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A PRAXIOLOGICAL MODEL OF A MACHINE MODERNISATION PROCESS

Key words: machine modernisation process, designing process, praxiological models, praxiology.

Abstract: The aim of the paper is to present the developed praxiological models of machine modernisation processes. The reasons for conducting machine modernisation processes and the aims of such processes were characterised in the paper. The structure of probably the simplest praxiological model that is a praxiological chain was described. The developed praxiological models of actions connected with the modernisation of machines were presented in their graphical forms as well as with the use of proper formulas. The action of a technical object modernisation was defined, and two types of modernisation processes were selected and described using the developed models. The models may be used during the analysis (e.g., being the basis for an evaluation) or synthesis (designing) of machine modernisation processes in order to achieve a better efficiency of the performed actions.

Prakseologiczny model procesu modernizacji maszyn

Słowa kluczowe: proces modernizacji maszyn, proces projektowania, modele prakseologiczne, prakseologia.

Streszczenie: W artykule przedstawiono przyczyny i cele prowadzenia procesów modernizacji maszyn. Po omówieniu wybranych zagadnień związanych z modelowaniem prakseologicznym − konstrukcją i wykorzystaniem łańcuchów działań i relacji zabezpieczenia, wyróżniono typowe procesy odnoszące się do technosfery, które mogą być rozpatrywane jako działania. W ich obrębie zlokalizowano procesy modernizacji maszyn; zdefiniowano działanie, jakim jest modernizacja obiektu technicznego, a także wyodrębniono dwa rodzaje procesów modernizacji. Przyjęte kryterium rozróżnienia stanowi fakt, czy modernizacja związana jest z likwidacją obiektów poprzedniej generacji, obok których wprowadzane zostają nowe, czy dotyczy ona wyłącznie fizycznej modyfikacji istniejących (eksploatowanych) maszyn. Procesy modernizacji obu rodzajów, jako zespoły działań, zostały opisane za pomocą opracowanych modeli prakseologicznych. Modele te mogą być wykorzystywane w czasie analizy (zwłaszcza stanowiącej podstawę oceny) albo syntezy (projektowania) procesów modernizacji maszyn oraz podczas opracowywania metod projektowania takich procesów w celu poprawy skuteczności prowadzonych działań.

Introduction

Machine modernisation processes are conducted in different circumstances, but the main reason for such actions are the changes of the needs which cannot be (further) satisfied with the use of the technical objects developed in the past. These needs (often indicated due to the market requirements) could be satisfied within the process of the operation of the modernised machines. Therefore, the aim of a modernisation process is to achieve better satisfaction of the indicated needs due to the proper operation of a modernised technical object, previously redesigned (Polish: *przeprojektowany*; at least partly newly developed) and newly manufactured or rebuilt (Polish: *przebudowany*) and being maintained according to a new maintenance technology (developed especially for this object). The described processes include a number of actions conducted by humans; therefore, they may be analysed and synthesised using praxiological models (and especially the praxiological chains).

1. Praxiological model of an action

Praxiology could be considered as the science of the efficacy of actions (cf. [3]). It was widely characterised in current papers, e.g. [3, 4]. There are praxiological models developed for the formal representation of actions. Probably the simplest praxiological model is a praxiological chain. It represents one single action and consists of three elements, which are essential to perform the modelled action. These are the subject performing the action, the tool used during the action, and the object of the action. The chain may be described with the use of Formula 1 [8].

$$C_1 = x_1, y_1, z_1 \tag{1}$$

where

C_1 represents the chain, x_1 represents the subject, y_1 represents the tool (the intermedium of the action) and z_1 represents the object of the action [8].

Praxiological chains are especially useful while modelling the relations of support that occur between different actions and are represented by the connections between the chains. The identified relation of support may allow one to more efficiently perform the supported action or to perform the action at all. An exemplary model including two chains C_1 and C_2, where the C_2 chain represents the action supporting the action modelled using the C_1 chain, is presented in the Fig. 1 [8]. It may be a part of a more complicated praxiological network [8].

