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METHOD OF ANALYSIS OF PRODUCTIVITY WITH AN INNOVATIVE MODEL OF THE WORKING CAPABILITY OF THE OBJECT IN THE BODY (ℂ) FOR THE NEW RESOURCE ALLOCATION ON INHERENT AND NON-INHERENT

METODA ANALIZY PRODUKTYWNOŚCI Z INNOWACYJNYM MODELEM POTENCJAŁU ROBOCZEGO OBIEKTU W CIELE ℂ DLA NOWEGO PODZIAŁU ZASOBÓW NA INHERENTNE I NIEINHERENTNE*

The aim of the article is to develop new methods of analysis, estimation and optimal selection of quantitative resources (inherent and non-inherent) in the planning of the product effect for specific environmental conditions. The required iterative approach in the construction of the mathematical model and analysis of its possible practical applications and search for how to figure those opportunities. As the testing method has been applied method intuitive, allowing you to use the experience of expert analysis from ongoing opportunities to make full use of the sustainability properties and customize to their processes. The results were presented in the form of mathematical models in the collection of complex numbers and graphically on the plane of complex numbers. Method to estimate changes inherent and non-inherent resources objects (machines, systems, organizations) on their productivity (P_o). The method uses the original, innovative, model potential workspace object (P_rO) in the form of a complex binding numerically inherent (Z_iO) and non-inherent ($Z_{ni}O$) resources objects. Evaluation of value Po it was proposed with the P_rO. The values of the Z_iO and $Z_{ni}O$ was adopted as two independent resources constituting the whole of resources in the required in the production (or in the service). Method evaluation Po illustrates for the resources object described model $R_o = \left| P_rO = f(Z_pO, Z_oO) \right|$, where Z_iO is a work resource (Z_pO), $Z_{ni}O$ is extracted from the operation of the resource service (Z_oO), and the generating capacity of the object P_o is described using a pointer named R object (R_o). Illustrated in the complex plane analysis results and the results obtained from the calculation P_rO and R_o, for contract values of the Z_pO and Z_oO, indicate the application capabilities developed method. Method allows a very clear description of the productivity changes objects (or processes, or production organization), in the context of the selection of manufacturing resource structure, through the separation of the factors causing these changes. Method can be adapted for optimal production costs (or services) through design changes object and/or design changes of the process exploitation. Developed the method brings new opportunities for theoretical and application in relation technical and economic sciences.

Keywords: *productivity, durability, reliability, operation and using and maintenance, maintenance of machinery, approved limit working time or approved number of working cycles, manufacturing resources, P_rO, Z_iO, $Z_{ni}O$.*

Celem artykułu jest opracowanie nowej metody analizy, szacowania i optymalnego doboru ilościowego zasobów (inherentnych i nieinherentnych) w planowaniu efektu produktowego w określonych warunkach środowiskowych. Realizacja celu wymagała iteracyjnego podejścia przy budowie modelu matematycznego i analizie możliwych jego zastosowań praktycznych oraz poszukiwaniu sposobu ilustracji tych możliwości. Jako metoda badawcza została zastosowana metoda intuicyjna, pozwalająca wykorzystać doświadczenie eksperckie z realizowanych analiz możliwości pełnego wykorzystania trwałości obiektów i dostosowywania do tego ich procesów eksploatacji. Wyniki zostały zaprezentowane w postaci modeli matematycznych w zbiorze liczb zespolonych i graficznie na płaszczyźnie liczb zespolonych. Metoda umożliwia szacowanie zmian inherentnych i nieinherentnych zasobów obiektów (maszyn, systemów, organizacji) na ich produktywność (P_o). W metodzie wykorzystano autorski, innowacyjny, model potencjału roboczego obiektu (P_rO) w postaci liczby zespolonej wiążącej liczbowo inherentne (Z_iO) i nieinherentne ($Z_{ni}O$) zasoby obiektu. Wyznaczanie wartości P_o zaproponowano z modułu P_rO. Wartości Z_iO i $Z_{ni}O$ przyjęto jako dwa niezależne od siebie zasoby stanowiące całość zasobów w realizacji danej produkcji lub usługi. Metodę oceny P_o zilustrowano dla zasobów obiektu opisanych modelem $R_o = \left| P_rO = f(Z_pO, Z_oO) \right|$, gdzie Z_iO to zasób pracy obiektu (Z_pO), $Z_{ni}O$ to wyodrębniony z eksploatacji zasób obsług (Z_oO), a zdolności wytwórcze obiektu P_o opisano za pomocą wskaźnika nazwanego resursem obiektu (R_o). Zilustrowane na płaszczyźnie zespolonej wyniki analiz i uzyskane wyniki z obliczeń P_rO i R_o, dla umownych wartości Z_pO i Z_oO, wskazują na duże możliwości aplikacyjne opracowanej metody. Metoda umożliwia bardzo czytelny opis zmian produktywności obiektów\procesów\organizacji, w kontekście doboru struktury zasobów wytwórczych, poprzez rozdzielenie czynników powodujących te zmiany. Metodę można adaptować na potrzeby optymalizacji kosztów produkcji\usług poprzez zmiany projektowe obiektu technicznego i\lub zmiany projektowe procesu jego eksploatacji. Opracowana metoda wnosi nowe możliwości teoretyczne oraz aplikacyjne w powiązaniu nauk technicznych i ekonomicznych

Słowa kluczowe: *produktywność, trwałość, niezawodność, eksploatacja, utrzymanie w ruchu maszyn, resurs, zasoby wytwórcze, P_rO, Z_iO, $Z_{ni}O$.*

(*) Tekst artykułu w polskiej wersji językowej dostępny w elektronicznym wydaniu kwartalnika na stronie ***www.ein.org.pl***

1. Introduction

New challenges for the organization of production (high competitiveness and complexity of manufacturing processes) require the modern changes in the management of the working environment [15]. Necessary for this innovative method of collecting, organizing, analyzing and processing data. What counts here most of all the response time to changing conditions internals (staff turnover service quality, adapting to the aging machine park) and external (change consumer expectations, conditions of environmental standards) [10, 35].

Is part of a global trend to improve competitiveness through productivity growth (P_o) [17.21].

This in turn generates demand for modern methods and models to optimize the distribution of resources (material, human, financial, information, management) for the purpose of their efficient use [17, 19, 26, 30]. There are many publications devoted to measuring P_o and describing indicators P_o to the estimate of the production processes, which are explained in more detail in [17]. A lot of scientific studies is also about ways to improve P_o for example the application of philosophy LP [22, 29, 32]. There are many publications in which it moves issues full [18, 22] and secure [3, 6, 7] use of the technical resources and the improvement of the service organization [3, 4, 11, 12, 23], as well as optimizing the distribution of resources [27]. Maintenance of machinery in motion has developed a variety of ways to control the production process and optimization used in material resources, human and financial, eg. TPM, 5S, etc. [24], whether the indicators OEE [1, 14]. They have their use in monitoring the efficiency of a particular production system, but are not so the overall rate as productivity [17].

In the literature, however, was not a method enabling the binding in one mathematical model of productivity (P_o) all the resources [1, 8, 14, 17, 23], proposed divide it by inherent and non-inherent [11], you need to obtain a result production (or service) i.e. in the form of a number or quantity of the product. With increasing complexity and technical excellence object in maintaining proper P_o increasing importance to human resources. Maintenance quality schedule services and operations by the operators [4, 7, 9, 18, 23, 25], requires not only the appropriate management of these resources, but also for resources development customizations objects. Human resources identified are mainly from the non-inherent resources in the production process. In this sense, optimal productivity can be obtained only if the object resources (inherent) will be adjusted accordingly to the existing human resources in your environment (non-inherent).

You can measure the impact of non-inherent resources to the value of the final production, but more important is how to optimize their selection in the context of the inherent to obtain the optimum indicator P_o or, conversely, how human resources (operating, environment) to choose the object resources.

