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Marginal Break Even Between Maintenance Strategies Alternatives

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This article describes the maintenance strategies, their costs and decision how to choose one or another strategy. Maintenance costs are one of the biggest costs categories in life cycle costing so it is very hard to estimate them. This costs category has some unique estimation characteristics; one of them is that maintenance costs are spent during a long period. So estimation of material, spare parts or direct labour costs is very difficult therefore maintenance costs calculation is based mostly on assumptions.

One of the maintenance classifications is based on maintenance strategies. The objective of any maintenance strategies is to minimize the total costs and maximize the asset operation time after setting preventive or corrective actions. Optimal decision is to pay attention to two main strategies – corrective and preventive maintenance. The purpose of corrective maintenance is to renew asset efficiency as soon as possible. Preventive maintenance is performed periodically before breakdown occurs.

Correct costs allocation has the main impact on deciding about the maintenance strategies. However, only a few companies pay attention to costing and cost effectiveness analysis. Maintenance cost planning ensures assets productivity, safety and profit maximization. Life cycle profit can be improved by reducing costs, improving ownership effectiveness and efficiency related to operations and management, as well as improving support. But minimizing the costs does not necessarily result in maximized profit. Production equipment operation, maintenance, and support planning need to be based on market dynamics. Opportunities for profit may be lost because of unavailability caused by badly planned preventive maintenance, unplanned corrective maintenance, as well as ineffectiveness in operations and maintenance strategy.

In order to choose which maintenance strategy shall be used marginal break even between maintenance strategies is calculated. The procedure is demonstrated according to one of the iteration methods - string method. The main aspect of this method is that the chosen interval should be isolating and it should meet all the requirements for isolating interval: 1. Function changes its sign in the interval; 2. The first derivative function does not change its sign in the interval; 3. The second derivative function does not change its sign in the interval. The calculation manifests that in the economical age 1.78 preventive maintenance costs are equal to corrective maintenance costs so it is worth to use preventive maintenance strategy starting from this point for Renault model vehicles.

Keywords*: life cycle costing, asset life cycle, preventive maintenance, corrective maintenance.*

Introduction

Maintenance process is one of the main activities in business companies (Pintelon et al., 2000). Maintenance process should keep assets in a desired operating condition in order to satisfy the primary process requirements (Cambell, 1998). The business goals of the maintenance process are:

- to increase primary process capability;
- to improve primary process performance, such as quality, profit, etc.
- to satisfy regulatory requirements, such as safety, hazards and environmental standards in a cost effective manner.

In order to achieve effective maintenance management, it is very important to understand the interrelationships between maintenance process and the primary process. These interrelationships are illustrated in Figure 1 (Kelly, 1998).

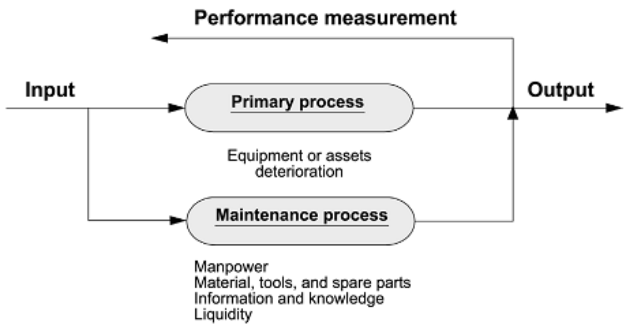

Figure 1. The interrelationships between the primary and maintenance process (Zhu et al. 2002)

Maintenance costs are one of the biggest costs categories in life cycle costing so it is very hard to estimate them. This costs category has some unique estimation characteristics; one of them is that maintenance costs are spent during a long period. So estimation of material, spare parts or direct labour costs is very difficult therefore maintenance costs calculation is based mostly on assumptions.

Variety of definitions of maintenance strategies is widely analyzed in scientific literature: Fox, 1966; Block, 1988; Nakagawa, 1988; Zhang, Jardine, 1998; Kevin, Penlesky, 1988; Sheu, 1991; Mann et al., 1995; Pham, Wang, 1996; Bevilaqua, Braglia 2000; Swanson, 2001; Grall et al., 2002; Jamali et al., 2005. Making the survey of maintenance strategies in scientific literature lots of classifications of maintenance strategies are found but Mirghani (2001) states that there are two main asset maintenance strategies: preventive maintenance and corrective maintenance.

