

## CONDITIONINGS OF MODELING OF ELECTRICAL DEVICES EXPLOITATION AND DIAGNOSTICS STRATEGIES

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**Abstract** Paper presents conditionings of exploitation diagnostics strategies of devices modeling of electro energetic distribution networks example. Management processes of technical infrastructure are described in exploitation theory and product's quality evaluation of installations, machines and devices, which concerns synthesis, analyzes and exploitation system researches, in particular problems of their utilization and technical services. There are presented reliability models of exploitation are interrelated with user's safety and device's quality parameters. Conditionings of existing types of exploitation strategies selection have been discussed in regard to high voltage electrical devices (transformers). As conclusion of thesis proposal of optimal selection of exploitation and diagnostic's strategy based on reliability strategy in compliance with technical status quo based service have been elaborated.

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## 1. INTRODUCTION

Manufacturing processes economy and effectiveness are important elements of enterprises' management. Modelling and manufacturing processes analyzes and taken production strategies up serve optimization of product's production costs, competitive advantage source of enterprises and in final market competitiveness of offered products. For consumer article has determined relative value in use, continued proportion to its quality and reliability and efficient customer service with reasonable prize.

Capital assets management's processes are described in exploitation and quality assurances theory concerning machines and devices. This theory is involved in synthesis, analyzes and exploitation system researches, specifically in servicing and support services processes. By her recommendation use in practice exploitation strategy rely on ways of conducting service and maintenance processes and relations between them according to chosen criterions and final after analyzing them designing application's paradigms. Mentioned above elements are important on energy market, which market regulations where the subject of Energy law edited in 1997. Electric and heat power are commodity, which come under specific requirements of partial price control by President of Energetic Regulation Authority and cost's conditionings of motion preservation of well-developed technical infrastructure. In energetic system this infrastructure is capital asset with very high value and technical condition of high-tension electricity transmissions and distribution networks is a determinant of supply energy with sufficient quality defined in Ministry ordinance (enclosed standards) and in individual trade agreements between suppliers and receivers for energy trade. Main operators of energy market (PSE) are responsible for proper maintenance of existing transmission and distribution networks and building new ones with high investment values and cost of launching.

That's why the key issue is maximal utilization of owned capital assets by taking adequate exploitation strategies and running wide open devices and energetic networks diagnostics to achieve mineralization costs of investment with fulfilling required reliability of energy supply. It's regarding particularly electro energetic networks with their devices, f.e. high voltage transformers located both in Main Supply Centres' and in larger industrial enterprises.

## 2. METHODS OF RELIABILITY OF MACHINERY AND ELECTRIC DEVICES DURING EXPLOITATION ASSURANCE

So far applied meaning of reliability in view of new documents are transformed and often need implementation of new denotations in aspect of definitions and terms applied in area of product's quality and reliability (Managing to Achieve Quality and Reliability).

Necessity of importance their systematic approach (not only as a technical/engineering work) is proven by fact that 85% of product's quality and reliability problems proceed from improper management or systemic organizational faults, since existing systemic connections between quality and reliability especially during product's exploitation. Enterprise' losing due to low level of product's quality and reliability can adjust 20-50% of incomings, so question of product's quality and reliability should be his strategic priority (Dwiliński, 2005).

Gather that product's quality is resultant of producer and his suppliers, competitors and customer activities with important factors as (Węgrzyn, 2006, p.60):

- provider standard and customer's requirement enclosed in order documentation,
- technological manufacturing processes based on know-how (technological frame and workshop instructions,
- execution terms including quality, safety of workers and environment included in Integrated Management System' organizational procedures and instructions,
- fulfilling of law ordinances recommendations – responsibility, guarantees, and service.

Delivery trials and exploitation's periodical tests, proper technical product's parameters – execution included in design construction drawings and technical specifications accepted initially by buyer.

Feigenbaum's definition terms „Quality as complex characteristics of make and service, with marketing, design, performance and maintenance consideration, which lead to that product and maker's servicing fulfilling customer's expectations”. Product's reliability is defined as his ability to meet one or more desirable functions in determined conditions and time range – by Working Group W6 13-06 CIGRE. Yardstick of technical devices reliability is probability to proper performance of involved functions.

In concept of reliability we can feature critical properties (Maksymiuk & Pochanke, 2001):

- expected possession value of product,
- preserving this value (property) in adjusted range of work (range of executed work),
- reference this property to kind of performed tasks executed by subject devices and to circumstances of their fulfilment,
- expressing this value in probabilistic categories, that means probability of fulfilment this function after time.