Based on its own expertise and on the results of analysis of the literature and by using intuitive method, it is considered that it will be necessary to divide production resources object and organizations on inherent production resources (related to technical, technological, reliability and durability capabilities of objects) and non-inherent production resources (resulting mainly from human decisions – policy of profitability, organization of work, operating strategies, activities and environmental conditions pro-quality-existing human potential, training, scientific, cultural, etc.). In the literature the author found no such allocation of resources (in the process of exploitation or maintenance of machinery) a mathematical model P_o. There is mentions only (in review the earlier publications), that their proper selection and behavior of the established quality determine the value of the P_o. In these publications, resources inherent and non-inherent, usually are analyzed separately or are not specifically divided. Hence, it was considered that in the evaluation P_o the object should be the method used for evaluation of the simultaneous impact of both of these resource groups i.e. inherent and non-inherent, which are all the resources for a given type of production (services). The initial discussion of this issue is outlined in the work [11].

Proposed in article method entering in a theory of resources of assessment P_o the object/ or organization, which replaces the traditional management, in which dominated the evolutionary approach. First of all, proposed in this work, method allow analysis and selection of optimal assignment of resources inherent resources non-inherent or vice versa (depending on what it is easier to fit) to achieve optimum value P_o the i.e. profit ratio of manufactured products in relation to invested in production funds. This means that you need to know, in which resources and how much you should allocate financial resources to achieve optimum productivity (P_o).

In English literature, there is no explicit descriptions of some terms and symbols (used in Polish literature) necessary for the understanding of the models described in this article. Hence the author introduced their English newly defined (fourteenth) meanings of words or symbols applied in this article. The first is P_o - *productivity* of technical object (or production process or production organization). The second is Z_iO - inherent resources in technical object (or production process or production organization). The third is $Z_{ni}O$ - non-inherent resources in technical object (or production process or production organization); The fourth is P_rO - potential workspace technical object (or production process or production organization) consequential to inherent and non-inherent resources. The fifth is *Object* - the technical object or production process or production organization (item technical, manufacturing plant, production facility, works technical device, assembly line, industrial organization etc.); everything what is producing technical products or products service. The sixth is *Exploitation - (in Polish - eksploatacja* [3, 4, 11]*):* servicing and uses i.e. organized or scheduled, in a rational way, exploiting the inherent potential of the technical object or production process or production organization for adopted criteria e.g. productivity, efficiency, durability, reliability, security, etc. The seventh is *Exploitation of object - operation, using* and *maintenance* the object, diagnostics, operational control and crew training, and continuous airworthiness management having an impact on safety. The eighth is *R - (in Polish - resurs* [3, 4, 11]*):* approved limit working time (or approved number of working cycles) of the technical object (or process or production organization or the number of made products or services) which guarantees the safety and efficiency of operation and support of object (or production process or production organization). The ninth is R_o - production index - *describes estimated* size output (or *production capacity* or *productivity* of object or production process or production organization). The tenth is Z_pO - production quality (with result of what are inherent resources - Z_iO). The eleventh is Z_oO - perfection of operating procedures (with result of what are none-inherent resources - $Z_{ni}O$). The twelfth is uZ_pO - hypothetical value Z_pO, for accepted contractual units – u. The thirteenth is uZ_oO - hypothetical value Z_oO, for accepted contractual units – u. The fourteenth is *c.u.* - contractual units *(in Polish - j.u.)*.

1.1. Allocation of resources used in the P_o

Based on the literature review, at the highest level of general allocation of resources to produce P_o it has been made in the work [9]. These are human resources (skills, knowledge, abilities and suitability of all employees in the enterprise), financial (the financial capital, which the organization uses to fund activities both current and long term), material (in the squad, which includes, among other raw materials, semi-finished products, office space and production and all kinds of equipment) and information (all kinds of useful information for effective decision making). By analyzing the binding capabilities of these resources for optimizing P_o encountered the difficulties arising from the diversity of the ways mathematical description of these resources. In the set of real numbers is not possible a simple bind these types of resources into a single mathematical model. Because these resources don't have mathematical common space, in which indicators could be described in one mathematical relation.

It was recognized that for this aim optimization, resources required is even more general allocation of resources. Therefore, the proposed allocation of resources necessary for the implementation of the object P_o not on four [9], and two independent of each other (however, one piece of resources in the production) resource group i.e. Z_iO (inherent) and $Z_{ni}O$ (non-inherent) resources of the object, as proposed in [11]. In relation to the [11] this article has developed a more general mathematical model P_o. Within the framework of the developed method for the analysis of productivity the object, that method may relate to the broader class of problems in manufacturing i.e.. for any products (machines, services, fuels, financial, human-training of specialists, etc.) allowing to meet all human needs.

To the resources of the inherent lists all material factors related to the technical and technological means of production (machinery, technological lines, software, database, and assigned to their creation of financial resources), and to non-inherent all the factors associated with the use of these factors inherent (human resources, organizational procedures, maintenance procedures of production and assigned to their maintenance of financial resources). Such the divide of resources to allow development of such a model to optimize them to get the not like the biggest effect, but optimal production effect, reference to the costs incurred in the manufacturing environment. One of the objectives of this modeling is the ability to minimize the planned costs for the type of production through selection of appropriate levels of resources inherent and non-inherent.

1.2. Characteristics of inherent (Z_iO) and non-inherent ($Z_{ni}O$) resources object

With the development of the theory of reliability [22, 25, 28, 33], the theory of maintenance objects in motion [6, 13, 19], the theory of exploitation [2, 3, 4, 12, 22, 25, 33, 34] and the development of theory, increasingly began to use the concepts in the form of: item durability [3:12], item operation [4] resource [11], the production potential [11, 123], resource techniques [3], an information resource [23]. PN-EN ISO 9000:2006 (now PN-EN ISO 9000:2015-10) emerged the concept of inherent in the definition of quality as "... the degree to which a set of inherent object ownership meets requirements". On this basis, the author suggested in [11] is a term to describe a work resource object (Z_pO), that in the spirit of the above definition describes the quality of the object. On these resources inherent consists of everything that follows from the inherent factors occurring in the manufacturing process of the goods (products). An example would be owned by the object its potential durability featured R since resources inherent object (R_{io}) [16, 20, 31, 32, 36], which was named in this method, the inherent resources object (Z_iO). You have the maximum value R object ($R_{i(max)o}$) of inherent resources (Z_iO) limits because the production capacity of the object (as well as utilities, or the ability of other tasks [31] for example, combat flight [36], removal of natural disasters, etc.). It can be generalized to the ability to perform the products in a general sense, i.e. both the material and the service (e.g. transportation). But the size of the degree of use of resources inherent (and hence the $R_{i(max)o}$) have a very strong impact your organization (assigned to the object and the resulting from the exploitation strategy [25, 34]) types of and the resources non-inherent [7], that can be described R since resources non-inherent object (R_{nio}) – consequential to assigned resources in exploitation system (facility management). The manner and quality of use of R_{nio} describe (according to the author) mainly non-inherent factors given to and dependent on the so-called the human factor, hence called them non-inherent resources object ($Z_{ni}O$). Selection of $Z_{ni}O$, in the framework of exploitation (machinery maintenance processes [13]), should enable the optimal use of the Z_iO with your object by taking into account optimizing global costs involved in the manufacture of products (described by P_o) for which it was intended. It's hard, and sometimes it is not possible to specify or extract the R_{io} and R_{nio} with R production or service object described here as R_o depending on (1). It is much easier to define the Z_iO and $Z_{ni}O$, and assess their impact on the value of P_rO. Hence the resources inherent and non-inherent create a larger resource that was called a potential workspace technical object – P_rO and described according to (1):

$$R_o = f(R_{io}, R_{nio}); \quad P_rO = f\,(Z_iO,\, Z_{ni}O), \tag{1}$$

where Z_iO can be described a numeric indicator R_{io} ($R_{io(max)}$), and $Z_{ni}O$ can be described a numeric indicator R_{nio} ($R_{nio(max)}$) from here P_o can be described a numeric indicator R_o. Indicator R_o can describe here the numerical value of the products (or services) get in object (or processes or organization) with their inherent and non-inherent resources. Ability to use P_o when depends on the functional value of therefore P_rO described dependency (2):

$$P_o\,(R_o) = f\,(P_rO). \tag{2}$$

It is assumed that the same value P_rO can be achieved as a result of the application of very different configurations of quantitative resources components Z_iO and $Z_{ni}O$. Therefore it is considered advisable to analyses their optimal allocation, in the strategy of exploitation within the limits of resources in the manufacturing environment aimed to optimize profits from executing (founded) the volume of production (services).