A lot of accounting researchers analyzed maintenance costs accounting (Mann et al., 1995; Maillart, 1999; Zhu et al., 2002) but there is no scientific analysis made about the relation between different maintenance strategies in asset economic age and costs allocation techniques in it.

The research object: management of asset maintenance costs.

The research goal is to choose optimal maintenance strategy that helps to plan asset maintenance and minimize maintenance costs after the calculation of marginal break even between maintenance strategies alternatives.

Research methods. The following research methods were applied for the analysis of theoretical alternatives of maintenance strategies and costs: the comparative analysis of scientific literature which involves comparison and generalization of theoretical proposition.

Performing empirical research regression analysis, correlation analysis and simulation modeling have been applied presenting the results in tables and pictures.

The marginal break even between maintenance strategies alternatives was calculated by using MS Excel, Statistika, VisSim 5.0. program.

Scientific novelty and significance. Marginal break even between maintenance strategies alternatives has been employed in order to make management decision about asset‘s operation in production and service companies.

Maintenance strategies

One of the maintenance classifications is based on maintenance strategies (Dytczak et al., 2009). In the literature the definition of the “maintenance strategy” is either too narrow or too vague. The objective of any maintenance strategies is to minimize the total costs and maximize the asset operation time after setting preventive or corrective actions (Mann et al, 1995). Commonly reviewing maintenance strategies in scientific literature there is such classification of maintenance strategies: *corrective maintenance strategy, preventive maintenance strategy and running (or predictive) maintenance strategy*. Swanson (2001) explains three types of maintenance strategies: *reactive strategy, proactive strategy and aggressive strategy*.

Bevilaqua & Braglia (2000) consider each maintenance strategy as a separate strategy. Kevin & Penlesky (1988) consider maintenance strategy as a mix of elements, such as maintenance policies, backup equipment and equipment upgrades.

Pham & Wang (1996) suggest classifying maintenance depending on condition after maintenance activities:

✓ *Perfect maintenance*. After maintenance activities asset condition is “as good as new“;

✓ *Minimum maintenance*. The main parts of the assets are renewed but total asset condition is not changed – “as bad as old”;

✓ *Imperfect maintenance*. Maintenance activity is dedicated to renew asset condition to the same as it was before maintenance. So asset condition is between “as good as new“ and “as bad as old“;

✓ *Bad maintenance*. Maintenance activity does not improve asset condition therefore it is not changed.

So optimal decision would be to pay attention to two main strategies and that will simplify conception of maintenance strategies.

Mirghani (2001) states that asset maintenance can have two main strategies: planned and unplanned maintenance. According to Pham & Wang (1996), the purpose of corrective maintenance is to renew asset efficiency as soon as possible. Preventive maintenance is performed periodically before breakdown occurs.

There are lots of wrong opinions about preventive maintenance practice. One of them is that preventive maintenance is too expensive. In a logical way this approach says that regularly planned downtime and maintenance are too expensive, and normal expenses would let asset work till maintenance will be absolutely required. But we should talk not only about expenses but about long term benefit and savings because of preventive maintenance. Without preventive maintenance because of not planned breakdown, expenses of lost production time would appear. Company could also save because of a longer effective useful time of the asset.

Maintenance cost accounting

According to Mann (1995), when making maintenance a very important task is cost accounting and its minimization, i.e. level of the asset‘s (Domeika, 2008) losses shall be measured (Boguslauskas & Kvedaraviciene, 2009) and/or quality of the asset shall be restored.

Mirghani (2001) agrees that correct costs allocation has the main impact on deciding about the maintenance strategies. He accents the meaning of effectiveness of cost allocation. But only a few companies pay attention to costing and cost effectiveness analysis (Strumickas et al. 2009). So Mirghani (2003) suggests this costing structure:

- Introduction to business organization that its success is heavily dependent on in-house preventive maintenance in operations.
- Argument that the existing costing system of preventive management and analysis gain familiarity in the business organization. This is achieved by a ‘walk-through” the system to understand its documentary cycle and information support.
- Compare the existing preventive maintenance costing system with the proposed costing framework and identify the gaps between the two.
- Make recommendation that would enable the organization under study improve its preventive management costing practices, identify critical implementation issued of the proposed costing framework.

Maillart (1999) models the best maintenance strategy but the control of the asset conditions is as a priority when looking at deprecation variation through the asset life cycle in order to estimate deprecation level as right as possible.

