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Modified Method for Reliability Evaluation of Condensation Thermal Electric Power Plant

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Abstract Present methods for forecasting and evaluation of thermal power plants reliability were based on appliance of statistics and probability calculation related to strength and in the same time leaning on modern methods for deterministic project-constructive calculations of elements, subsystems and systems. Applying the advantages of modern directions in system reengineering and structural or RCM (Reliability Centered Maintenance) way of using the best methods in reliability analysis of complex systems, the block diagram of modified method for basis referential 300 MW block has been created. As a starting database, the results of research of basic configurations of thermal power plants for solid fuel "Ugljevik" and "Gacko" with nominal referential power of 300 MW were used. For other facilities inside thermal power plants witch nominal power differs from 300 MW, recalculation of reliability indicators has to be carried out. Whereat the simple empirical relation in dependence of previously determined reliability indicator for 300 MW system is used so as the exponent determined on basis of statistical data processing from the exploitation during the lifespan of the power plant. The method is of the iterative nature and is about to be terminated as the starting hypothesis related to matching of results of the forecasting and real exploitation results affirms. The research related for suggested modified method gave several relatively new results which are presented inside the paper. The result represents the algorithm of modified method for evaluation of reliability of referential thermal power plant system and its modification aiming to include thermal power plants of other nominal powers.

Keywords Thermal Electric Power Plant, Basic 300 MW Power Block, Algorithm, Modified Method, Interval Assessments, Dynamic Corrections

1. Introduction

The issues of finding the thermal electric power plant optimal reliability have been explored by using the scientific prevention and scientific identification as a modern approach of the TQM, which has been used in high technologies so far. The question of creating the basic method of reliability evaluation for the referential (basic) 300 MW power block is based on the co-ordination of separate specialist analysis within the framework of a complex algorithm, with a certain probability interpretation aiming to obtain a prognostic reliability assessment, and later also its optimization on the basis of a selected criterion. Any change of the project–prognostic conditions also requires additional consideration of other information sources, mostly from the lower hierarchical stages and with higher level of detailing the facilities and processes that take place within them.

It is also necessary to complete the basic method of structural calculation of reliability indicators for the conditions of operational and non operational capacities with adequate supplementary correctional factors. Because of the presence of conditions resulting from the random processes effects (mostly of non stationary character) and also due to the difficulties in establishing the correlative connections when there are data limitations, the two-step system of corrections is most frequently used in practice. The first step is the creating of the reliability characteristics change dependency on the basis of the existing data of adequate statistic analysis, the expert evaluations and prognosis, the interval assessments of the mean and limit values and the prognosis of a possible behaviour trend of the dependencies and reciprocal relations, with simplified graphic interpolations according to the mean and final values, with their further supplementing and corrections. Applying the analogous combined approach at the second step the direct relations will be determined, or the differences and dynamic corrections, and with respect to the adopted classification according to the nominal power, with the carrying out of corresponding statistic and graphic extrapolations and mutual linking of the project reliability indicators for the thermal electric power plant system which was considered. Reliability, as a probability that the thermal electric power plant system will meet the required function within particular

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period of time and under certain conditions, includes four substantial factors: probability, the required function, periods of time and working conditions. Such a manner of presenting reliability enables easier compression and more effective employment. The issues of finding the thermal electric power plant optimal reliability have been explored by using the scientific prevention and scientific identification as a modern TQM approach, which has been used in high technologies so far,[1]. One of the basic goals is also the research on to what extent and in what structural form such an approach can be applied with profitability, also in the classical production systems, such as thermal electric power plants.

Nomenclatures

CTEPP : Condensation Thermal Electric Power Plant

A: is a nominal power of the thermal electric power plant system, MW

B_{300}: a reliability indicator for the thermal electric power plant system of 300 MW power

C_A: a reliability indicator for the thermal electric power plant system of the power different from 300 MW

m: the exponent value obtained on the basis of statistical data processing from the exploitation during the thermal electric power plant life cycle

2. Methods for Reliability Evaluation

There are a large number of methods for the assessment of a system and conducting the reliability analysis. Starting from a concept of defining a diagram of activities development for the purpose of the reliability evaluation and optimization of the thermal electric power plant system at all stages of its life time, and like of existing partial solutions it can be concluded as follows:

- The analysis of the thermal energetic facility reliability and disposability by a combined procedure for a short term prognosis (ten coefficients method for the assessments of electric power plants engagement, disposability and reliability) represents an attempt of unification and defining of a unique methodology for a short time prognosis of electric power plants operation within the scope of the electro energetic system. The selection of coefficients for the correction of the facilities reliability and disposability indicators obtained by means of using the classical statistical methods was risk bearing in certain respects. Specifically, these coefficients required additional analysis related to the technical diagnostics application level that is the conditions of particular facilities within the system, which might be leading to the possibility of their subjectification by the experts. By applying the coefficient k_2 the equipment condition is already "installed" through carrying out the statistical analysis for a five-year period which has been considered, so the blocks correction with above- average good condition was made with the $k_2>1$ value. The next reason of the obtained results deviation is connected with averaging procedure itself and the curve approximation of a five year average (with an error up to 2%).
- In the thermal electric system the statistical methods for plant experience analysing have found a place, the Bayes method, while for the reliability and disposability evaluations the following methods were used: failure trees, Markov's and Monte Karlo, Pareto, as well as the extreme values statistics. The analysis results obtained by the use of these methods were generally based on the research of separate unities in a precisely determined system or of its elements and therefore it is very difficult to generalize them to the system in its entirety. Thereby the mutual comparison of solutions and similar problems of the thermal electric plant system with different nominal power has been aggravated.
- On the other side, the application of the Total Productive Maintenance – TPM concept aiming to the maximization of the equipment effectiveness and the establishment of preventive maintenance throughout the whole lifetime, as well as the methods required in the TPM application are not recent either. These methods mostly have not been used in the analysis of the thermal electric power plant system reliability and disposability so far, although they can be very efficiently applied to a thermal electric system. Their application opens a possibility of unification of obtained results and their standardization according to particular typified classes defined by their nominal power.
- Aiming to increase objectivity of the analysis, it often happens that intensity of malfunction is being given by interval, which may lead to certain problems connected with the development of procedure for critical control point establishing. This method has shown to be very efficient for the analysis of manners, effects and critical stage of failure connected with the most critical elements for the system of a nuclear power plant, submarines, aircrafts etc., so for these reasons there are indications of its applicability in the thermal electric power plant system as well.
- As elements of identification theory of the technical state of the system the statistical, metrical and logical methods have been used. Here the concept of control and diagnostics should be pointed out based on the set theory and topology. In that case it is necessary to define each technical system by hierarchical structure, somewhat extended in relation to the reliability theory which, besides the technical system, also includes a part connected with the capacity, surface and linear constituent part of the system, as well as the diagnostics levels. It should be emphasized that these issues are also accompanied by diagnostic software which is based on the macro and micro diagnostics.
- The approach to RCM, despite not containing any new method, it introduces the structural manner of applying the best methods. On the basis of such a presentation it is possible to create the diagram concept of activities

development of the basic modified method (for the 300 MW power referential block), with its modification and unification for the other blocks, classified according to their nominal power. On the ground of such a method it is possible to take decisions connected with the need of preventive maintenance and of its being founded on time or condition. The RCM process as developed so far, contains three key characteristics:

a) The RCM recognizes that internal reliability of any element depends on its project and the way of construction, and that not a single form of maintenance can create reliability which would overcome the reliability installed in the course of projecting. The RCM analysis starts with defining the desired performance for each system and establishing whether reliability is such that maintenance can provide those characteristics. If it appears that it can, then it throws light upon the problems outside the maintenance scope so other activities are required such as projecting, improvement, the operation procedures changes, or the changes of the basic material.

b) The RCM recommends that the failure effects are more significant than their technical characteristics. Constructive considerations of the failure effects direct the attention to the failures which, to the maximum extent, affect the safety and the system performances.

c) The RCM includes the last research of the causes of the system failure in improved diagram of the course of taking decisions activities, with a selection of preventive maintena nce tasks, or activities which have to be taken in case that no convenient task can be found. This approach identifies all significant forms of maintenance securing the criteria for taking decisions, which is most convenient in any situation.

Potential effects of conducting the reliability and disposability analysis through the possible application in the reengineering process, that is after the expiry of the "basic" operating life, are based on potential improvements on the parts connected with the most critical part of the facility, and thereby indirectly on the system itself in its entirety. Such a reengineering approach should provide the realization of adequate level of required disposability or reliability, with the costs reduction which would cause a stoppage because of waiting for the task execution in the maintenance process of the thermal energetic power plant system. As in most of different industries (nuclear power plants, petro chemistry, thermal electric power plants, industrial power plants) the requirement for establishing the risk probability evaluation has been increased, the number of protection devices and alarm systems has continuously been growing, aiming to encompass the most important elements with the highest degree of risk in the exploitation process. As a result of this is also the increase of components in the reliability analysis chain, which affects the obtained evaluation accuracy.

3. Modified Method for Optimal Reliability Evaluation of CTEPP

Using the advantages of current re-engineering system and structural or the RCM (Reliability Centered Maintenance) way of using the best methods in the complex systems reliability analysis, a block scheme of modified method for 300 MW power basic referential block has been created, Figure 1.

This method also includes the risk level evaluation and indirectly also the evaluation of the way of maintenance of these systems or of their components. The choice of the most adequate maintenance task is realized through using the development of decision making activities diagram which takes in consideration technological possibilities of the proposed tasks and verifications of the realization of that. In the activities development diagram of this method the current knowledge related to the application of the TPM (Total Productive Maintenance) methodology have been incorporated, that is the application of a concept of total productive maintenance, similar to the maintenance according to condition, with the fact that the maintenance requires a special relation of the consumers toward the system and the "total" responsibility for the maintenance quality procedure of all employees within the scope of the thermal electric power plant. The aims of previously stated concept can be reduced to the equipment effectiveness maximization and the establishment of complete preventive maintenance system in the course of the whole lifetime of components and/or of the systems and their auxiliary equipment. The TPM approach is applied through different sectors in a company, covering every employee, and is based on preventive maintenance through the *"managing motivation"* which includes smaller groups activities.

Results of former appliance of this concept highlight the major losses or disturbances such as: losses regarding the duration of malfunction (malfunction of equipment and its impact on unscheduled maintenance, demands regarding the tuning, adjustment and synchronization, activities regarding preventive maintenance of other units during the malfunction duration) losses caused by decreased power in comparison with projected power or working on minimum stable operating level and losses regarding continuity and quality of the electricity distribution. This enables the exploitation of various methods from Table 1 (particularly FTA and FMEA/FMECA) in the lifetime development of the system, with the orientation on the preventive maintenance program. Using the data about the similar facilities operation within the countries of the former JUGEL, then the SSSR, the USA and some European countries (e.g.[2],[4],[6-8]) the obtained results for the lower interval evaluation have been corrected.