It is considered that only the optimum selection of Z_iO to $Z_{ni}O$ for the current exploitation conditions and objectives set production plans (services), enables the optimal use of the existing potential of the working organization or object (P_rO). Determination of optimal value productivity object P_o can be expressed by a numeric indicator R_o (R production technical object or organization service or production product). The results of such analyses can be used for example to adjust too ambitious production plans or justification offset excessive resources to other tasks.

2. Assumptions to the method

Developed method is the result of an intuitive process expertise author, obtained in the analysis of the exploitation processes within the framework of the multiannual research capabilities from strategy to operation according to the preventive work (R) on operation strategy according to the condition for complex technical systems. The development of these (published mainly in materials for business use) concerned the weapons systems of aircraft and helicopter, carried out surveys in terms of causes of damage to the weapon and pursued research reliability-durability aircraft cannons [31]. In addition, imposed on many years of experience in the analysis of reliability-durability objects in lectures, exercises and projects with the subject "Reliability, durability and exploitation of objects". The aim of all these studies was the search for answers to the question of how to model the use of the object in the event the placement in another exploitation system (than has planned for these objects their manufacturer), in order to use the whole work resource object while maintaining the required level of reliability of its activities during the periods of use [11.12]. The main conclusions, which have been obtained from these analyses is that the use of labor resources object depends on the adopted exploitation procedures, and they in turn depend on the assumptions made use of the object. In addition, that way the design objects is strongly dependent on the exploitation conditions to which had hit object. The next important conclusion was that comparing the quality of objects does not make sense without reference to (or comparison) of exploitation assumptions, in which it had to operate. On the basis of this the author came to the conclusion that optimizing the efficiency of the use of the object should be implemented simultaneously with the optimization of the efficiency of operation object. Hence, one step to the allocation of resources involved in productivity factors **inherent** (describing the applied technical solutions) and factors non-inherent (describing the service solutions used in the exploitation process). The consequence of this was to optimize the allocation of productive resources for the object, possible to recruit and assign him a service resources in its exploitation system. Hence, the allocation of resources needed to implement the effect of productive (or service) on the non-inherent and inherent requires indicate which ones belong to the production structures and that to the control structures separate from the exploitation system in which they are maintained. General illustration of this division is shown in Fig. 1 and Fig. 2 and described in section 2.1.

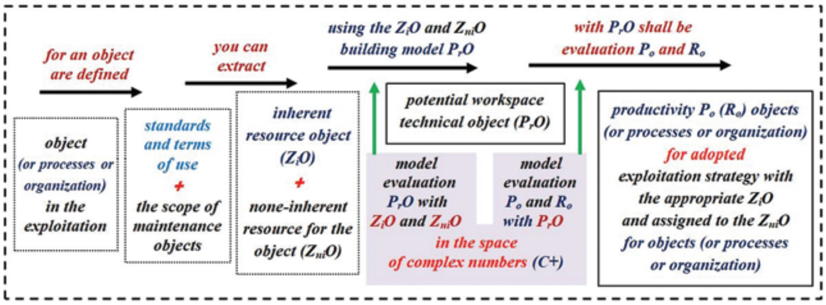


Fig. 1. *Illustration of the links to the inherent work resources (Z_iO) and assigned him to non-inherent service resource ($Z_{ni}O$) from its exploitation system of its productivity (P_o) and R object (R_o) and illustration of the location of the proposed model evaluation P_rO with Z_iO and $Z_{ni}O$, and P_o and R_o with the P_rO, with the use of the space complex numbers (C^+)*

It is assumed that the proposed article method should be so universal, that will be broadcast to both assess the productivity of a single machine or mechatronic system, as well as the production and the complex organization of production and services. What determines the distribution of the inherent and non-inherent resources and the quality of their use is directly related to the applied exploitation strategy, or in a narrower range of applied strategy of maintaining machinery in motion. Hence the change of conditions affecting the ability to implement, founded the exploitation strategy at the same time affects the quality level to change P_o. In addition, in the changed conditions exploitation often required is a different allocation of the inherent and non-inherent resource object or organization.

Proposed in section 2.1 model to allow analysis of the optimization of the inherent and non-inherent resource object (or manufacturing organizations) in different exploitation conditions for different classes and object size (or organization). The method described is at a very high level of generality. However, it has no restrictions on the amount of at issue constituent elements and types of resources provided to correctly qualify the resources to Z_iO or $Z_{ni}O$ (3):

$$P_rO = \mathrm{f}\,(\Sigma\, Z_iO,\ \Sigma\, Z_{ni}O) \tag{3}$$

or (4):

$$P_rO = \Sigma\, P_rO_{\mathrm{j}} \tag{4}$$

where *j* is a constituent working potentials i.e. for the same number of production lines.

2.1. Modeling of the relationship Z_iO and $Z_{ni}O$ with P_rO and P_o in the exploitation

In each exploitation system there is a limited resource non-inherent Z_{ni} depends on strong from conditioning environmental (especially educational level and technical culture of human potential – operators and support objects). That it can be fully handled ("well maintained" [22]) must be assigned and maintained [24] the competent $Z_{ni}O$. It determines the ability to use Z_iO in exploitation. For the purposes of the developed in article model P_rO assumes that each object in your exploitation system has a numerically specified value Z_iO and allocated him to the numerical value of $Z_{ni}O$ on the basis of which specifies its numeric value P_rO. With the value of the P_rO is determined for the object value P_o (R_o) (Fig. 1).

In the production process the value P_o it is determined on the basis of your Z_iO for specifically assigned to $Z_{ni}O$, taking into account the limitations of illustrated in Fig.2. In the new exploitation system conditions, it should be verify that P_o adopted in the existing exploitation of the object will not be changed due to the inability to secure appropriate values of $Z_{ni}O$.

A problem which was solved by the construction method, is how to adjust the links to the numeric resource Z_iO and $Z_{ni}O$ with P_rO and P_o through one mathematical relationship, would have been possible to calculate this depending on the numeric value having a meaningful unit of measuring. In Fig. 1 we read that the two models are needed. The first is the model for calculating the P_rO with numeric values Z_iO and $Z_{ni}O$, and the second is the model for calculating the P_o (R_o) with P_rO.

The model for calculating the $P_rO = \mathrm{f}(Z_iO,\ Z_{ni}O)$ has been proposed in section 2.2 of this article. It is assumed that the full use of the Z_iO and allocated him to $Z_{ni}O$ is synonymous with getting the maximum value of the P_rO_{max} users achieve $P_{o\,max}$ (Fig. 3). However, because the other constraints (e.g. the number of repair or indicators reliability, the actual quality of service) the value of P_rO usually is less than the P_rO_{max} (Fig. 2).

Therefore, when you enter the object to a new exploitation system, with the appointment of its new value P_o [5], it should be refer to the initial value of the Z_iO and $Z_{ni}O$, and not only to the adopted, by the previous user (or administrator-using) it in other the conditions, value P_o. As the new exploitation conditions (operating and/or use) used by the manufacturer of the restrictions (on Fig. 2 - I and II type) may be different. For example, type I. increase reliability operation object, and for type II. this for example reduce operating costs, the reference exploitation economy until the more modern design objects.