The best maintenance strategy has to balance costs and benefit in asset breakdown process based probability theory (Zavadskas, 2008). The control (Ciegis et al., 2009) of asset condition helps to estimate the depreciation level more precisely than it is done by the common statistical information.

Louit & Knights (2001) make an assumption that maintenance cost planning is very important in the strategy of maintenance costs management in the company. Maintenance cost planning ensures assets productivity, safety and profit maximization. Poor technical supervision raises not only unplanned breakdowns but it exceeds operation costs and makes danger for employee's safety.

Zhu et al. (2002) analyze the problem of costs minimization as one of the most important parts in maintenance strategy. According to them asset acquisition costs are lower than ownership costs due to asset physical deprecation and life cycle costs. The type of the asset determines ownership costs during the whole life cycle and can differ 10 or even 100 times from acquisition costs.

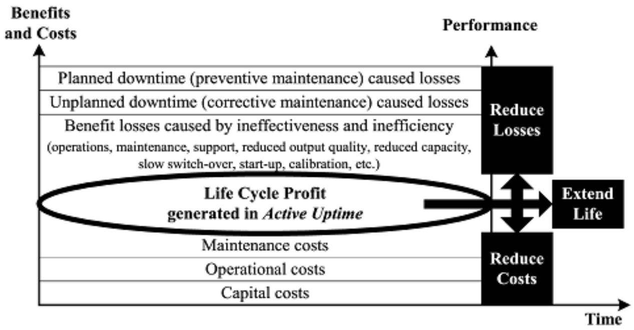

Figure 2. Possibilities in asset life cycle (adapted from Ahlmann, 1984)

In Figure 2 life cycle benefits and costs are shown in a time perspective. Life cycle profit can be improved by reducing costs, by improving ownership effectiveness and efficiency related to operations and management, and by improving support (Kaklauskas et al., 2009). One needs to keep in mind that minimizing the costs does not necessarily result in maximized profit (Burinskiene, 2009). Production equipment operation, maintenance, and support planning need to be based on market dynamics. Opportunities for profit may be lost because of unavailability caused by badly planned preventive maintenance, unplanned corrective maintenance, as well as ineffectiveness in operations and maintenance strategy (Gokiene, 2009).

Assessment of marginal breaks even between maintenance strategies alternatives

The maintenance of vehicles (Zvireliene et al., 2009) has significant impact on supply, quality and costs. By using optimal maintenance strategy business company can increase its potential, competence (Valanciene, Gimzauskiene, 2009) and is able to supply the undertakings successfully (Zinkeviciute, 2007). Maintenance activity, using preventive planned and unplanned actions keeps asset‘s condition in acceptable level, decrease undesirable risk, secure asset‘s reliability, decrease costs and not earned income.

The marginal break even between maintenance strategies means economical age when it is better to use preventive maintenance strategy in order to minimize maintenance costs.

The break even was calculated with the help of one iteration solution method – string method (Lapasinskaitė & Boguslauskas, 2005, 2006) and will be equal to the point where the curve $y = 160.09 \cdot \ln(x) + 1081.50$ breaks the curve $y = 894.66 \cdot e^{0.1526x}$. The equation $160.09 \cdot \ln(x) + 1081.50 = 894.66 \cdot e^{0.1526x}$ is changed to two functions:

$$g(x) \rightarrow 0.18 \cdot \ln(x) + 1.21\,;\quad h(x) \rightarrow e^{0.1526x}$$

The graphs of the given are drawn. The interval [1; 2] is chosen where one function breaks the over function (see Figure 3).

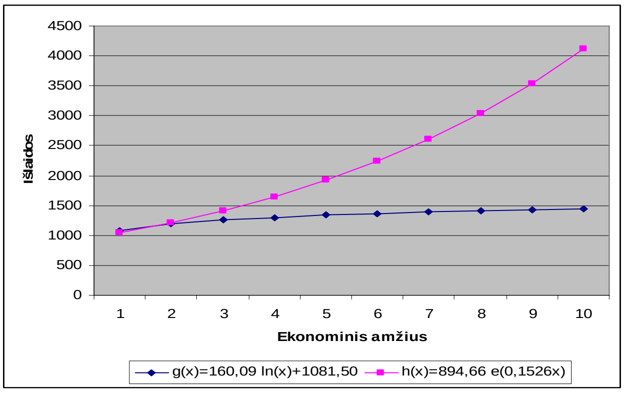

Figure 3. Functions f(x) and g(x) graphs

Then function's $F(x) := 160.09 \cdot \ln(x) + 1081.50 - 894.66 \cdot e^{0.1526x}$ graph is prepared. It is seen that the given function changes its sign in the interval [1; 2].