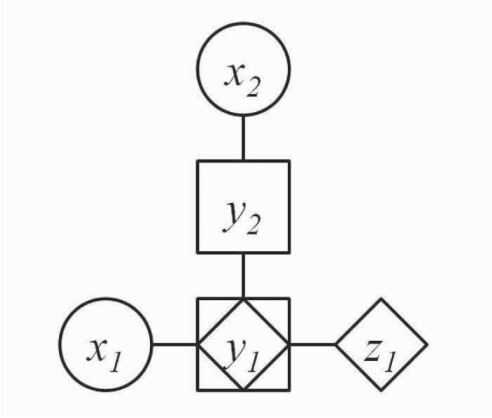

Fig. 1. A graphical representation of the action modelled using the C_2 praxiological chain supporting the action presented by the C_1 chain [8]

In general, the relation of the direct support between two actions may be described with the use of the set of the following formulas (2) and (3) [8].

$$C_i = \langle x_i, y_i, z_i \rangle \wedge C_j = \langle x_j, y_j, z_j \rangle \tag{2}$$

$$C_i \vdash C_j \Leftrightarrow x_j \left| \frac{x_i}{z_i} \vee x_j \right| \frac{y_i}{z_i} \vee y_j \left| \frac{x_i}{z_i} \vee y_j \right| \frac{y_i}{z_i} \tag{3}$$

where

$\vdash$ – refers to the relation of the direct support between the chains representing the actions,

$e_j \left| \frac{e_i}{z_i} \right.$ – presents the relation of the e_j element of the j-chain supporting the e_i element of the i-chain relative to the subject z_i of the i-chain; therefore $e_i = \{x_i, y_i\} \wedge e_j = \{x_j, y_j\}$.

2. Actions applied to technical objects

According to the selected typical approaches to the problems of a machine's life-cycle and satisfaction of human needs [7, 11], the changes being done within the technosphere (described as the system consisting of the artefacts which become an artificial environment for human beings [1]) are the results of the following processes: designing (and constructing), manufacturing, using and maintaining, and withdrawing the machines from use (cf. [1, 6, 11]), shown in Fig. 2 (but often classified in more complex ways). These processes may be modelled as actions (or sets of actions); therefore, it becomes possible to model them with the use of praxiological models [8].

Such a set of actions is performed each time a new series of machines occurs. Because of it, an important relation between the sets of actions taking their place in time may be indicated relating to the fact that the experience of all of the people involved in these actions (and especially the ones performing these actions) is developed due to the collected data and its exchange [5, 6]. A number of these relations may properly function thanks to the research conducted during the regular operation and maintenance of machines (Polish: *badania eksploatacyjne*; cf. [10]). The selected relations are presented in Fig. 2 (cf. [5]). The ones drawn with the regular lines represent the data exchange processes, and the ones marked with the bold lines refer to the sequence of actions relating to a single object (or a single series of objects). The following letters represent: *D* – 'designing' as well as designing methodology, *M* – 'manufacturing' and manufacturing technology, *U* – 'using and maintaining' as well as operational and maintenance technologies, *W* – 'withdrawing from use' and its technology. Additionally, *B* refers to 'database' and *P* refers to 'process'. Consequently, each pair of the letters, always followed by a time index, represents the