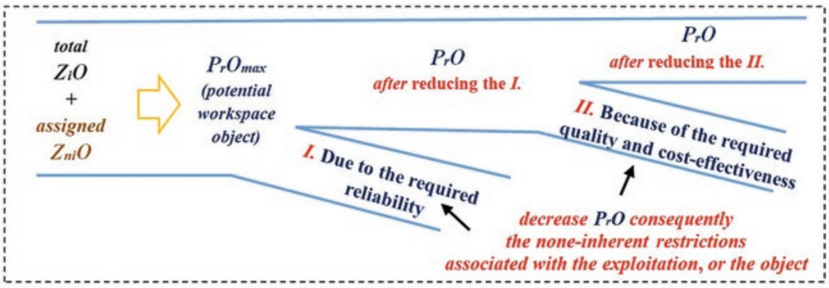


Fig. 2. *Illustration of the relationship Z_iO and $Z_{ni}O$ with the potential of the working objects (P_rO) and illustration of the reduction of the P_rO as a result of the admission of non-inherent limitation (type I. i.e. to increase the reliability of the operation object or type II.- reduce operating costs, reference operating economy until the more modern design objects)*

In the field of organization management of production (or of the service industry) to recognize factors that affect the processes can be difficult to identify when trying to deal with factors or resources reciprocally conjugated as independent. Hence the proposed in the article model assumes a breakdown of the factors or resources (inherent, non-inherent), which describes the regularity of exploitation and change the state of objects or processes affecting independently from each other on production capacity or service capacity organization. Used for the modeling of the space complex numbers combines these independence without complicated relationships and brings new opportunities in the analysis of their impact on the desired parameter assessment organization (or processes, or object), which represents a new quality in the formulation mathematical models that describe the simultaneous impact of environment and object to the manufacturing facilities capacity of the organization of any type (e.g. production, services). This type of modeling simplifies especially analysis of the actual causes of changes in manufacturing processes, cost and quality in technical systems (inherent - requiring redesign object and process or non-inherent - demanding taking into account the impact of the quality of work, level of culture or technical mentality in the country or the region, the corresponding organization of production and handling). Included in the work of the general model potential workspace technical object (P_rO), after appropriate changes in assumptions can be used to R analysis, cost, performance marketing, and so on, what the author intends to present in the next articles.

2.2. Mathematical model P_rO in a set of complex numbers

The mathematical form of model P_rO presented in the form of equation (5) is illustrated in Fig. 3. The mathematical model the numeric indicator P_rO allows you to link the inherent and non-inherent resources and exploitation system generating a result one numeric value.

$$P_rO = z = a_i + i\,b_j = \left(Z_iO\right)_i + i\left(Z_{ni}O\right)_j \tag{5}$$

where:

- P_rO – the potential workspace technical object
- Z_iO – inherent resource object
- $Z_{ni}O$ – non-inherent resource object
- i – contains in the range $i_{min} \div i_{max}$,
- j – contains in the range $j_{min} \div j_{max}$,
- $i_{min\backslash max}$ – minimum\maximum (limit) value inherent resource object
- $j_{min\backslash max}$ – minimum\maximum (limit) value non-inherent resource object

The potential workspace technical object (P_rO) described of equation (5) is based on the mathematical notation the complex number $z = a_i + ib_i$, where the real part describes the inherent resource object ($a_i = Z_iO$), and the imaginary part of the non-inherent resource object ($b_i = Z_{ni}O$). In Fig.3 the location of the complex numbers that describe the characteristic values P_rO. On it shown in the general case, numerical P_rO described the equation (6):

$$\left(P_rO\right)_{a_i,b_j} = \left(Z_iO\right)_{a_i} + i\left(Z_{ni}O\right)_{b_j} = z_{\,a_i,b_j} = a_i + i\,b_j, \tag{6}$$

as well as the distinctive position of the complex number P_rO on the complex plane such as:

a) $\left(P_rO\right)_{a_{max},b_{max}}$ – for adopted maximum values: $(Z_iO)_{max}$ and $(Z_{ni}O)_{max}$,
b) $\left(P_rO\right)_{a_{min},b_{min}}$ – for the adopted minimum values: $(Z_iO)_{min}$ and $(Z_{ni}O)_{min}$,
c) $\left(P_rO\right)_{a_{min},b_j}$ – for values: $(Z_iO)_{min}$ and $(Z_{ni}O)_{bj}$,
d) $\left(P_rO\right)_{a_i,b_{min}}$ – for the value of: $(Z_{ni}O)_{min}$ and $(Z_iO)_{ai}$.

With illustration, P_rO (Fig. 3) we conclude that when you change the value of the $b_i = Z_{ni}O$, or change the value of $a_i = Z_iO$ (or change them both at once) changes us value P_rO. This means that each change of exploitation conditions such as the pace of wear (a –changes to standards of use), whether the change in quality of service (ib) entails changing the value of P_rO, and thus changing the location of the complex number P_rO on the complex plane.

Comparison (inequality) of two P_rO represented by two complex numbers [29] is not possible, because the body of $\mathbb{C}$ (complex numbers) is the body of disordered. The lack of order in $\mathbb{C}$ makes the inequality between complex numbers, such as $z_1 > z_2$ (in our case, the $P_rO_1 > P_rO_2$) do not make sense, unless apply to the real numbers. Although there is a fine for two complex numbers such as (7):

$$a_1 + i\,b_1 \ge a_2 + i\,b_2 \Leftrightarrow a_1 \ge a_2 \quad or \quad a_1 = a_2 \;\; and \;\; b_1 \ge b_2\,, \tag{7}$$

however, it connect it with arithmetic and get a numeric value, that was to make sense of a volumetric units for the whole of the complex number, and not just for its components. This relationship describes how it changes the place of a complex number represented by described by the point on the complex numbers. Based on changes to this point on the plane of complex numbers can be assessed only, that of the basic types of resources you must change, or has changed since the last evaluation the value P_rO.

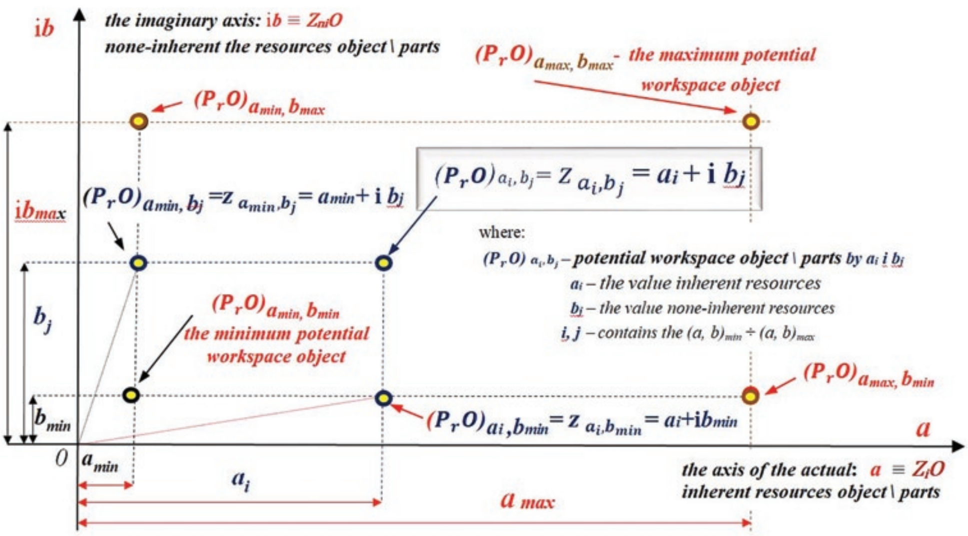


Fig. 3. Model potential workspace object (P_rO) on the I. quarter of the plane of complex numbers (P_rO) a_i,b_j – working potential object obtained on the basis of the adopted a_i,b_j ib_{max} – the maximum value of the resource non-inherent object a_{max} – the maximum value of the resource object inherent

However, the developed model binding P_rO resources Z_iO, $Z_{ni}O$ in the area of complex numbers contains one more, very useful information, in the form of the module number of P_rO.