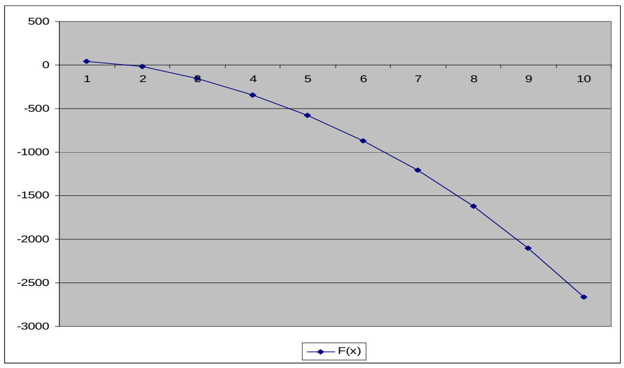

Figure 4. Function F(x) graph in the chosen interval

The first derivative is analyzed in order to check if the chosen interval [1; 2] is isolating (see Figure 5).

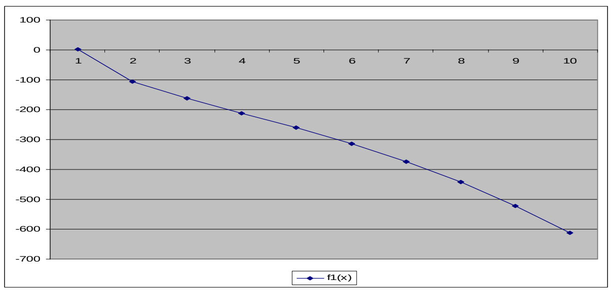

Figure 5. The first derivative graph

Figure 5 shows that the first derivative graph changes its sign in the interval [1; 2], so the given interval is narrowed till [1.7; 2], where the first derivative does not change its sign in the interval. Then the second derivative is calculated that does not change its sign in the interval [1.7; 2].

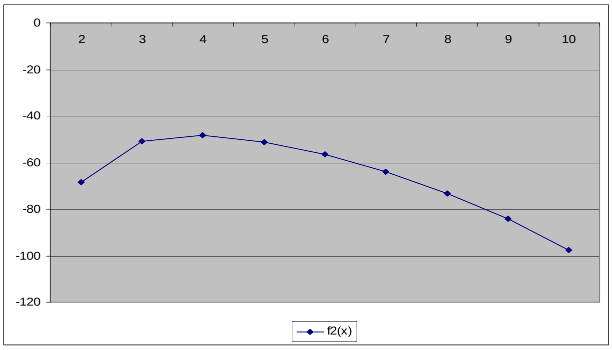

Figure 6. The second derivative graph in the interval

Figures 4, 5 and 6 prove that the chosen interval [1.7; 2] is isolating because it meets all the requirements for isolating interval. The constant end of the interval [1.7;2] is found: it is where the second derivative sign is equal to the function sign in the interval. The second derivative is negative in the point x=2, so the constant point is x=2.

$$x_{const} := r_{gl} := 2\,;\; x_0 := m_{pr} := 1.7$$

The proximities are calculated. The results are presented in Table 1.

Table 1

Proximities

x	Proximities	Function's module min	F(x)
1.8	1.7809234	-1.769947465	-1.871715545
1.77918	1.7791892	0,00	0,00
1.75	1.7766829	2.428677596	2.568321209

The results are checked with the help of Microsoft Excel function Solve.

$$f(x)\, solve \;, x \rightarrow 1.7791892794 \quad 4159$$

So in the economic age 1.78 preventive maintenance costs are equal to corrective maintenance costs, so it is worth to use preventive maintenance strategy starting from this point for Renault model vehicles in order to minimize maintenance costs and not earned income, to prolong useful time of the vehicle and to increase profit.

