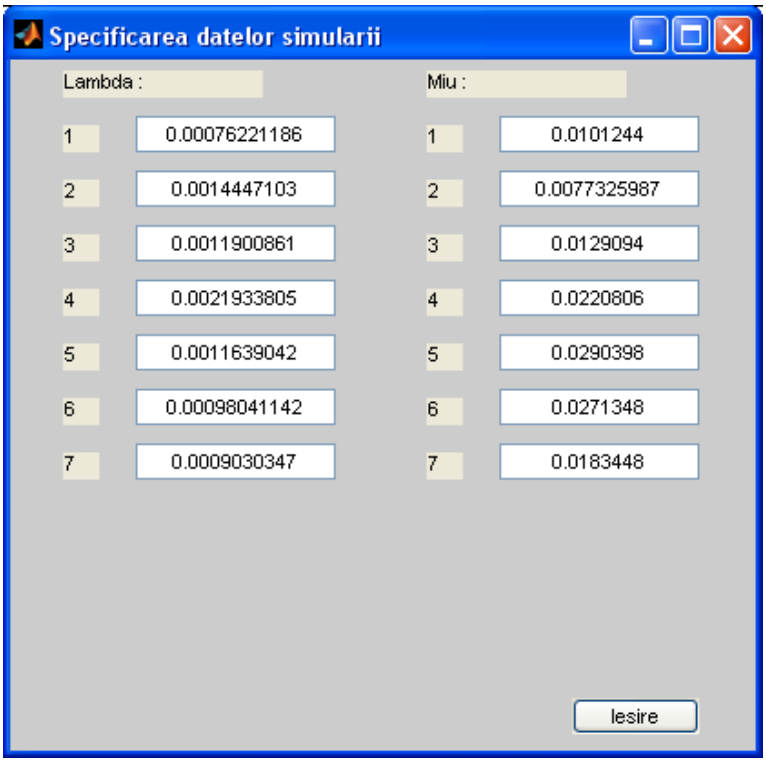

Fig. 4. – Specifying the simulation data of system

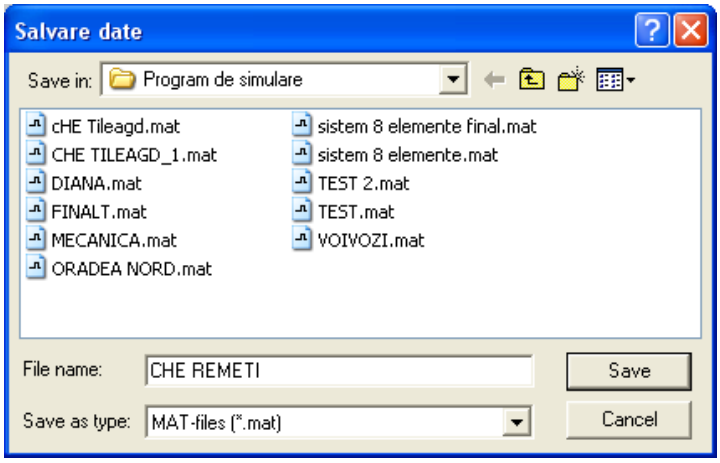

Fig. 5. - The saved data window for system analysis

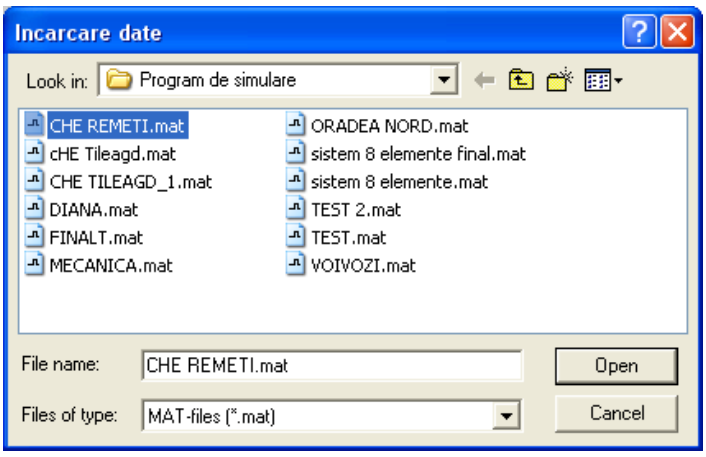

Fig. 6. - The loading data window of analyzed system

Figure 7 shows how to display the results for 12 years of analysis and 10.000 simulations, so that in figure 8 is presented the simulation results display window