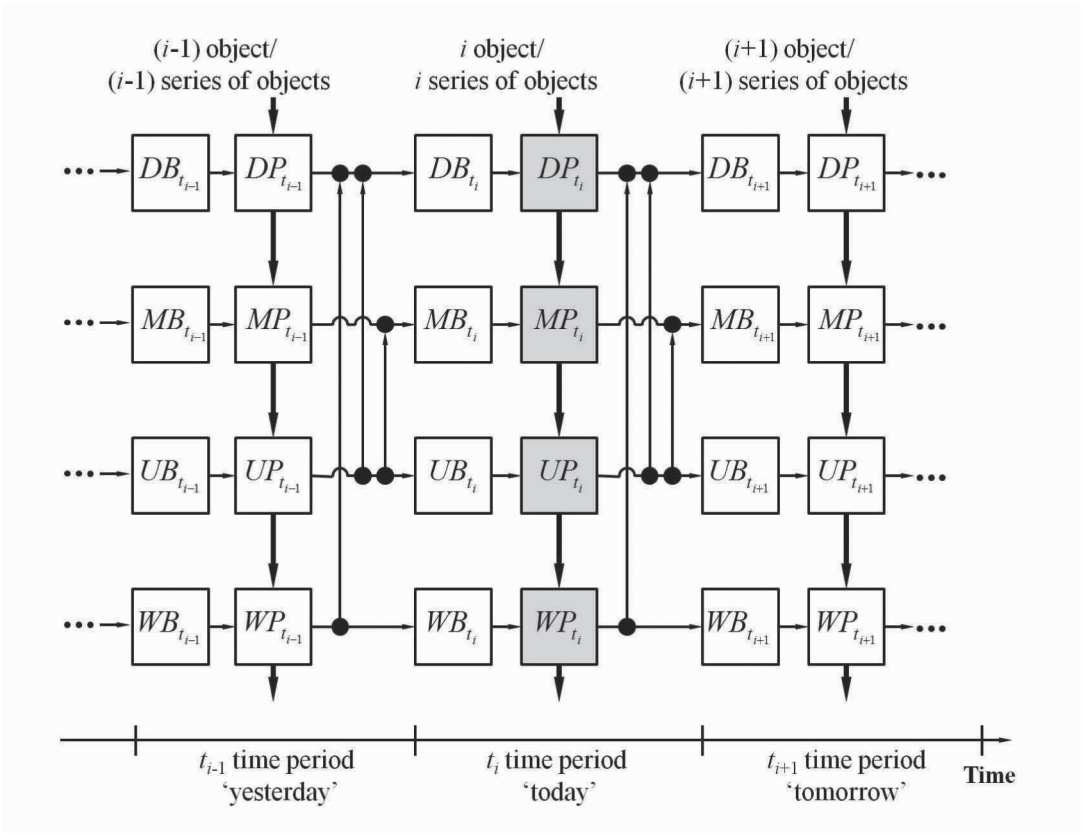

Fig. 2. Typical relations between the sets of processes applied to the technosphere (cf. [5])

proper database or process as well as the time period it operates at (cf. Fig. 2).

Another problem within the presented field is the modernisation of machines that, depending on its circumstances, occurs occasionally or constantly. The constant processes of technology and technical objects development may be characterised with the use of, e.g. S-curves model and was widely described in [7]. Eventually, the machine modernisation process may be considered as a set of actions selected from the ones presented in the first paragraph of the current section of the paper.

3. Machine modernisation process modelling

Generally, it could be assumed that the machine modernisation processes may be conducted in two different circumstances; therefore, two different types of such processes may be indicated.

In the first case, the previously developed solution is modernised during designing a new series of machines (obviously according to the new, current, or forecasted needs but on the basis of the solutions incorporated in the previous series) that are to be manufactured later. The costs of such a modernisation are incurred by the designer and the manufacturer of the machine. The exemplary reasons for such a modernisation may include the following:

- Aiming at the development of a better product due to the market requirements (generally speaking);
- Aiming at the better performance of the machine (being the result of a higher efficiency, reliability, durability, better environmental protection as well as a lower operational risk, mass, fuel consumption, etc.);
- Aiming at the reduction of the manufacturing costs (or simplifying the manufacturing technology) of the machine being currently designed; and,
- Aiming at the reduction of the maintenance costs of the machine being now designed (cf. the life-cycle costs [13]).

A simplified praxiological model of the described modernisation process is presented in Fig. 3. The meanings of the symbols used in the figure are as follows: D – designer, M – manufacturer, U – user, S – maintenance staff, TO – technical object (machine), OO – operational object, D_{MI} – designing methods and instruments, M_{TI} – manufacturing technology and instruments, S_{TI} – maintenance technology and instruments, D_{MIS} – data management instruments used by the maintenance staff, and D_{MIU} – data management instruments used by the user of the technical object (TO).

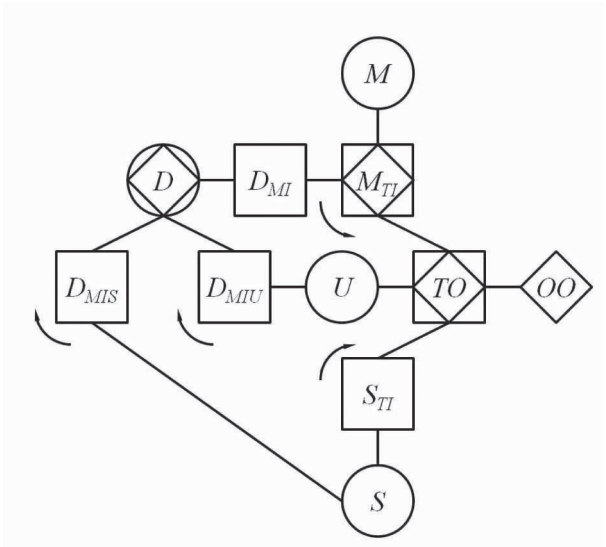

Fig. 3. A praxiological model of the first type of machine modernisation process (developing and introducing new, modernised generations of machines)