Conclusions

The following conclusions may be drawn:

1. There are two main asset maintenance strategies: preventive and corrective maintenance. When comparing both strategies most of researchers have a wrong opinion about high preventive maintenance costs but they do not pay attention to long term benefits and savings.
2. Opportunities for profit may be lost because of unavailability caused by badly planned preventive maintenance, unplanned corrective maintenance, as well as ineffectiveness in operations and maintenance strategy.
3. Marginal break even between alternatives shows economical age where corrective maintenance costs become higher than preventive maintenance costs in a long term period. It was fixed that preventive maintenance costs become less than corrective maintenance costs in 1.78 th economical age, the probability of downtime declines, so it is worth using preventive maintenance strategy for Renault model vehicles since this economical age in order to minimize maintenance costs through life cycle of the vehicle.

References

Ahlmann, H. R. (1984). Maintenance effectiveness and economic models in the terotechnology concept. *Maintenance Management International*, 4, 131-9.

Bevilacqua, M., & Braglia, M. (2000). The analytic hierarchy process applied to maintenance strategy selection. *Reliability Engineering and System Safety*, 70, 71-83.

Block, H. W., Borges, W. S., & Savits, T. H. (1988). A general age replacement model with minimal repair. *Naval Research Logistics*, 35, 365-72.

Boguslauskas, V., & Kvedaraviciene, G. (2009). Difficulties in identifying Company's Core Competencies and Core Processes. *Inzinerine Ekonomika-Engineering Economics*(2), 75-81.

Burinskiene, M. (2009). New methodology for sustainable development towards sustainable transportation system. *Technological and Economic Development of Economy, 15*(1), 5-9.

Campbell, J. D. (1998). *The Reliability Handbook*. Cliffor/Elliot, Burlington.

Ciegis, R., Ramanauskiene, J., & Martinkus, B. (2009). The Concept of Sustainable Development and its Use for Sustainability Scenarios. *Inzinerine Ekonomika-Engineering Economics*(2), 28-37.

Dytczak, M., & Ginda, G. (2009). Identification of building repair policy choice criteria role. *Technological and Economic Development of Economy, 15*(2), 213-228.

Domeika, P. (2008). Creation of the Information System of Enterprise Fixed Asset Accounting. *Inzinerine Ekonomika-Engineering Economics*(5), 7-15.

Fox, B. (1966). Age replacement with discounting. *Operations Research*, 14, 533-537.

Gokiene, R. (2009). The model of tangible movable asset operation cost management. *Management Theory & Studies for Rural Business & Infrastructure Development,* 16 (1), 53-60.

Grall, A., Dieulle, L., Berenguer, C., & Roussignol, M. (2002). Continuous time predictive maintenance scheduling for a deteriorating system. *IEEE Transactions on Reliability*, 51, 2, 141-50.

Jamali, M. A., Ait-Kadi, D., Cle´roux, R., & Artiba, A. (2005). Joint optimal periodic and conditional maintenance strategy. *Journal of Quality in Maintenance Engineering*, 11(2), 107-14.

Kaklauskas, A., Zavadskas, E. K., & Raslanas, S. (2009). Modelling of Real Estate Sector: The Case for Lithuania. *Transformations in Business & Economics*, *8*(1), 101-120.

Kelly, A. (1998). *Maintenance Strategy*. Butterworth & Heinemann, Oxford.

Kevin, F. G., & Penlesky, R. J. (1988). A framework for developing maintenance strategies. *Production and Inventory Management Journal*, First Quarter, 16-21.

Lapasinskaite, R,. & Boguslauskas, V. (2005). The maintenance cost allocation in product life cycle. *Inzinerine Ekonomika-Engineering Economics*(4), 17-23.

Lapasinskaite, R., & Boguslauskas, V. (2006). Maintenance cost model for transport equipment. *Mechanika 2006 : proceedings of the 11th international conference*, Kaunas University of Technology, Lithuanian Academy of Science, IFTOMM National Committee of Lithuania, Baltic Association of Mechanical Engineering, 193-198.

Lapasinskaite, R., & Boguslauskas, V. (2006). Non-linear time-cost break even research in product lifecycle. *Inzinerine Ekonomik-Engineering Economics*(1), 7-12.

Louit, D. M., & Knights, P. F. (2001). Simulation of initiatives to improve mine maintenance. *Mining Technology (Transactions of the Institute of Materials, Minerals & Mining A)*, 110, 47-58.

Maillart, L. M., & Pollock, S. M. (1999). The effect of failure-distribution specification-errors on maintenance costs. *Proceedings of the Annual Reliability and Maintainability Symposium, Washington, DC,* January 18-21, 69-77.