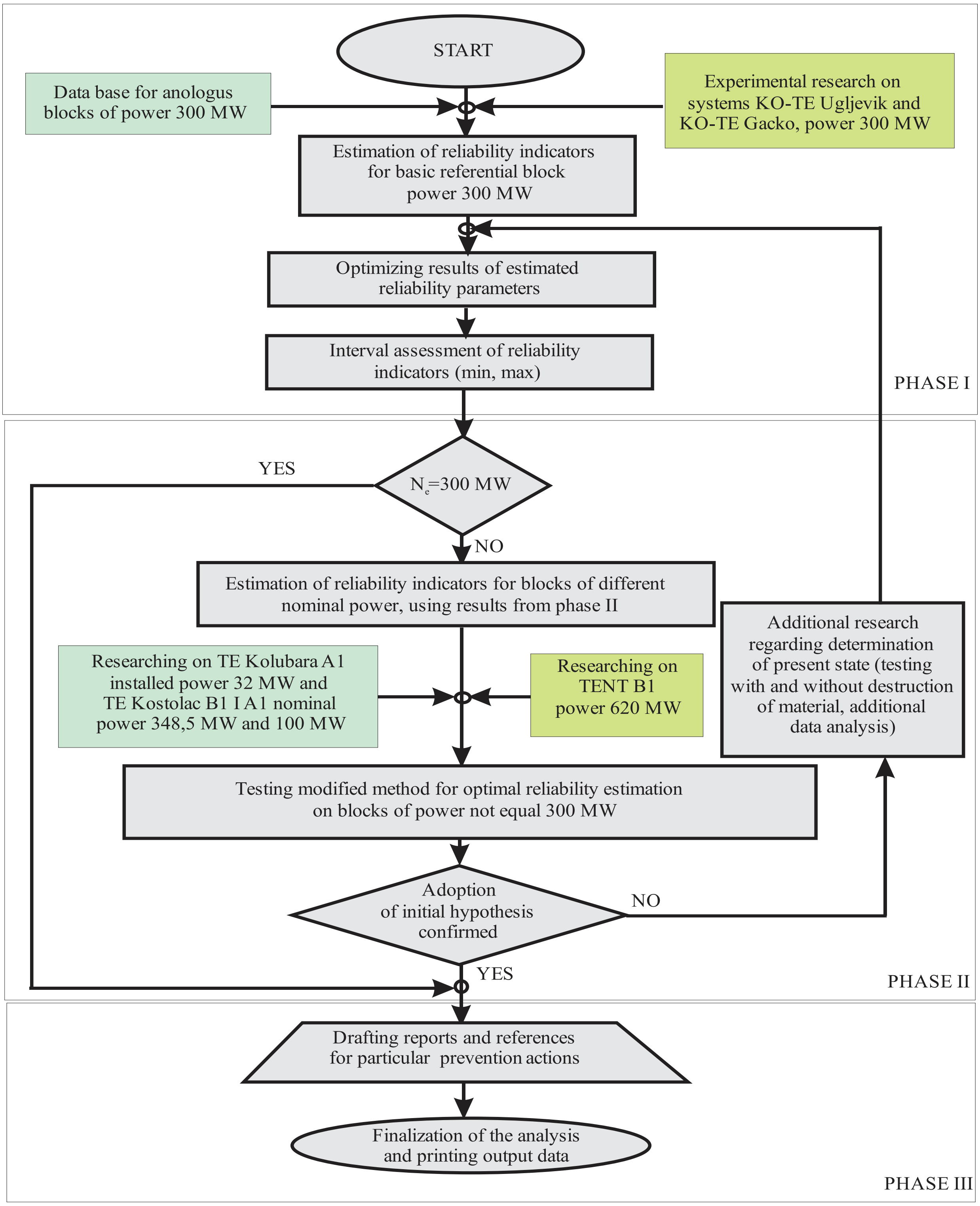

Figure 1. Block diagram of modified method for reliability evaluation of condensation thermal electric power plant

Table 1. TPM methods for the system assessment

Method	Description
Life Cycle Cost Analysis - LCCA	Determining costs of a lifetime cycle of the process, high costs share, ratios "cause-consequence", domain of the risk and identification of domains for improvement (decreasing) of the costs.
Reliability and maintainability prediction / estimation	Evaluation of the system (product) of process (element) by means of: operating duration between malfunctions, time duration between maintenance, time factor in malfunction, hours of maintenance by hour in use.
Failure Modes, Effects and Criticalit Analysis - FMECA	Identification of potential failure of the system and/or process, manner and cause of the failure, frequency and rate of criticality towards consumers
Maintenance Task Analysis - MTA	Evaluation of functions/tasks of maintenance by time, number of stuff and level of training, demands for supporting: spare/repaired parts, corresponding inventory, tools and equipment for testing, possibility for transport and adoption, technical data, stuff training and computer software. Identification of domains of strong consumption of resources
Level of Repair Analysis - LORA	Evaluation of existing maintenance policy in form of level of the repair, respectively whether the component will be: repaired between maintenance activities, repaired on the level of suppliers' maintenance or rejected due to irreparable malfunction. Identification of policy where changes by means of improvement are possible.
Reliability - Centered Maintenance - RCM	Evaluation of system/process in respect to its life span in order to determine the best overall program for preventive and/or corrective maintenance. Establishing the program of preventive maintenance in order to decrease costs is based on information about reliability, i.e. identification of a failure, types and frequency of failures, rate of criticality and carrying out.
Maintenance Data Collection, Analysis and Corrective - Action System- MDCAS	Evaluation of system (product) of process by constant collecting and analysing the data through involving of tracing changes in order to carry out corrective actions and/or for needs of decisions improvement. Ensuring sources of data for constant improvement.