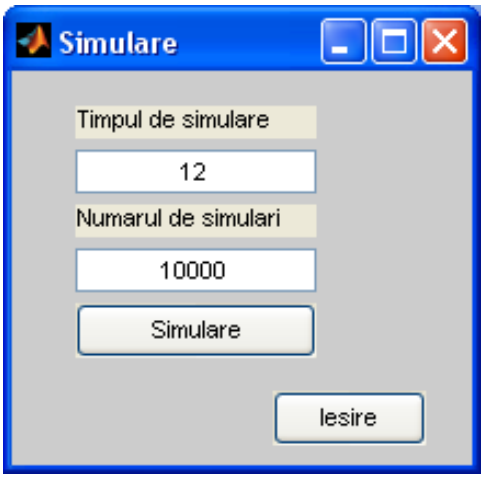

Fig. 7. – The simulation module for 10 years and 10 000 simulations

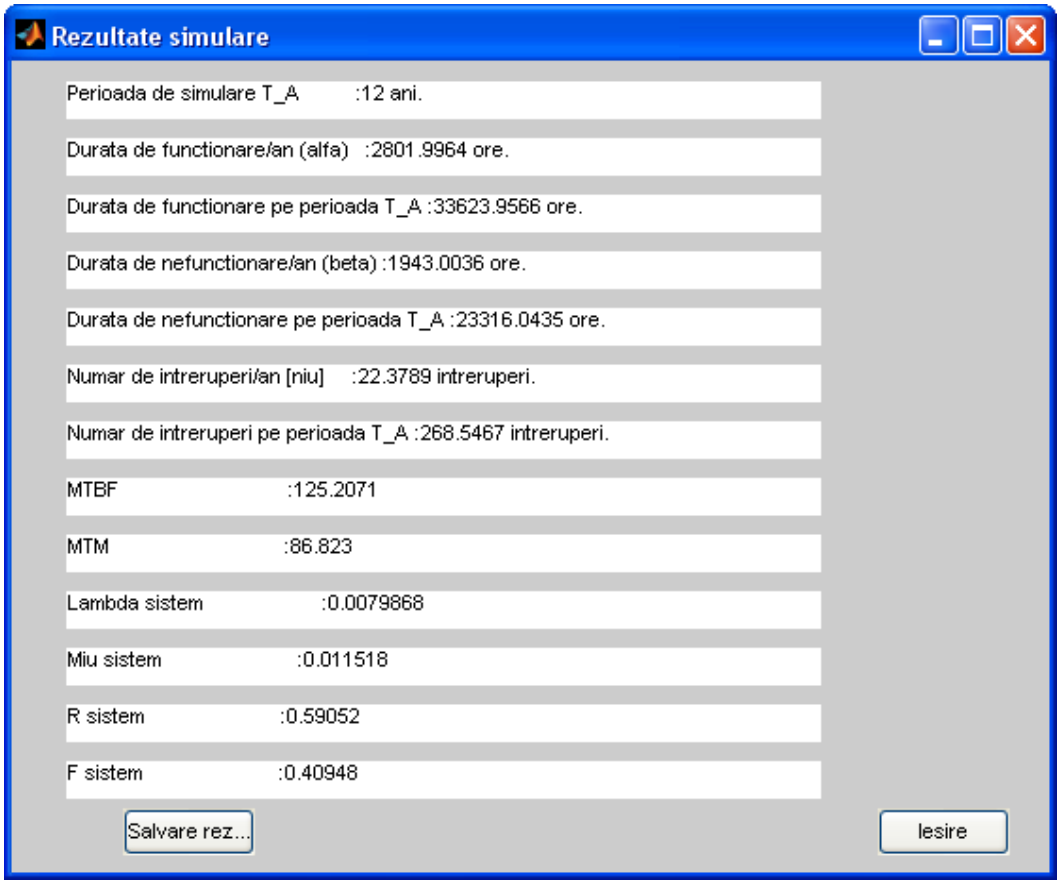

Fig. 8. - The simulation results display window

Figure 9 shows the display module of operating diagrams and diagram in figure 10 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.