Mann, L, Saxena, A, & Knapp, G. (1995). Statistical-based or condition-based preventive maintenance? *Journal of Quality in Maintenance Engineering*, 1, 46-59.

Mirghani, M. A. (2001). A framework for costing planned maintenance. *Journal of Quality in Maintenance Engineering*, 7(3), 170-82.

Mirghani, M.A. (2003). Application and implementation issues of a framework for costing planned maintenance. *Journal of Quality in Maintenance Engineering,* 9(4), 436-49.

Nakagawa, T. (1988). Sequential imperfect preventive maintenance policies. *IEEE Transactions on Reliability,* 37, 295-298.

Pintelon, L., Gelders, L., & Puyvelde, F. (2000). *Maintenance Management*. ACCO, Leuven.

Pham, H, & Wang, H. (1996). Imperfect maintenance. *European Journal of Operational Research*, 94, 425-38.

Shey-Huei Sheu (1991). A generalized block replacement policy with minimal repair and general random repair costs for a multi-unit system. *Journal of the Operational Research Society,* 42, 331-341.

Strumickas, M., & Valanciene, L. (2009). Research of Management Accounting Changes in Lithuanian Business Organizations. *Inzinerine Ekonomika-Engineering* Economics(3), 26- 32.

Swanson, L. (2001). Linking maintenance strategies to performance. *International Journal of Production Economics*, 70, 237-44.

Valanciene, L., & Gimzauskiene, E. (2009). Dimensions of Performance Measurement System in Changes Research. *Inzinerine Ekonomika-Engineering Economics*(4), 41-48.

Zavadskas, E. K. (2008). Methods and Models of Research in Construction Project Engineering. *Journal of Business Economics and Management, 9*(3), 240-243.

Zhang, F., & Jardine, A. K. S. (1998). Optimal maintenance models with minimal repair, periodic overhaul and complete renewal. *IIE Transactions,* 30(12), 1109-1119.

Zinkeviciute, V. (2007). Evaluation of business strategic decisions under changing environment conditions. *Journal of Business Economics and Management, 7*(4), 267-274.

Zhu, G., Gelders, L., & Pintelon, L. (2002). Object/objective - oriented maintenance management. *Journal of Quality in Maintenance Engineering*. 8, 4. 306-318.

Zvireliene, R., Buciuniene, I., et al. (2009). Customer Retention through Supplier-Organization-Customer Relationship Management. *Transformations in Business & Economics, 8*(1), 137-151.

Rūta Gokienė

Ribinis taškas tarp remonto strategijų alternatyvų

Santrauka

Remonto procesas yra laikomas viena iš pagrindinių įmonės verslo veiklų. Jis turėtų padėti išlaikyti turtą esant norimai stadijai tam, kad patenkintų pirminio proceso reikalavimus. Remonto proceso tikslai yra šie:

- padidinti pirminio proceso pajėgumus;

- pagerinti pirminio proceso veiklą, tokią kaip kokybė, pelningumas ir kt.;
- patenkinti reikalavimus, tokius kaip saugumo, pavojingų medžiagų ir aplinkos apsaugos standartai išlaidų efektyvumo srityje.

Siekiant efektyviai valdyti remonto veiklą, svarbu suprasti santykį tarp remonto ir pirminio proceso.

Remonto išlaidos yra bene didžiausia gyvavimo ciklo išlaidų kategorija, todėl jas labai sudėtinga vertinti. Ši gyvavimo ciklo išlaidų kategorija turi keletą unikalių vertinimo charakteristikų, iš kurių viena yra ta, kad remonto išlaidos susidaro per daugelį metų (metų skaičius priklauso nuo nagrinėjamo turto naudojimo ciklo). Nuspėti medžiagų, dalių ir personalo išlaidų tendencijas per ilgą laiką yra labai sunku, nes apskaičiuojant remonto išlaidas labiau nei naudojant kitus apskaičiavimo būdus, remiamasi prielaidomis.

Remonto strategijas nagrinėjo daug tyrėjų: Barlow, Proschan, 1965; Fox, 1966; Glasser, 1967; Nakagawa, Osaki, 1974; Block, 1985, 1988; Nakagawa, 1988; Zhang, Jardine, 1998; Kevin, Penlesky, 1988; Sheu, 1991; Jayabaian, Chaudnuri, 1992; Jack, Dagpunar, 1994; Mann, Saxena, Knapp, 1995; Pham, Wang, 1996, 2000; Bevilaqua, Braglia, 2000; Swanson, 2001; Liu, 2001; Saranga, Knezevic, 2001; Grall ir kt., 2002; Marseguerra ir kt., 2002; Jamali ir kt., 2005.