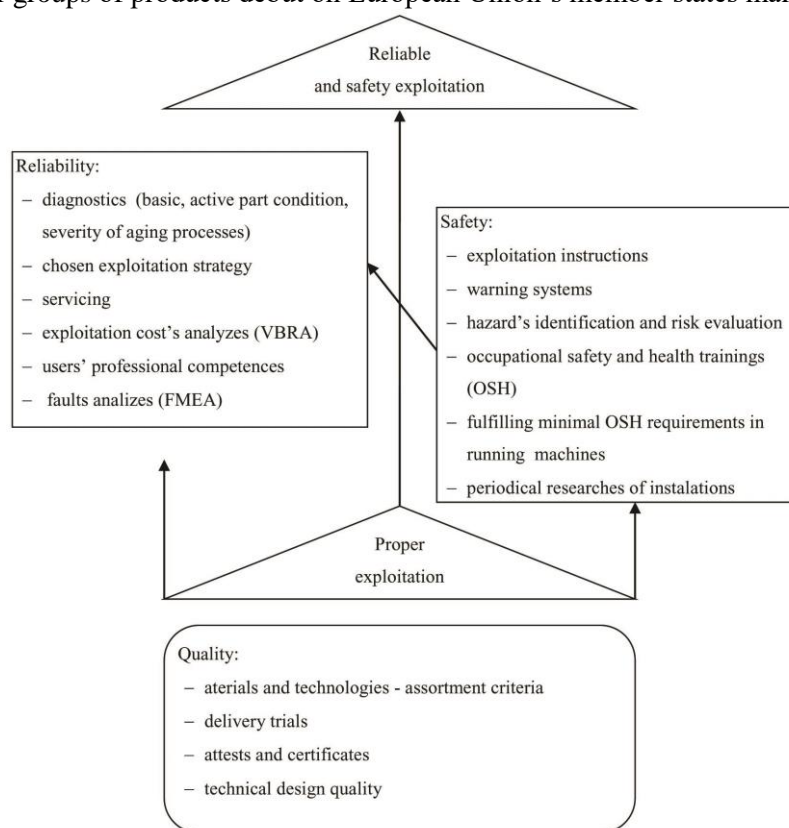
Concept of safety concerning machinery can be defined as „Realized quality, is stating, to which level of management, technical measures and system performance are not dangerous to human life, health and natural environment” – by prof. Kuo (Fellow of the Royal Institution of Naval Architects, UK).

Safety entails close with concepts (OECD, 1991):

- hazard – as property of substance, factor, energy source or situation, which have potential ability to cause flip sides and
- risk as a category showing links between implications and occur probabilities.

In cause and effect chain of accident important role plays human factor in form of personal competences and abilities with product, his software, documentation, ergonomics, and production culture – target is: effective execution of work and device or installation use.cji (OECD, 1991).

Electrical devices safety exploitation is the basic criteria, which should be positively fulfilled in view of fire and shock protection. According to UE directives, as a minimal, accepted standard of product's safety usage is marking CE (Certificate European) – specified OHS' requirements are included in detailed harmonized standards for groups of products debut on European Union's member states markets.



**Fig. 1** Model of performance of reliability and safety during electro-mechanical devices exploitation based on (Węgrzyn, 2013, p.19)

Between these elements are critical dependents which determine reliable machinery and electromechanical systems exploitation. Figure 1 shows determinants

of reliable and safety exploitation of electromechanical devices implementation in aspect keeping in motion (continuous power supply) implementation on high voltage transformers example.

Reliable and safety electric al devices exploitation, especially high voltage transformers (above 1kV) are determined by their quality accomplished on designing and manufacturing stage by proper assortment criteria materials and technologies, results of delivery trials, attests and certificates and technical design quality. Positive results of delivery tests is a basis for enterprise director taking decision of launching installation or devices into exploitation, production processes, where these elements plays important technological role.

Conditions of safety exploitation have critical impact on devices exploitation reliability by contents (reliability criteria) included in OSH exploitation instructions and results of periodical tests (examinations and surveys), especially guarantee effective shock and fire protection. Results and conclusions of these analyzes have impact on enterprise director about complex refitting execution or device's recall from z exploitation.

Reliability parameters, being results of product's assured quality and safety usage fulfils conditionings of economic exploitation effectiveness. Taken exploitation strategy and exploitation costs analyzes based on statistics and costs of failure clearing are basis for design solutions evaluation and technically-economic premises – their subsystem decomposition and modifications – in view of their high exploitation reliability achievement.

Product is designed to estimated usage and exploitation conditions. Typical user often cannot precisely define in which working conditions device is or will be used and which functional parameters of devices are critical for safety and reliable exploitation.

This question has two aspects: (1) insufficient knowledge of user, who operates machine in improper and unplanned working conditions – even doesn't know about it, (2) insufficient professional designers or technologists skills, who design device to working condition which can occur episodically.