The obtained value after the correction is defined as higher (upper) maximal value of the interval evaluation of the basic referential block reliability characteristics. The prognostic evaluation form (short-term prognosis), cross-section of the current condition (long term prognosis) have also been taken in consideration. The results of the research conducted for the essential configurations of the Ugljevik and Gacko thermal electric power plant systems on solid fuel, of 300 MW nominal referential power, have served as the starting date base. Because of the specific system operation of the Ugljevik thermal electric power plant, the initial problems with cindering and a longer period of break due to the imminent military action in the vicinity of the plant during the war, as well as frequent unstable system operation of the Gacko thermal electric power plant and the problems connected with the deviations between the projected and actual fuel quality, the obtained results have served as a good ground for displaying the lower (underneath) minimal value of the interval evaluation of the basic referential block reliability characteristics. Any change of the project-prognostic conditions also requires additional consideration of other forms of information sources mostly from lower hierarchical stages and with higher level of detailing the facilities and processes that take place within them. It is also necessary to complete the basic method of structural calculation of reliability indicators for the conditions of operational and non operational capacities with adequate supplementary correctional factors. Because of the presence of conditions resulting from the random processes effects (mostly of non stationary character) and also due to the difficulties in establishing the correlative connections when there are data limitations the two-step system of corrections is most frequently used in practice:

■ Creating of the reliability characteristics change dependency on the basis of the existing data of adequate statistic analysis, the expert evaluations and prognosis, the interval assessments of the mean and limit values and the prognosis of a possible behaviour trend of the dependencies and reciprocal relations, with simplified graphic interpolations according to the mean and final values, with their further supplementing and corrections;

■ By applying the analogous combined approach at the second step the direct relations will be determined, or the differences and dynamic corrections, and with respect to the adopted classification according to the nominal power, with the carrying out of corresponding statistic and graphic extrapolations and mutual linking of the project reliability indicators for the thermal electric power plant system which was considered.

■ Such an approach is convenient for all kinds of corrections and accuracy improvements, test-examinations and decision making at variable potential solutions at the stage of elaboration and projecting or for the possible evaluations of particular effects. The concept defined in this form can be used for a series of orientational evaluations of the systemic characteristics impacts, such as unit power, a type of fuel which is burning, basic structural characteristics (mono block or double block structure, the position on a load graph of the electro energetic system basic or the variable regime, a number of facilities or aggregates in a series), the exploitation duration, basic constructive differences (a boiler with or without a drum, mono or double axis turbine, below or above-critical levels of the specific steam parameters, the presence or absence of intermediate overheating of steam, the location impact etc.). To provide a rapid and effective application of the above stated modified method, in relation to a referential block, on a wide range of energetic blocks, with differently installed nominal power, the position within the framework of the electro energetic system and the specific maintenance system, it is necessary to examine adequate possibilities of taking into consideration certain reserves and analyse their potential effect with respect to the outgoing results of the analysis according to this method. Starting from the assumption that the reliability securing manners at the different stages of lifetime can be provide through the taking of the certain reserves forms, with the elimination of all other superfluous parameters, both for the basic and the prolonged operating life, their most frequent representatives have been stated as follows: the functional reserve form, load reserve, time reserve, the reliability dependence assessment of the facility on adopted repair programs and repair contents and the thermal electric power plant reliability, security and duration assessments with taking part of the technological and information form of reserve.

Optimal control of the thermal electric power plant system has to be based on the assessment and complex optimization of the reliability indicators in dependence of the ways for their providing and of the hierarchical level of the system detailing in its entirety, as well as of the lifetime phase of the facility. For those reasons the optimization process includes the essential structure, parameters and construction solutions connected with the thermal electric power plant system through the transformation of its major characteristics: energetic effectiveness, maneuvering capacity, reliability in general.

The optimization goals domain is finalized in the total selection of the criteria and reliability characteristics and possible ways for providing them, and with respect to already adopted rules related to a higher hierarchical level – electro energetic system. Accordingly, the realization of reliability indicators optimization process goes along in one of the two following ways: the direct way of securing the facility's reliability, with its reliability maximization level at the specified maximally permitted costs level concerning the facility, and the indirect way, based on the costs minimization at the specified minimally permitted reliability level. If a system is considered whose nominal power differs from the referential one, it is necessary to carry out certain recalculations of the obtained reliability characteristics of the referential block. For those reasons the proposed activities course diagram is modified (Figure 1 phase II). By means of the mathematical statistics standard methods, as well as the Total Productive Maintenance (TPM), relative dependencies of the system parameters, with and without the most critical component operation, have been obtained for the previously defined reliability indicators. The criteria for the selection of the most critical component operation in the thermal power plant system were earlier formulated taking into account the specific working conditions of the sophisticated thermal electric power plant complex within the framework of the electro energetic system. As to the other thermal electric power plant facilities whose nominal power is different from 300 MW, it is necessary to carry out the reliability indicators recalculations according to the following empirical relationship

$$C_A = \left(\frac{A}{300}\right)^m \cdot B_{300} \ . \qquad (1)$$

The obtained values for the reliability indicators represent their calculated evaluations. In this connection, for the purpose of simplification, the data given in a diagram form of analogous facilities can be used in the first iteration. By further iterative process the obtained values accuracy is improved to a certain, in advance defined, accuracy level.