Apžvelgiant mokslinėje literatūroje analizuojamą remonto strategiją, galima aptikti labai įvairią remonto strategijų klasifikaciją, tačiau apibendrintai galima išskirti dvi pagrindines strategijas: prevencinio ir korekcinio remonto.

Nemažai autorių nagrinėjo ir remonto išlaidų apskaitą, tačiau mokslinių darbų, siejančių skirtingas remonto strategijas su naudojamo turto ekonominiame amžiuje patiriamomis išlaidomis, nėra arba tik fragmentiškai aprašomi jų tarpusavio ryšiai.

Tyrimo objektas – turto remonto išlaidų valdymas.

Tyrimo tikslas – suskaičiavus ribinį tašką tarp remonto strategijų alternatyvų. parinkti optimalią remonto strategiją, siekiant planuoti turto remontą ir minimizuoti remonto išlaidas.

Tyrimo metodai. Analizuojant teorines remonto strategijų alternatyvas ir remonto išlaidų apskaitą, straipsnyje taikoma lyginamoji mokslinės literatūros analizė, apimanti teorinių teiginių palyginimą ir apibendrinimą.

Empiriniai tyrimai atlikti taikant regresijos metodą, koreliacijos analizę bei imitacinį modeliavimą. Rezultatai pateikiami lentelėse ir grafikuose.

Naudojant MS Excel, Statistika, VisSim 5.0. programinę įrangą, suskaičiuotas ribinis taškas tarp remonto strategijų alternatyvų

Mokslinis naujumas. Suskaičiuotas ribinis taškas tarp remonto strategijų alternatyvų pritaikytas su turto naudojimu susijusiems valdymo sprendimams priimti gamybinėse ir paslaugų įmonėse.

Viena iš remonto klasifikacijų yra pagal jo strategiją. Tinkamos remonto strategijos parinkimo tikslas - suplanuoti prevencinius ar korekcinius (kuriamuosius) veiksmus, siekiant minimizuoti remonto bendrąsias išlaidas ir (arba) maksimizuoti turto gyvavimo laikotarpį. Mokslinėje literatūroje teigiama, jog turto remontas turi dvi pagrindines strategijas: planuoto ir neplanuoto remonto. Planuotas (prevencinis) remontas apima turto remonto arba rekonstrukcijos sąvoką ir naudojamas kaip prevencinė priemonė per visą turto ekonominį amžių netikėtiems gedimams išvengti. Neplanuoto (korekcinio) remonto pasekmės yra pavojingos ir tampa rimtu kliuviniu bet kuriame versle. Planuotas remontas gali būti pagrįstas laiko / naudojimo pagrindu arba būsenos / kontrolės pagrindu.

Yra daugybė klaidingų požiūrių į prevencinio remonto taikymą. Vienas iš jų – prevencinis remontas yra pernelyg brangus. Remiantis šiuo požiūriu, reguliariai planuojamos prastovos ir remontas būtų brangus, o normalios išlaidos leistų įrengimui dirbti tol, kol remontas būtų neabejotinai reikalingas. Tai gali būti taikoma tik kai kuriems komponentams. Tačiau reikėtų kalbėti ne tik apie išlaidas, bet ir apie ilgalaikę naudą ir ekonomiją, kurios susijusios su prevencinio remonto strategijos taikymu įmonėje. Nenaudojant prevencinio remonto, pavyzdžiui, dėl neplanuoto įrengimo gedimo būtų patirtos prarasto gamybos laiko išlaidos. Taip pat naudojant šią strategiją įmonė sutaupytų dėl prailgėjusio efektyvaus sistemos tarnavimo laiko.

Svarbus uždavinys, vykdant planuotą remontą, yra išlaidų apskaita ir jų minimizavimas, t. y. turi būti tinkamai įvertintas turto nuostolių lygis ir (arba) atkurta turto kokybė. Tinkamas išlaidų paskirstymas turi pagrindinį poveikį naudojant bet kurią remonto strategiją.