Intuitively, assume that the value of the module with the number of P_rO can be regarded as axiomatically as the value of the productivity (P_o). After a number of considerations in the search for the inadequacy of such an approach, it was considered that but it has meaning and can be practically implemented. The model relationship P_o with P_rO shows in p. 2.2.

2.3. Mathematical model P_o the set of complex numbers

Although the value of a complex number P_rO does not meet the requirement of arithmetic, but the module P_rO so. This module axiomatically is assigned (in the proposed method) as the value P_o. In accordance with [27] expression $|z_1| > |z_2|$ (in our case $P_rO_1| > |P_rO_2|$) it is completely doable, because (8):

$$|Z_1|,|Z_2| \in \mathbb{R}; |P_rO_1| > |P_rO_2| \in \mathbb{R} \tag{8}$$

and the real numbers are the body ordered

Interpretation of geometric module P_rO on the complex plane, is the distance of a point of a complex number (representing the P_rO) from the origin. Hence module, or otherwise the absolute value of the number of $z \in \mathbb{C}$ save as (9):

$$|z| = |a_i + i b_i| = \sqrt{a_i^2 + b_i^2} \quad \text{thus} \quad P_o = |P_rO| = \sqrt{(Z_iO)^2 + (Z_{ni}O)^2}. \tag{9}$$

In Fig. 4 illustrates three cases of specific pairs of values Z_iO, $Z_{ni}O$ for which it was obtained $(P_rO)_{1,1}; (P_rO)_{2,min}; (P_rO)_{min,2}$ giving the same value P_o i.e. $P_{o1,1} = P_{o2,min} = P_{omin,2}$ what has been described the set of equations (10)

$$P_{omin,2} = \left|(P_rO)_{min,2}\right| = \sqrt{x_{min}^2 + y_2^2}; \; P_{o1,1} = \left|(P_rO)_{1,1}\right| = \sqrt{x_1^2 + y_1^2}$$
$$P_{o2,min} = \left|(P_rO)_{2,min}\right| = \sqrt{x_2^2 + y_{min}^2}; \; P_{o1,1} = P_{omin,2} = P_{o2,min}. \tag{10}$$

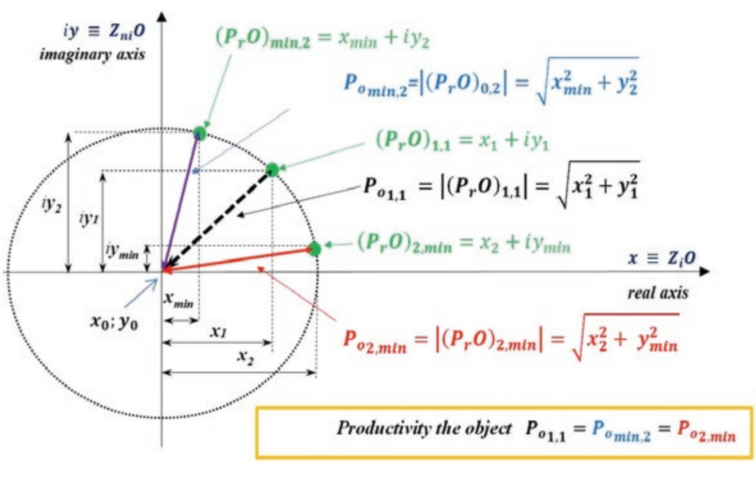


Fig. 4. The model relationship P_o with P_rO illustrated on I. quarter of the plane of complex numbers: $(P_rO)_{1,1}$ – working potential object obtained from the resources of $Z_iO=x_1$ and $Z_{ni}O=y_1$; $(P_rO)_{2,min}$ – potential working object obtained from the resources of the $Z_iO=x_2$ and $Z_{ni}O=y_{min}$; $(P_rO)_{min,2}$ – potential working object obtained from the resources of the $Z_iO=x_{min}$ i $Z_{ni}O=y_2$

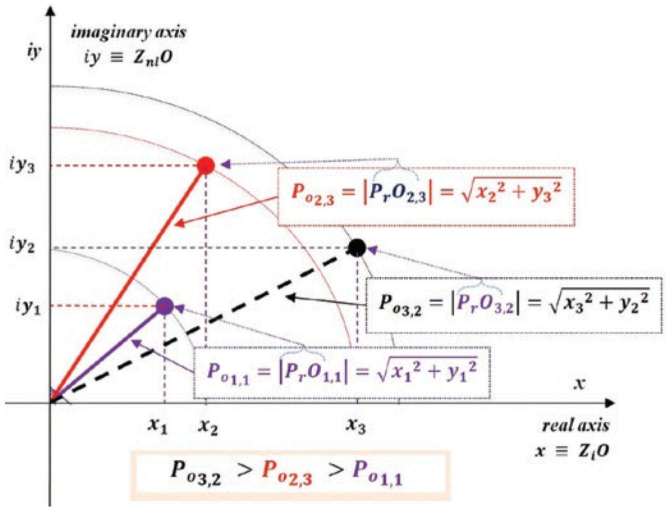


Fig. 5. Illustration of increase P_o by simultaneous improvements in exploitation procedures and service quality (increasing $Z_{ni}O$; $y_1 < y_2 < y_3$) and the improvement of the object or a more effective use of its resource (increasing the Z_iO; $x_1 < x_2 < x_3$)

While the Fig. 5 illustrates the three cases of the characteristic values of the Z_iO, $Z_{ni}O$ from which were obtained $(P_rO)_{1,1}; (P_rO)_{2,3}; (P_rO)_{3,2}$ giving different values P_o. Resource values Z_iO, $Z_{ni}O$ have been selected that obtained increasing the value productivity of the object (P_o) i.e. $P_{o3,2} > P_{o2,3} > P_{o1,1}$ what has been described the set of equations (11):

$$P_{o2,3} = |P_rO_{2,3}| = \sqrt{x_2^2 + y_3^2}; \; P_{o3,2} = |P_rO_{3,2}| = \sqrt{x_3^2 + y_2^2} \tag{11}$$
$$P_{o1,1} = |P_rO_{1,1}| = \sqrt{x_1^2 + y_1^2}; \; P_{o3,2} > P_{o2,3} > P_{o1,1}$$

By analyzing the information that contains the graph in Fig. 4 and Fig. 5, we conclude that we can adjust to changing in time resource values to productivity was fixed (Fig. 4). Simultaneously (Fig. 5) we have a simple illustration of that when, for the same category of objects, but different their perfections and various possibilities of them maintenance resources, their productivity (P_o) is different. Hence by obtaining or having the knowledge of existing or projected changes to the technical level service staff, their technical culture (described in the form of changes in the value of $Z_{ni}O$) and the possible updating of the standards use objects and changes environmental conditions (described in the form of changes in the value of Z_iO) we can preemptively correct our plans for the expected productivity. In conclusion, it must be find that the developed models (P_rO and P_o) should be very useful especially for predictive analytics. Using the conclusions of such analysis, you can make optimal decisions on construction schedules, allocation of resources to the given the production activity. We can also assess possession resources on the system exploitation and possession resources object in the forecast productivity necessary to undertake further production jobs or services.