At the next stage specific corrections are carried out in relation to: the taking part of functional reservation, then taking part of load reservation, taking part of time reservation and so on. The evaluation of reliability indicators dependency is also given in relation to the repair programs, and the very repair cycles contents. On the level of elaboration and projecting, the previous calculation comparisons of mono and double block structure are additionally carried out, as well as of the selection parameters of operating reserves, fuel and heat carrier. In the case of obtaining bad results for some of the reliability characteristics it is necessary to conduct additional research which, most frequently, include the examinations with and without destroying the material, and also the additional analysis of the data connected with the exploitation of the observed system or its analogues. The procedure being of iterative character breaks off after confirming of an initial hypothesis connected with the accordance of the prognosis results and actual exploitation data.

Figure 1 Phase III encompasses the time planning elaboration of specific activities aiming to achieve a higher reliability level, by using some of the standard methods (a net plan method - Program Evaluation and Review Technique or PERT, Gantt diagram or linear chart-graph and so forth). As the possible criteria for the selection and formulating mathematical model contents and calculation methods of the thermal electric power plant reliability system in the course of life cycle, depending on the choice of its principled scheme, the construction variant and parameters, the manner and character of the reserves envisaging, the repair and technical maintenance system, diagnostics and protection, will appear as follows: the relation forms in connection with reliability, the operation regimes of the basic and auxiliary equipment, as well as other conditions defining the ways of reliability securing of the facilities in their entirety and of the constituent parts, the processing procedure of operating and non operating activities conditions of the elements and the system as a whole, their mutual linking and possible forms of presenting their change in time; the defining of criteria, the basic and supplementary reliability indicators for resolving the optimization tasks per elements and of the thermal electric power plant system as a whole; the defining of limitations and additional conditions with respect to the tasks for optimal reliability evaluation, as well as the additional conditions, the specified quota or possible forms of their representing; the scope and characteristic of initial information (parameters), with the assessment of their completeness, a form of representing, the accuracy etc.; the applicability of the current programs of using computer techniques, the volume, periodicity, evaluation speed and limitations of the existing methods.

4. Results

On the basis of the obtained and processed data concerning the exploitation of the Ugljevik thermal electric power plant system and partially of the Gacko thermal electric power plant, of 300 MW referential power, referential power 300 MW, empirical dependencies of the reliability characteristics have been established for the operation state, which served as the starting initial iteration for further improvement of the output accuracy. The complex or single reliability indicators of the thermal electric power plant system in the most general form can be given in a form of extrapolation prognostic medium values and their potential dispersion, with a change tendency according to time. In Figures 2 – 7 a presentation of averaged values for the reliability parameters of the thermal electric power plant system of 300 MW power has been given, while a little more detailed presentations of the intensity course of boiler facility failure for the mono block structure of identical power are given for the case when brown coal is used as a fuel.

5. Discussion

The research related to the proposed modified method has given some relatively new results. With the aim to meeting the basic requirement in the thermal electric power plant exploitation in terms of continuity in the electric energy generation and the reliability and safety in work, and because of reducing the large consumption of material, the time, the staff and the funds for their investigation and maintenance on a proper level, the criteria have been formulated for the quantity description of the characteristics concerning the disturbances of the capacity for work of the thermal electric power plant condition and established efficiency within the framework of the electro energetic system. The basic and supplementary reliability indicators of the facility as a whole have also been specified, as well as the indicators of their constituent parts on the first hierarchical level of dividing into sections. By using a combination of competitive engineering method and classical statistical methods for determining the malfunction probability the frequency and their duration, used in the analysis of security and reliability of complex mechanical systems, the synthesis of all the investigations so far has been carried out related to an early foreseeing of hidden defects and the thermal electric power plant system reliability level increase. The result of this synthesis is represented by algorithms of the modified method for the reliability evaluation of thermal electric power plant referential system and its modification with the aim of encompassing the thermal electric power of the rest of nominal powers. Because of the exceptional complexity and a large number of constituent components of the thermal electric power plant system a methodology of ranking has been established concerning the most critical facility with respect to the possibility of a failure emerging and its potential effects on the environment and economy of the facility operation. The main technological system (the boiler, turbine and generator facilities) or the boiler plant, as its most sensitive element, has been defined as such. This analysis correctness is also confirmed by another basic element in the system of gathering data on technological systems reliability, through the FMEA/FMECA subsystem. The FMEA/FMECA procedure has been carried out with the boiler facility and terminated by the elements ranking according to the critical stage degree of a particular element failure (e.g. the piping system). In case of lacking the data about the single element failure intensity, the assigning of a scale of values has been suggested for which, through the statistical modelling procedure, the corresponding probabilities of appearance will be established. A special emphasis has been given to the defining of structure and preparing the date base for the case when there exist the data for the *"zero"* state, as well as for the case of necessity of defining a methodology for the parameters establishment for evaluation of the remaining components operational life for which there are no adequate statistical data and no *"zero"* state of an object has been precisely established.