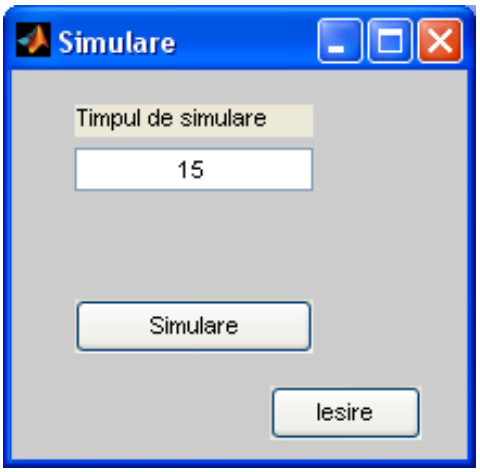

Fig. 9. - The window display module of operating diagram for analysis system

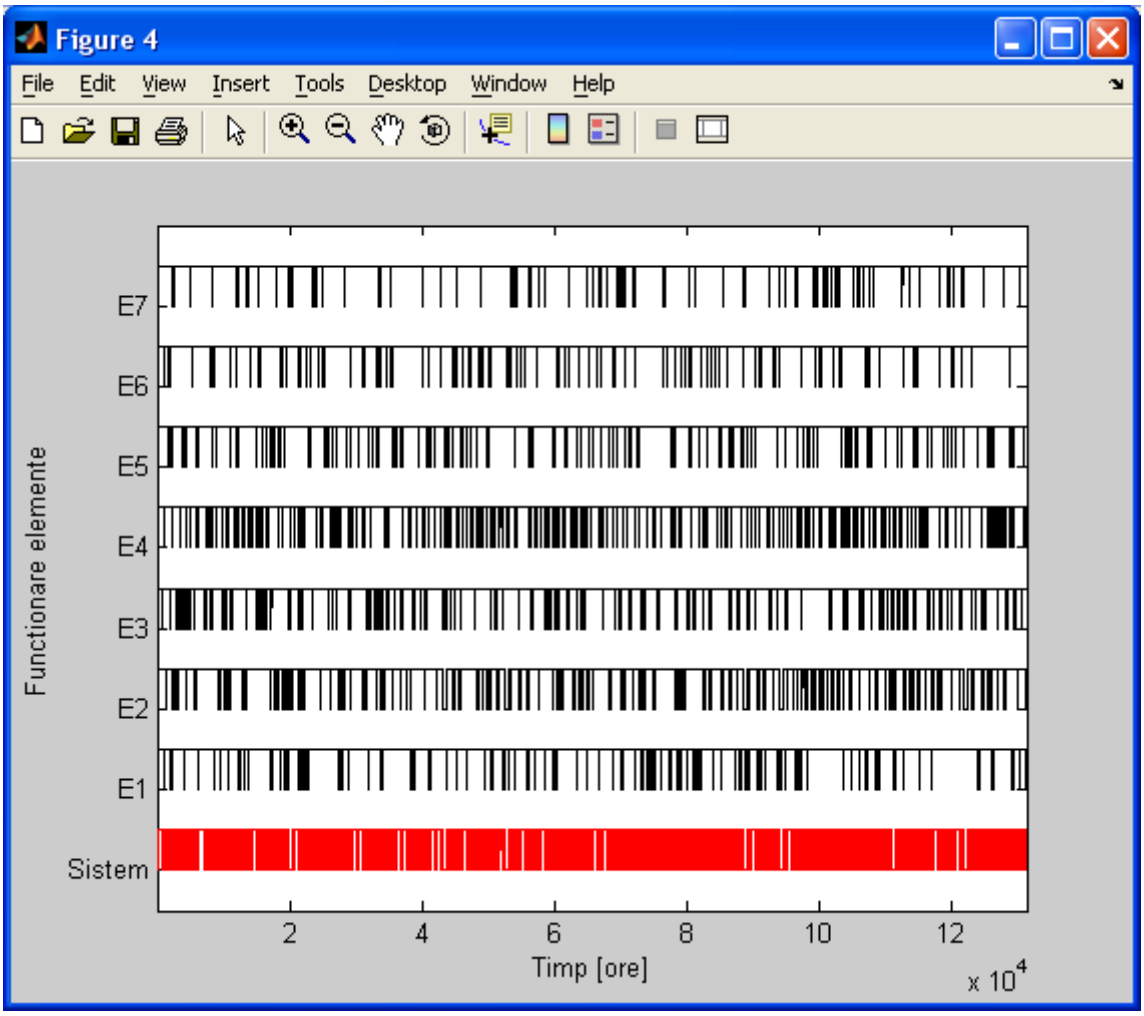

Fig. 10. – The operating diagram of analized system

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 $R_{sis} = 0{,}5905168$, comparable to that obtained in the simulation, which was: $R_{sis} = 0{,}59052$.

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 hydro generator group as a complex system consists of seven subsystems connected in series.

2. For complex systems, the program presented in [2] and run for hydro generator group 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
Hydro generator group	$R_{sis} = 0{,}59052$	$R_{sis} = 0{,}5905168$

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

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