2.4. Mathematical model of R_o in the collection of com plex numbers

If the value P_o the express using a numeric indicator, called here a R product technical object or production organization (R_o) with their production process (service), the model $P_{o1,1}$ based

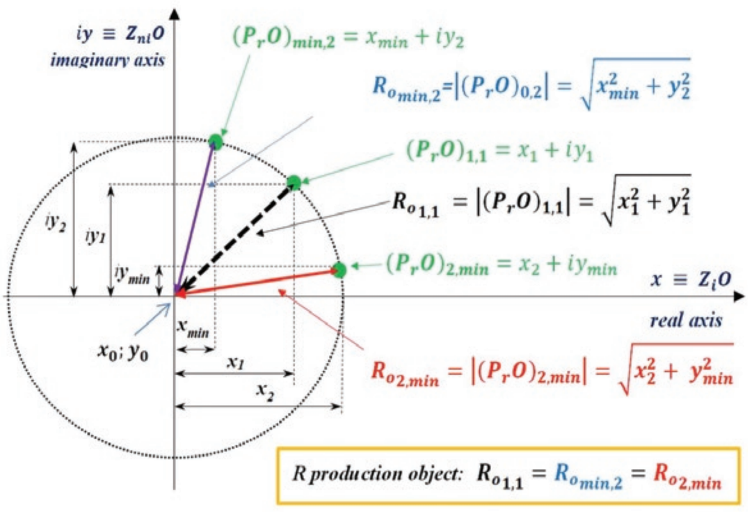


Fig. 6. The model calculated R production object (Ro 1,1) on I. quarter of the plane of complex numbers: (PrO)1,1 – potential working object from the resources of the ZiO=x1 and ZniO=y1; (PrO)2,min – potential working object from the resources of the ZiO=x2 and ZniO=y0min; (PrO)min,2 – potential working object from the resources of the ZiO=xmin and ZniO=y2

on dependencies (9, 10, 11) takes the form of (12). R object (R_{a_i,b_j}) is described (12) as a module complex number $(P_rO)_{a_i,b_j}$ (9) whose components are the contractual work resource object $(uZ_pO)_{a_i}$ with the value a_i and contractual service resource object $(uZ_oO)_{b_j}$ with the value b_j. The concept of a „contractual", has all the necessary match the types and the size of these types of resources in the group and detailed models to assign them the appropriate measures numbers. Consider the special case values $uZ_pO = x_1$ and $uZ_oO = y_1$ described a complex number $(P_rO)_{1,1}$ and shown in the Fig. 6. The value of the R object $R_{o1,1}$ is module of complex number $(P_rO)_{1,1}$ and is calculated in accordance with the equation (12):

$$R_{a_i,b_j} = \sqrt{(a_i)^2 + (b_j)^2}\Bigg|_{\substack{i=1 \\ j=1}} = R_{o1,1} = \left|(P_rO)_{1,1}\right| = \sqrt{(x_1)^2 + (y_1)^2} \quad (12)$$

where:

$R_{o\,1,1}$ – R productive(service) object *for* $(P_rO)_{1,1}$

$(P_rO)_{1,1}$ – working potential object for $uZ_pO = x_1$ and $uZ_0O = y_1$

x_1 – value uZ_pO, y_1 – value uZ_oO, i – is $i_{min} \div i_{max}$, j – is $j_{min} \div j_{max}$.

In Fig. 6 shows the two characteristic of the complex numbers i.e. $(P_rO)_{min,2}$ i $(P_rO)_{2,min}$ and with calculated them the value of R_o:

1) $R_{omin,2}$ for zero values $uZ_pO = x_{min}$ – described the expression (13):

$$(P_rO)_{min,2} = x_{min} + iy_2 \Rightarrow R_{omin,2} = \left|(P_rO)_{min,2}\right|, \quad (13)$$

2) $R_{o2,min}$ for zero values $uZ_oO = y_{min}$ – described the expression (14):

$$(P_rO)_{2,min} = x_2 + iy_{min} \Rightarrow R_{o2,min} = \left|(P_rO)_{2,min}\right|. \quad (14)$$

Marked on the Fig. 6 the two extreme cases can have the following interpretation:

a) when $R_o \cong R_{omin,2}$ (after $R_{min,2} \to x_{min}$) which means that it is a object with a small post-production excellence. Only for very good service or control can it achieve the accepted value of $R_o \cong R_{o2,min}$ (13). This type of resource allocation, we prefer for objects far less time than waiting time for work, a large resource maintenance for that object (e.g. for air cannons).

b) the second case, when the $R_o \cong R_{o2,min}$ (after $R_{o2,min} \to y_{min}$) means that the object is almost maintenance-free, i.e. is so perfect technically, that adopted the values R_o of control slightly and support requires (14). The type we prefer for use in a continuous manufacturing process, where we want to minimize the interruption to the service.

In the analysis of exploitation process illustrate the presented in Fig. 6 enables good visualization of existing joins between adopted the value R_o, production quality objects (Z_pO) and perfection of exploitation procedures (Z_oO). Also gives great opportunities to the theoretical estimation of quality (or numeric) changes P_rO and R_o due to changes in the uZ_oO and/or uZ_pO. Extreme cases R_o (using equations 13 and 14) describes the equations (15) and (16). On the basis of the appropriate selection of contractual value uZ_oO about assuming the y_{min} calculates the value of the R_o resulting from the capabilities and vulnerability of the maintenance object – $R_{o\,min,2}$ (the equation 15):

$$R_{omin,2} = \sqrt{x_{min}^2 + y_2^2} \quad (15)$$

On the basis of the appropriate selection of contractual value uZ_pO about assuming a_{min} calculates the value of the R_o resulting from the **inherent** of work by object $R_{o2,min}$ (the equation 16):

$$R_{o2,min} = \sqrt{x_2^2 + y_{min}^2} \quad (16)$$

Important is that all the objects that have the same value P_rO (or the object for different exploitation conditions with the same value P_rO) have the same value of the module and thus obtain the same value R_o (17).:

$$R_{o1,1} = R_{omin,2} = R_{o2,min} \quad (17)$$

This means that the selection of the value of the R_o object, to the required level, we can shape both by modifying its technical excellence, and by changing the environment to support it in a way that maintains the expected value of the R_o. Dependencies (12, 15, 16) can be applied in practical computer data collection system exploitation management system (machinery maintenance) [10, 29, 32, 33].

2.5. Illustration of the P_rO and R_o the object as a function of the Z_pO and Z_oO on the plane of complex numbers

To illustrate the potential of optimization resulting from the model P_rO and model evaluation it R_o shown in Fig. 7, Fig. 8, Fig. 9 the characteristic three cases how to obtain a specified value R_o by matching value of Z_oO and/or Z_pO :

1) case I. (Fig. 7) - the constant value uZ_oO and three different values of uZ_pO,
2) case II. (Fig. 8) - three different values uZ_oO and constant value uZ_pO,
3) case III. (Fig. 9) - three different values uZ_oO and three different values uZ_pO to ensure that the a fixed value R_o.

Case I. (Fig. 7) To increase the R_o was obtained by increasing the uZ_pO (e.g. improving the technical object and/or more effective use of its Z_pO or/and by changing standards of use [31]) while maintaining a constant value uZ_oO (stability environmental conditions, quality service and control object).

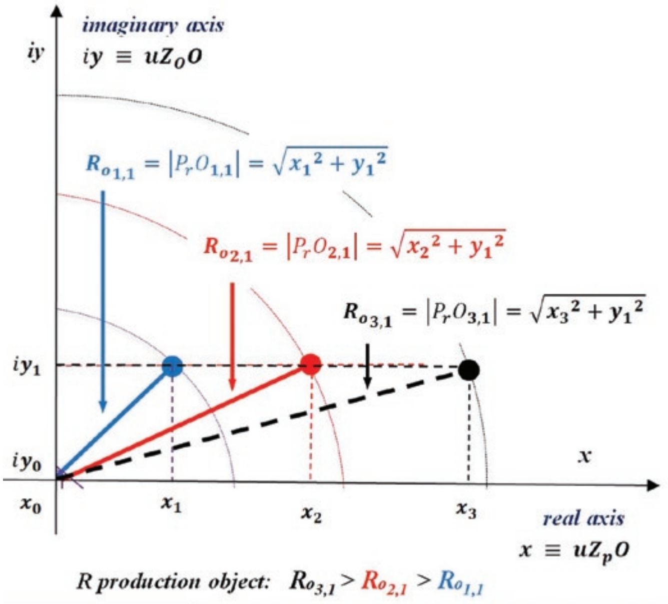


Fig. 7. (Case I.) Illustration values $Ro_{1,1}$, $Ro_{2,1}$, $Ro_{3,1}$ for three values of uZ_pO ($x_1 < x_2 < x_3$) with a constant value uZ_oO amount to y_1

Case II. (Fig. 8) Increase R_o was obtained by improvement exploitation procedures and improve the quality of service (uZ_oO takes the values $+iy_1 < +iy_2 < +iy_3$). By what the technical excellence of the object (uZ_pO) is fixed at is x_1. Points to describe the complex number P_rO flow on a simple in parallel to the imaginary axis.