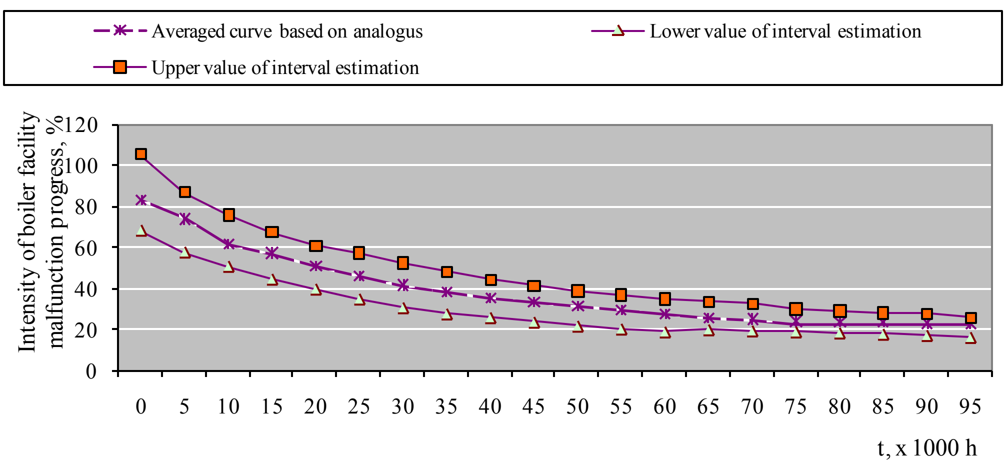

Figure 2. Graphical representation of reliability and unreliability function of the thermal electric power plant referential block of 300 MW power in its entirety

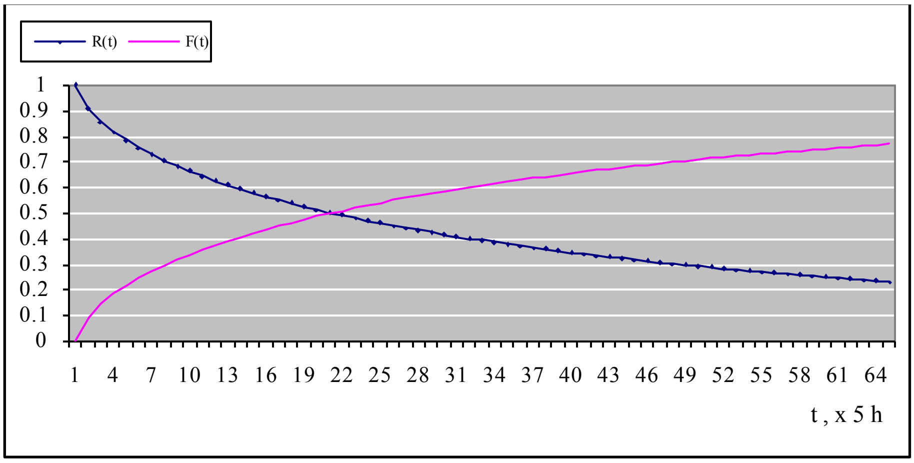

Figure 3. Graphical representation of the function of intensity and density of referential block failure in entirety of power 300 MW, for time-picture of state in labour

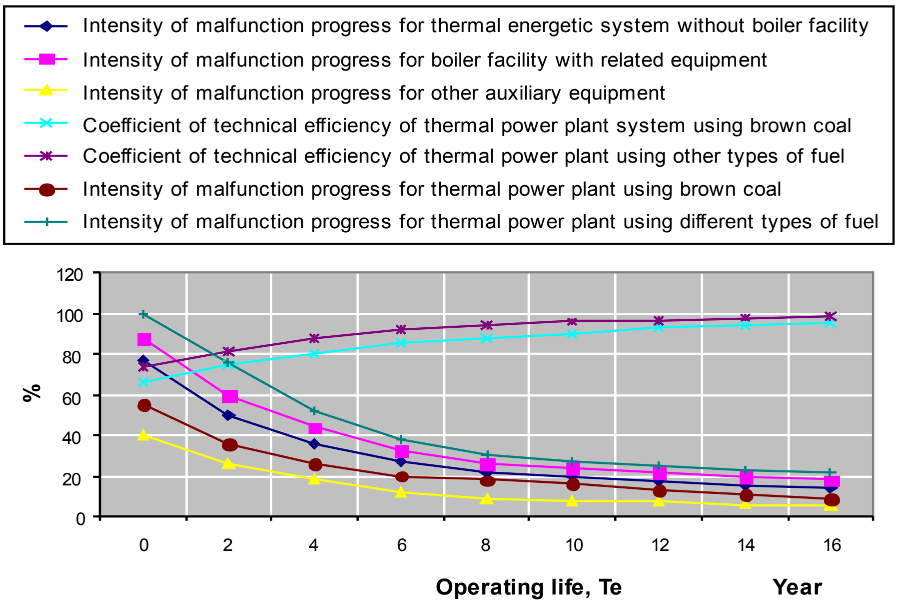

Figure 4. Graphical representation of starting values for some of the reliability indicators of the referential thermal power plant system and their change in time,[2]