Taking in consideration these elements in connection with product and his usage by consumer is critical for choosing by enterprises' exploitation strategy and keeping in motion technological production devices and their reliability in aspect of quality and continuous electro energetic power supply.

### **3. CONDITIONINGS OF HIGH VOLTAGE DEVICES EXPLOITATION STRATEGY SELECTION**

The way of thinking about keeping in motion functions in company is formed now by (Januszewski, Sagan, Szczucki & Świątek, 1999):

- intense changes in industry reliant on amount growth, diversity and level of complication of technical objects and automation and robotization manufacturing processes,
- new ways of work performance in keeping in motion of devices due to development of diagnostic technologies,
- new concepts of enterprises' management and organization, particularly quest to wrestling's management in favour to Just in Time (JiT) concept and philosophy and practices of Total Quality Management (TQM),
- rise costs of keeping in motion (maintenance) and in some industry branches (f.i. energetic) are even highest operational costs element (transmission and distribution fees), constant grow standards of occupational health and safety and natural environment,
- new orientation on connection between physical aging of devices and machinery and intensity failures.

As consistency of above mentioned changes is inception of new methods of machinery keeping in motion and maintenance. Classical approaches based mainly on surveys and repairs importance. Nowadays we take into consideration also:

- tools for decision support: risk evaluation, models of failures intensity and their effect's analyzes as well as expert's systems,
- new techniques of keeping in motion, f.i. technical state monitoring (diagnostics),

changes in thinking about managing and organization leading to participation and team work in connection to quality approach with quality management systems tools implementation.

Two essential concepts of keeping in motion should be pointed out:

- RCM (Reliability Centred Maintenance) – reliability strategy,
- TPM (Total Productive Maintenance) – integrated keeping in motion with production processes.

It is observed, that in practice, keeping in motion base on predictive (proactive) maintenance. To achieve this target we use preventive inspections, technical state monitoring with devices and installations operators also (simultaneously) in the field of maintenance. Power and distribution company, having in mind owned huge network's capital value, have implement in their strategy in critical manner course actions in capital asset's management. It comprises several issues, some most important are mentioned below: (1) keeping up capital asset's capital objects (appropriate support, maintenance, refurbishment and modernization), (2) capital assets utilization, (3) investment in capital assets, (4) decommissioning of tangible assets.

In subject bibliography machinery exploitation strategies are distinguished:

- preventive exploitation strategies,
- potential exploitation strategies,
- reliability strategy,

- strategy of effectiveness,
- planning and preventive strategy,
- mixed strategies (from technical-motion documentation),
- strategy by state (technical),
- strategy by utilization potential.

Basis for modern support services strategies is utilization's effectiveness strategy of machinery. Follow that they prefer exploitation with focus on technical state evaluation instead of meet very often Exchange after completion of failure-free period work. Virtually now we can meet four essential groups of strategies based on effectiveness (costs) criteria:

CM – Corrective Maintenance, in which repair, overhaul or replacement of device is forced by unexpected failure. This approach is usually taken, when cost of exchanging is slow and necessary spare parts are easily available or stored in magazine. Usually this kind of maintenance is provided when devices are low value or they are not playing critical small role in production system. In implication of these facts exploitation takes place with very limited range diagnostics researches and basic current maintenance are examinations.

TBM – Time Based Maintenance executed in fixed time periods and involved chosen devices, which are overhauled regularly or being replaced. This strategy was usually used in the past and nowadays is considered as noneconomic, because these devices are not fully exploited during their whole life time. Also practical experiences from exploitation indicates, that implementation of TBM maintenance is little effective from the point of view identification of precipitate process of technical state's degradation. In consequence we can observe increased failure rates caused by f.i. abnormal prediction of defect's development and too late decision about the date of general overhaul.

On special attention with reference to electro-mechanical devices – high voltage transformers, deserve reliability strategy in connection with accepted exploitation effectiveness' parameters, in form of two complementary models.

CBM (Condition Based Maintenance), in which scope and terms of services and diagnostics' tests depends of technical condition of device. In this exploitation are used approved, advanced diagnostics' instruments with current technical state monitoring in on-line mode. Due to their flexibility CBM service has high technical and economical efficiency. It needs high qualified exploitation personnel. Besides huge advantage of CBM is possibility for using to servicing devices, which are in critical technical condition (parameters exceeded alarm levels) or their range in technological system is predominant. In these cases it's necessary to prepare individual manual and implementation of technical state set of monitoring and diagnostics instruments. In CBM strategy decision about devices overhaul is taken according to its present technical state and not depends to earlier planned maintenances. That's why in power companies this strategy is progressively popular, because allows increasing efficiency of network capital management.