We can see in Fig. 7, that exploitation procedures and quality of service were adopted here as constants ($uZ_oO = +iy_0$). Increasing the R_o, to assuming the constancy of the characteristics of non-inherent is possible by improving the technical excellence of the object or reduce workloads of the object (uZ_pO takes the values $x_1 < x_2 < x_3$). Points describing the complex number P_rO flow on a simple a parallel to the real axis, and R_o amount to the values $R_{o3,1} > R_{o2,1} > R_{o1,1}$.

Case III. (Fig. 9) Expected constant value R_o. Behavior of the established value of R_o illustrated by choosing three pairs of values uZ_oO and uZ_pO (y_1, x_3; y_2, x_2; y_3, x_1). We can see that the decrease in the value uZ_oO of the increase in the value of forces

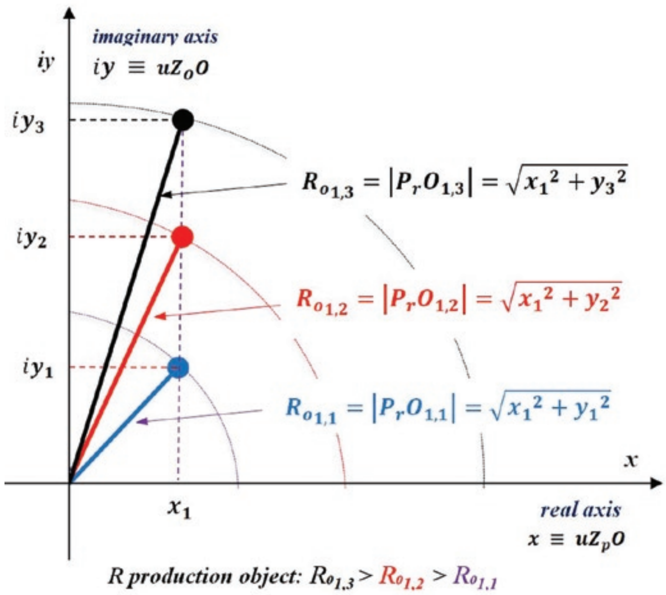


Fig. 8. (Case II.) Illustration resources $Ro_{1,1}$, $Ro_{1,2}$, $Ro_{1,3}$ for three values uZ_oO ($y_1 < y_2 < y_3$) at constant values of the Z_pO amount to x_1. The value of the R_o is growing, because $uZ_oO \rightarrow$ grows by uZ_pO = constants

uZ_pO and vice versa diminished value of uZ_pO forces increase in the value of uZ_oO.

In conclusion (Fig. 7, Fig. 8) it can be concluded that increasing the R_o is possible by increasing the uZ_pO (Fig. 7) and by increasing the uZ_oO (Fig. 8). Of course, it is possible in certain specific limits the possibility of technological and technical object and organizational setting and its exploitation process.

2.6. Summary of the picture value P_rO and P_o (R_o) as a function of changes Z_pO and Z_oO

The main purpose of illustration P_o (R_o) (Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9) was to show how changes to the Z_iO (Z_pO) and $Z_{ni}O$ (Z_oO) affect change the position of the P_rO on the

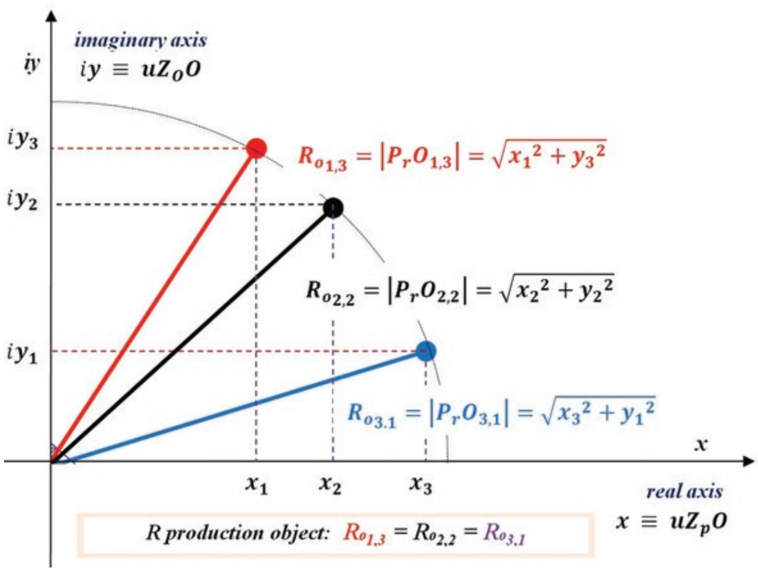


Fig. 9. (Case III.) Illustration of the increase R_o obtained by improving exploitation procedures and improving service quality (increasing uZ_oO; $y_1 < y_2 < y_3$) and improvement of the technical object or the more efficient use of the resource (increasing uZ_pO; $x_1 < x_2 < x_3$).

complex plane, and as shall be determined from the P_rO value $P_o(R_o)$. P_rO points equal distant from the origin shall determine the same value $P_o(R_o)$ for various combinations of the Z_pO and Z_oO. P_rO, and placed on the line parallel from the imaginary point to the stability of the Z_pO, and placed on a parallel line from the real axis on the stability of the Z_oO. This means that:

1) To preserve the value of $P_o(R_o)$ = constant, at changing *a* needs to be changed i*b* and vice versa, when you change the i*b* needs to be changed *a*.
2) To $P_o(R_o)$ increased, required is growth of at least one factor *a* or i*b* at non-decreasing the value of the second (but the most adequate evaluation of growth is when the sum of the geometric changes *a* and i*b* is positive).
3) If the value of the i*b* is decreasing at a constant value *a*, a force to be reckoned with reduction in the $P_o(R_o)$, which is the ability to:
   a) the increased number of failures,
   b) accelerate the achievement of the limit states,
   c) faster wear of the object.
4) If the exploitation research shows the deterioration of the i*b* is to maintain a constant value $P_o(R_o)$ should accordingly increase the value *a* the meaning:
   a) improve the quality/frequency service,
   b) apply the new operating procedures, etc.

2.7. Sample calculation of R_o for hypothetical value uZ_oO and uZ_pO

To illustrate how to use the developed models to determine the P_rO and $P_o(R_o)$ for technical objects shows the characteristic example of exploitation analysis (Table 1 and Chart 1). In Table 1. located for seven object, hypothetical value - uZ_pO = (5, 10, 15, 22.5, 30, 35, 40 *c.u.*) each of which is supported on the other system exploitation with numbers 1 to 7, which was allocated for the object values - uZ_oO = (40, 35, 30, 22.5, 15, 10, 5 *c.u.*). For the adopted data calculated P_rO and $P_o(R_o)$ for individual objects. Summary of data and calculation results are presented in Table 1 and Chart 1.