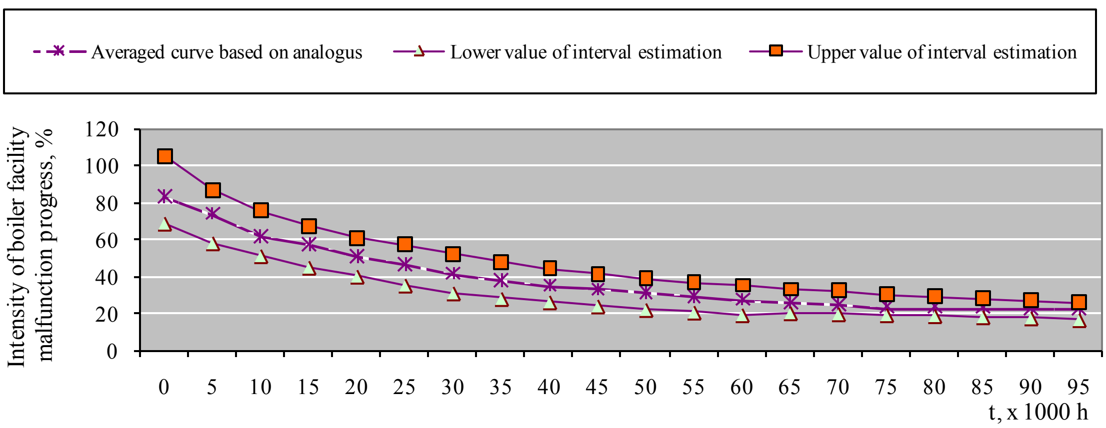

Figure 5. Prognostic assessments of relative intensity of malfunction progress for boiler facility (mono-block structure) for referential block of 300 MW

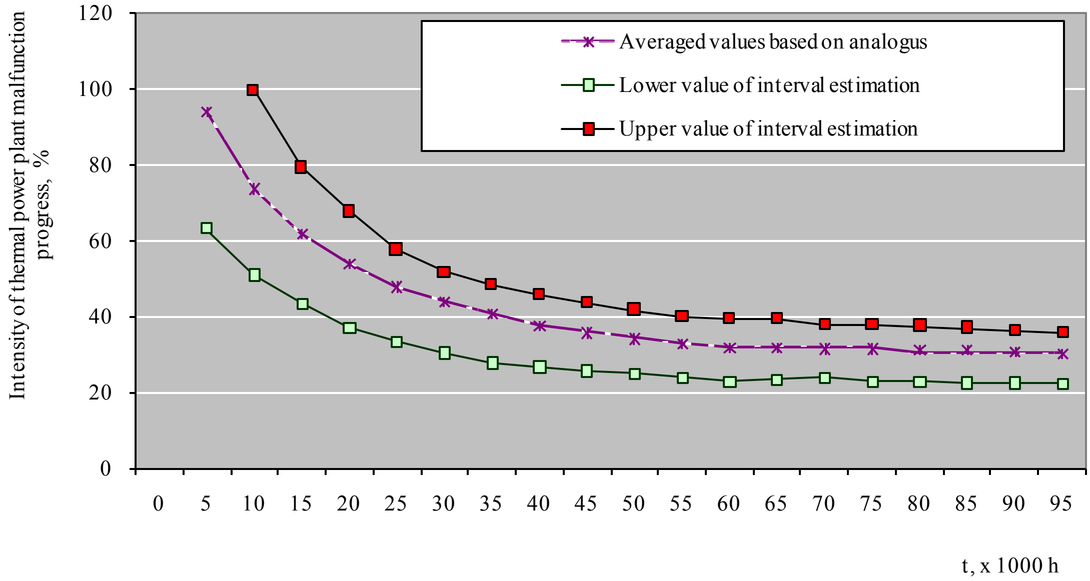

Figure 6. Prognostic assessments of relative intensity of malfunction progress for referential block of 300 MW, using coal as a fuel (mono-block structure)

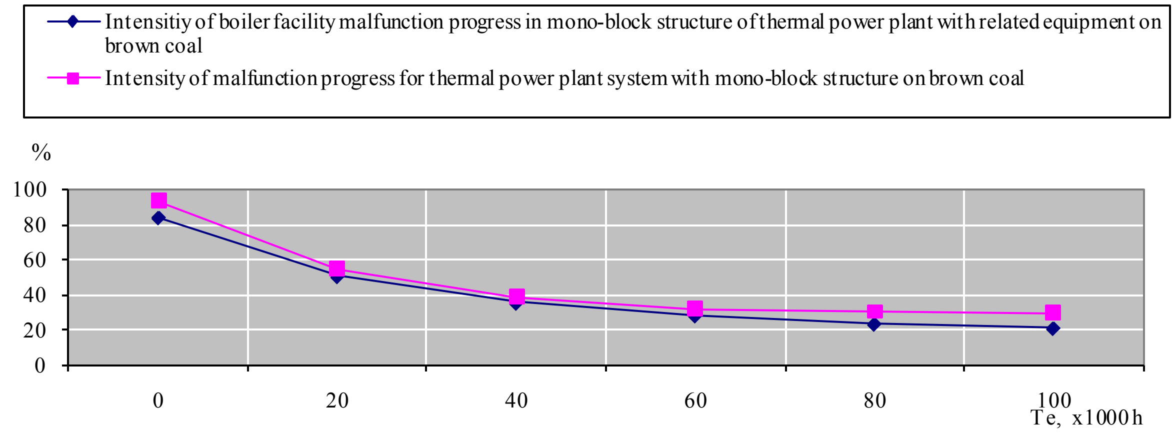

Figure 7. Graphical representation of intensity of malfunction progress of referential thermal power plant system without boiler facility

Starting from the lifetime engineering principle, and also from the preventive engineering requirement, a detailed analysis of the system reliability and disposability has been given at all stages of the thermal electric power plant lifetime, beginning with the elaboration and projecting, through the revitalization and reconstruction with modernization (extended exploitation lifetime), until the withdrawal of a facility from exploitation. In any case, for this purpose a broad spectrum of information was necessary because of their approximation with respect to the referential block.