RCM (Reliability Based Maintenance), which major task is providing accepted devices' reliability. It is based on prediction of occurrence of failure or alarm condition. Due to this the fundament of decision process is advanced analyze of diagnostics exams, which permits calculation effects of presumptive failures on the basis of machinery and failures reasons specialized knowledge. Implemented sphere of RCM service (frequency of reviews and scope of diagnostics tests) results not only from devices technical state evaluation, but also takes into consideration its influence (range) for reliability of whole system activity. In tendency for power energy market's liberalization this aspect is the key cost parameter for strategy's selection, because supports more efficient capital assets management.

Choosing of adequate strategy usually is not ultimate decision. During exploitation depends of current, altering economical and technical conditions we can implement optimal strategy for selected devices. Showed on drawing 5 algorithm of device's service strategy selection proves that main criteria of choice should be its position in technological system. If this position is not significant, we prefer CM or CBM strategies. In this case determinant of choice is scope of diagnostics. If device's position in system is important then depending of scope of performer diagnostics exams we prefer TBM or RCM services.

Procedure of changing service strategy for selected device can be showed on unit, which technical condition is critical, but its work in technical system is very important. Selection of RCM service mode and implementing advanced on-line monitoring allows for continued devices existence. On the other hand after overhaul this device can be serviced f.e. in CBM system.

#### 4. CONCLUSION

Choosing of adequate strategy usually is not ultimate decision. During exploitation depends of current, altering economical and technical conditions we can implement optimal strategy for selected devices. Showed on drawing 2 algorithm of device's service strategy selection proves that main criteria of choice should be its position in technological system. If this position is not significant, we prefer CM or CBM strategies. In this case determinant of choice is scope of diagnostics. If device's position in system is important then depending of scope of performer diagnostics exams we prefer TBM or RCM services.

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Synergy effects in move maintenance field in enterprise are provided when there are integrated activities of servicemen (RCM) and users of machineries and devices (TPM). As the example of this conclusion in we can intimate implementation concept of integrated service and maintenance works in car industry, which gained even 50% increasing of technical availability of technological means of production (Jasiulewicz-Kaczmarek, 2005).

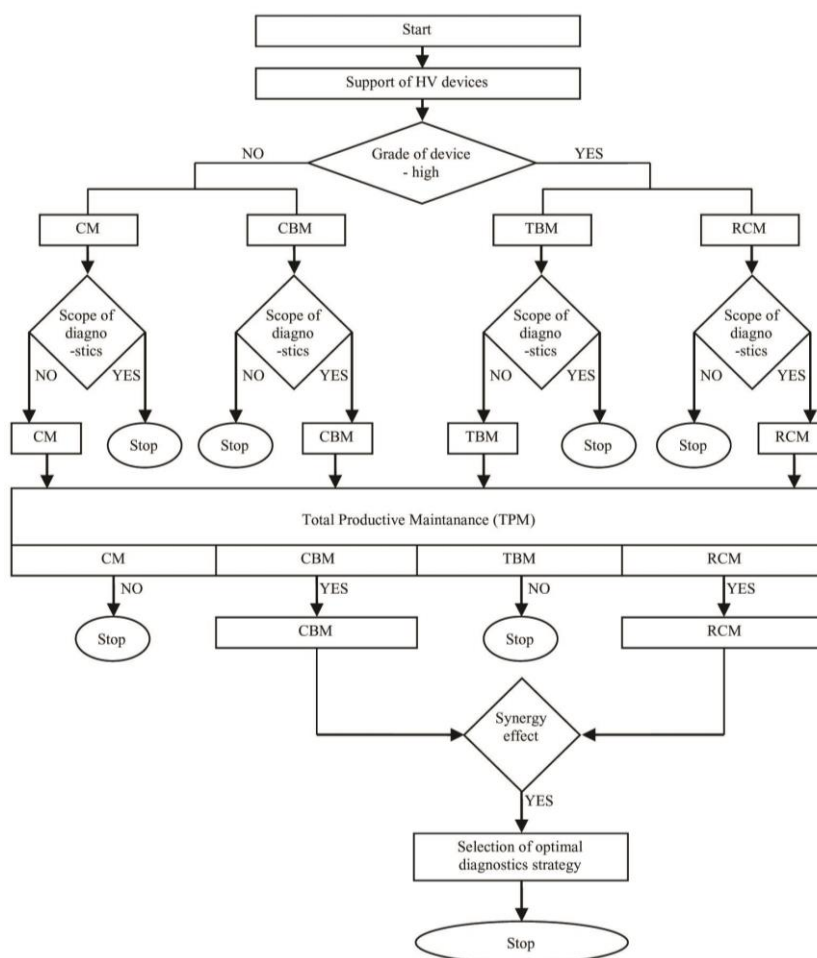


Fig. 2 Algorithm of maintenance high voltage electrical devices strategy selection

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## **BIOGRAPHICAL NOTES**

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