From the sample (Table 1 and Chart 1) shows that on the same simple arithmetic sum of units uZ_pO and uZ_oO of 45 *c.u.* value $P_o(R_o)$ calculated from the different P_rO does not have a constant value. Interestingly, minimum of $P_o(R_o)$ received by using a balanced level of resources of the Z_pO and Z_oO. This can be explained by that for the average excellence service system and an average of excellence quality of the object, the risk of state failure is the biggest and the largest is the risk of inefficient use of those resources. For objects with low technical excellence (small values of the Z_pO), but in a very good exploitation system (large value Z_oO) is more likely to fully use the resource work (Z_pO). However, for objects with high reliability and durability (a large value of the Z_pO) in a small resource maintenances exploitation (low value Z_oO) we have minimized the impact of the low quality of service tasks. In addition, such systems typically support professionals and highly qualified service and uses them with dedicated diagnostic systems.

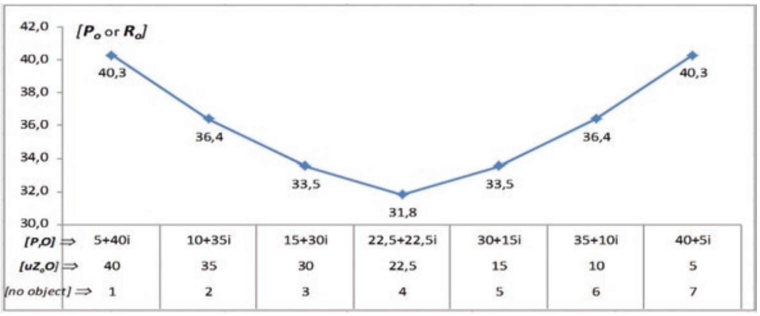
This is what it would seem natural that you should balance the chapter of excellence to object and its control system, it turned out to be by example calculated challenged.

One way to interpret the description of the contractual of the units (*c.u.*) value can be a description of the cost. We assume that the objects 1, 2, 3, 4, 5, 6, 7, pursue the same production. Using the proposed model we can make analysis of this, when it pays us to incur more costs, whether at the stage of the production (or buying) object, whether at the stage of his operating and maintenances of exploitation.

Table 1. Data sheet hypothetical values uZ_oO and uZ_pO and the results of calculations P_rO and R_o

Technical object	uZ_pO (Z_iO)	The type of exploitation system	uZ_oO ($Z_{ni}O$)	P_rO	$P_o(R_o)$
[No objects]	[c.u.]	[No systems]	[c.u.]	a complex number	[c.u.]
1	5	**1**	40	5+40i	**40,3**
2	10	**2**	35	10+35i	**36,4**
3	15	**3**	30	15+30i	**33,5**
4	22,5	**4**	22,5	22,5+22,5i	**31,8**
5	30	**5**	15	30+15i	**33,5**
6	35	**6**	10	35+10i	**36,4**
7	40	**7**	5	40+5i	**40,3**

Chart 1. Contract value $P_o(R_o)$ for the object as a function of simultaneous changes uZ_pO = (5; 10; 15; 22.5; 30; 35; 40 c.u.) and uZ_oO = (40; 35; 30; 22.5; 15; 10; 5 c.u.) so that was maintained constant cost value units (45 c.u.) in the number of complex P_rO.



For example, for the manufacture of the first object we had to spend 5 *c.u.* costs. Due to used savings in its manufacture (compared to 7 to produce which we have used 40 *c.u.*) necessary to apply more expensive procedures for its exploitation (in terms of use of his entire *R*) measured at 40 *c.u.* with costs. Contractual units (*c.u.*) can be for example in thousands of dollars. Because P_rO describes the costs is obtained with the chart R_o (Chart 1.) shows us how to choose the cost of production and exploitation for maximum effect R_o. Assuming we have limitations when increasing production quality (or buy a property for example, 1) to get a specific R_o (e.g. 40.3 *c.u.*) we have to incur the costs of the exploitation in terms of 40 *c.u.* costs. It is still only analysis quality but show us that to evaluate productivity and the R_o objects we lead simultaneous analysis of the cost of both production (or buying) objects, that are necessary to bear to the productivity $P_0(R_o)$. Of course, the model has entered restrictions to min\max production cost and max\min cost of exploitation for specific objects in specific in conditions of their exploitation.

3. Conclusion

Developed an innovative method of analysis, estimation and optimum amount of resources inherent Z_iO (Z_pO) and non-inherent $Z_{ni}O$ (Z_oO) in evaluation the productivity $P_o(R_o)$ object (or economic organization) with the use of the copyright the model potential workspace object (P_rO) in the space of complex numbers (in the body $\mathbb{C}$) brings new opportunities for theoretical and application in association areas technical sciences and economics. In the field of technical sciences can be used for optimal design object for fixed system exploitation or service resource selection to the perfection of the object and the intensity of its use. In the field of economics can be used to optimize productivity for available (or will plan) inherent and non-inherent manufacturing resource in order to of maximizing or optimize profits.

Developed the model P_rO gives you great possibilities of a figurative the conduct of analysis and estimates, using a single numeric indicator global impact of manufacturing resource selection i.e. quality of service/operator ($Z_{ni}O$, Z_oO) and/or quality changes production of objects (Z_iO, Z_pO). While the developed model use values P_rO to evaluation the value $P_o(R_o)$ allows easy transition from workspace potential analysis on the assessment of productivity object (or process or organization).

Therefore, the method includes two stages of analysis: possible technological and technical (engineering design object and engineering procedures exploitation) related to the selection of quality objects to exploitation systems (or system maintenance to the object or processes or production organizations), and resources-economic estimation of production capacity and the number of optimization products and profits.

Developed models can also be used (especially after the application of models to data collection and processing system) to monitor changes to the process exploitation and the technical state of object (or process or organization) on the changes of production capacity the test object in your environment .

In presented in the article as the models enable you to estimate P_o (R_o) on the large level of generality is dependent on how the selection of the contractual units (*c.u.*) for Z_iO (Z_pO) and $Z_{ni}O$ (Z_oO). Shown in article to illustrate the usefulness of the proposed models P_rO in estimate values P_o (R_o), for specific cases uZ_pO and uZ_oO, indicates on the application capabilities developed method with the developed models for it P_rO and P_o (R_o). Based on these examples, it can be concluded that the proposed model P_rO allows you to:

- very good to illustrate the impact of changes of the Z_pO and Z_oO to the value of the P_rO,
- simple estimate of the P_rO changes P_o (R_o) the technical object or production processes or production organizations,
- quick assist current production capacity of objects by changes in exploitation conditions and/or changes the condition of an object based on the values P_o (R_o) of objects.

Shown in the final part of the article (using the expert method) diagram for estimating values P_o (R_o) objects for the adopted values of the uZ_pO and uZ_oO gave interesting results. Minimum P_o (R_o) we get at sustainable level the value of the uZ_pO and uZ_oO objects. That is, balancing the financial expenses incurred on the growth of uZ_pO and uZ_oO does not give optimum values P_o (R_o) of the object. The results obtained show that the proposed models P_rO and P_o (R_o) for objects bring a new quality in the rapid assessment of the adequacy of the adopted resources Z_iO (Z_pO) and $Z_{ni}O$ (Z_oO). This knowledge should be particularly useful to those who must change the use of objects or bring object to a different exploitation system than recommended by the manufacturer or want to point out the possible directions of modernization of the exploitation of its objects.

Presented in the article sample interpretations to illustrate only the areas of application and are not ready-to-use models for specific objects. First of all it would be the above analysis linked with the cost of obtaining increased uZ_pO and the costs of obtaining increased uZ_oO. The results of such analysis may allow a choice between the improvement of the object and the improvement of the system's maintenance and help in determining the optimum boundaries of these changes.

As the developed models may be particularly useful when you automate the process of calculating the aggregated values of uZ_pO and uZ_oO, and with them the summed values P_o (R_o).

The same P_rO model can be useful also as an indicator of the efficiency of production, and in the monitoring of the level of stability of the process exploitation and maintenance of objects.

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