On the assumption that the introduction of technical control has been carried out concerning the condition and failure diagnostics within the thermal electric power plant system and that a corresponding date base was created for the foreseen information system, with supporting consideration of all specific qualities related to the work and exploitation of the system and the critical analysis results of all proposed methods according to the facility lifetime stages, a set of a priori information has been established on the basis of analogues which has a specific place in the elaboration and projecting phase, and can also be used in the exploitation process of older energetic facilities for which no initial "zero" state was established.

Taking as a starting point the significance of effective experimental investigations procedures, possible approaches have been theoretically explained to their development for the reliability evaluation of the thermal electric power plant system, and in terms of shortening the length of research, reducing the pattern size by the selection and analysis of a representative (the most critical facility or element in dependency of the required evaluation accuracy) and the level increase of the procedures automatization for registering failures of – "on line" technological systems.

The analysis has been made of potential effects of carrying out the reliability and disposability analysis through the possible application in the reengineering process of relatively new concept of control over the thermal electric power plant system maintenance projects, as well as of possible modernization procedure, reconstruction and revitalization of the facility after the expiry of the "basic" operating life. This specifically concerns the possible improvements on the parts of processes connected with the most critical facility, and thereby indirectly on the process in its entirety. Such an approach should, and it can ensure the realization of an adequate level of required disposability or readiness, as well as the reduction of costs which would be entailed by stoppages due to expecting the maintenance tasks in the thermal electric power plant system to be performed. This includes carrying out of "automatization" of the course of work, with minimal stoppages and the labour force equipped with necessary technique, knowledge and with the means for speeding up the necessary revision of jobs which they perform (redesigning of the space which is occupied by the most critical facility partly or in its entirety, supplying the thermal electric power plant system with fuel and other operational media, planning and supplying the facility with spare parts in due time, purification of the discharge gases, slag and cinder discharge, coordination of activities connected with the maintenance in dependency with the encompassed level and volume of the maintenance aiming to reduce the total time for the maintenance, the maintenance process re-engineering in relation to the necessary conditions and the availability factor and also the hierarchical connection of particular components, the maintenance process re-engineering in relation to the mean time of stoppage because of preventive and corrective maintenance and performing of the internal control process). It is necessary to critically consider each of the above stated activity from the aspect of the costs which were involved with it.

For the evaluation of optimal reliability of thermal electric power plants of all powers the original algorithms have been given, in the terms of which is also the original formula for re-calculation from the referential system to the observed one. The Formula (1) is unified and typified into two variables: the nominal power N_x and the exponent determined as interval (m_{min}, m_{max}) for all classification groups, and in dependency with the specificity of the macro region in which the observed facility is located (electro-energetic system of the Republic of Srpska, the former SFR Yugoslavia, the area of the former SSSR, the USA, Europe and other countries). The corrective coefficients for the specific deviations have been partly determined of both the conditions and the operating regime of the thermal electric power plant within the framework of the electro energetic system, and from the aspect of previously counted reserve forms, repair programs contents and their plans,[1]. The reliability evaluations, for the worst case verification (the TE Kostolac B1 system), obtained in that way are about 80% agreeable with actual exploitation conditions. Further accuracy increase of the method will require additional research relating to the work of particular groups of blocks on the basis of the referential power, with the aim to defining the accords of the foreseen solutions with actual conditions of the facility work.

On the basis of the adopted criteria and indicators for the reliability evaluation and the considered and suggested algorithms have been created on the ground of which, besides the efficient use of computer technique and classical program packages, in a short time the basic reliability evaluation can made in practice through the required accuracy and iterative accuracy increase until the required level, and with the aim of taking corrective actions, additional experimental laboratory analysis or continuation of reliable exploitation.

The suggested algorithm is easily to be transferred from the referential block to any other one, by means of very simple and unified expressions (necessary the knowledge of the block nominal power, corrective coefficients given in tables and the facility location). The developed method has been tested and verified on relatively stable facility of the TENT B1 block of relatively high power, on exceptionally unstable facility TE Kostolac B1 of medium power and the TE Kolubara A1 of small power and with alternating annual periods of stable and unstable work. The results have also been confirmed in the analysis which was carried out for the period after the first half of the year 2001,[3].

6. Conclusions

The methods which so far have been applied in the thermal electric power plant systems prognosis and reliability evaluation were based on general methods of elementary reliability assessment developed in the framework of the theory of reliability on the basis of the application of statistical and probability calculations concerning the strength, with their simultaneously leaning on the current methods determinative projecting- constructive calculations of elements, subsystems and systems. The issue of creating a basic reliability evaluation method for the 300 MW power referential block is based on co-ordination of particular specialist analysis in the framework of one complex algorithm with certain probability interpretation with the aim of reaching a prognostic reliability assessment, and later also its optimization on the basis of a selected criterion. The above stated conclusions lead to the possibility of synthesis of the given methods through a specific course of activities diagram for the entire lifetime of a facility and speeding up the process of giving prognostic assessments through generalizing the obtained results of the previously defined most critical facility (or its elements) on the system as a whole. To ensure that such an activity be realized it was necessary, before that, to create an adequate date base for 300 MW power referential block. Thereby, it is also important to point out the necessity of a precise defining of the initial, the so-called "zero" state of elements in the thermal electric power plant system, which coincides with the delivery time of the steam block to the consumer and its transfer to regular exploitation (end of guarantee testing). In case of analysing an older thermal energetic facility for which no "zero" state exists, the evaluation of indispensable reliability indicators is founded on the date base created by means of the specific methodology.

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