Įmonėje valdant bet kurio turto remonto išlaidas svarbią vietą užima remonto išlaidų planavimas. Remonto išlaidų planavimas užtikrina turto našumą, saugumą ir įmonės pelningumo rodiklių maksimizavimą. Prasta techninė priežiūra sukelia ne tik neplanuotus gedimus, tačiau didina eksploatacijos išlaidas ir kelia grėsmę darbuotojų saugumui.

Išlaidų minimizavimo problema yra viena iš svarbiausių sudedamųjų dalių turto remonto politikoje. Priklausomai nuo turto fizinio nusidėvėjimo ir įvertinus gyvavimo ciklo išlaidas, turto komplekso įsigijimo išlaidos paprastai yra žemesnės negu nuosavybės išlaidos. Turto tipas lemia nuosavybės išlaidas per visą gyvavimo ciklo trukmę ir gali skirtis net 10 ar 100 kartų nuo įsigijimo išlaidų.

Žinios dėl pagrindinių išlaidų kilmės leidžia optimizuoti įmonės išteklių naudojimą planuotu remontu. Taip pat išlaidų apskaita leidžia atskleisti neefektyvų remontą ir nustatyti reikalingų medžiagų poreikį pageidaujamam darbingumui palaikyti.

Gyvavimo ciklo pelnas gali būti padidintas mažinant išlaidas, gerinant nuosavybės efektyvumą ir efektyvumu paremtą eksploatavimą bei remontą. Svarbu paminėti, kad tik išlaidų minimizavimas negarantuos pelno maksimizavimo. Turto naudojimo valdymas, remontas ir palaikymas turi būti orientuoti į rinkos pokyčius. Galimybės padidinti pelną gali būti prarastos dėl blogai suplanuoto prevencinio remonto, neplanuoto korekcinio remonto ar neefektyvios remonto strategijos parinkimo.

Transporto priemonės remontas turi reikšmingą įtaką tiekimui, kokybei ir išlaidoms. Naudodama optimalią remonto strategiją, įmonė gali padidinti savo galimybes, kompetenciją ir sėkmingai vykdyti savo įsipareigojimus. Paskutiniu metu aktyviai tyrinėjama problema remonto modeliavimo ir optimizavimo lygmeniu. Remontas, atliekant prevencinius planuotus ir neplanuotus veiksmus, palaiko turto būseną priimtinu valdymui lygiu, susilpnindamas nepageidaujamą riziką, užtikrindamas turto patikimumą, mažindamas išlaidas ir neuždirbtas pajamas.

Ribinis taškas tarp remonto strategijų alternatyvų reiškia ekonominį amžių, kuriame verta pradėti taikyti prevencinio remonto strategiją, siekiant minimizuoti remonto išlaidas.

Ribinis taškas yra kreivių $y = 160,09 \cdot \ln(x) + 1081,50$ ir $y = 894,66 \cdot e^{0,1526x}$ susikirtimo taškas, kuris ieškomas taikant vieną iš iteracinių metodų – stygų metodą.

Nubraižius pateiktų funkcijų grafikus, pasirenkamas intervalas, kuriame viena funkcija kerta kitą funkciją. Iš funkcijos grafiko galima matyti, ar funkcija keičia ženklą jame. Tuomet tikrinama, ar pasirinktas intervalas yra izoliatyvus. Dėl šios priežasties reikia analizuoti pirmąją ir antrąją funkcijos išvestines.

Izoliatyvus yra tas intervalas, kuris atitinka visus izoliatyviam intervalui keliamus reikalavimus:

- funkcija keičia ženklą intervale;
- pirmoji funkcijos išvestinė nekeičia ženklo intervale;
- antroji funkcijos išvestinė taip pat nekeičia ženklo intervale.

Atlikus detalius analitinius skaičiavimus, buvo nustatyta, kad 1,78 ekonominiame amžiuje prevencinio remonto išlaidos tampa mažesnės už korekcinio remonto išlaidas, sumažėja prastovų tikimybė. Todėl nuo šio ekonominio amžiaus verta pradėti taikyti prevencinio remonto strategiją Renault modelio transporto priemonėms, siekiant minimizuoti remonto išlaidas bei neuždirbtas pajamas, ilginant naudojimo trukmę ir didinant pelną.

Raktiniai žodžiai*: gyvavimo ciklo išlaidų apskaita, turto gyvavimo ciklas, prevencinis remontas, korekcinis remontas.*

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