The presented actions are performed in a continuous, fixed sequence (cycle), including designing, manufacturing, using and maintaining, reporting and so on. The relations of support between them may be presented using Formula (4).

$$D\left|\frac{M_{TI}}{TO}\wedge M\right|\frac{TO}{OO}\wedge S\left|\frac{TO}{OO}\wedge U\right|\frac{D}{M_{TI}}\wedge S\left|\frac{D}{M_{TI}}\right. \quad (4)$$

In the second case, the already existing machine is modernised (adapted) during the process of its physical modification (rebuilding), which includes its disassembly and assembly operations. The costs of such a modernisation are incurred by the user of the machine. The exemplary reasons for such a modernisation may include the following:

- Aiming at the reduction of the maintenance costs (as well as time or work) of the machine;
- Enabling the possibility of using cheaper replacement parts;
- An inadequate performance of the machine (e.g., as a result of a mistake at the moment of its purchase or designing and/or manufacturing); and,
- An increase of requirements for the operational safety of the machine or the protection of the environment (especially as a result of the civilisation progress).

A simplified praxiological model of such a modernisation process is presented in Fig. 4. The meanings of the symbols used in the figure are as follows: D_1 – designer designing the technical object (*TO*) as a new one, D_{MI1} – designing methods and instruments used by the designer (D_1), D_2 – designer redesigning the technical object (*TO*), D_{MI2} – designing methods and instruments used by the designer (D_2), *R* – staff in charge of the modernisation process physical realisation (e.g., disassembling and assembling the machine as well as manufacturing new parts that will be included in it and withdrawing from use the ones which will not be needed any more), and R_{TI} – modernisation technology and instruments. The remaining symbols should be interpreted according to the description of Fig. 3.

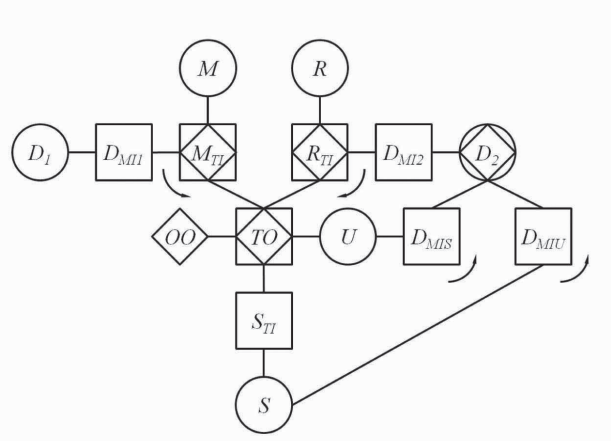

Fig. 4. A praxiological model of the second type of the machine modernisation process (rebuilding an existing machine)

In the presented case, the actions are performed once but still in a fixed sequence, including redesigning, manufacturing new /additional/ parts, disassembling, removing selected parts and often scrapping them, target rebuilding operations (modifying some of the remaining parts of the machine), and assembling. The praxiological network presented in the Fig. 4 may be described using the following set of formulas (5).

$$D_1\left|\frac{M_{TI}}{TO}\wedge M\right|\frac{TO}{OO}\wedge S\left|\frac{TO}{OO}\wedge D_2\right.$$
$$\left|\frac{R_{TI}}{TO}\wedge R\right|\frac{TO}{OO}\wedge U\left|\frac{D_2}{R_{TI}}\wedge S\right|\frac{D_2}{R_{TI}} \quad (5)$$

Taking into consideration both types of modernisation processes presented in this section of the paper, the machine modernisation process may generally be described as a set of actions, where an approved technical solution is taking place, aiming at its adaptation (Polish: *dostosowanie*) to the requirements resulting from the current (new) needs without changing its main function.

The first stipulation 'an approved technical solution' allows one to differ the modernisation process from a regular designing process, which normally includes iterations connected with the improvements of the technical object being developed before its final approval.

The second stipulation 'without changing its main function' allows one to differ the described process from any action connected with the change of an existing machine's construction. For example, a passenger tramcar may be rebuilt in order to obtain a snowplough, but then its main function is completely changed. This is the reason why the snowplough should not be considered as a modernised passenger tramcar (but only as a rebuilt one).

Conclusions

Modernisation may be efficiently performed only according to the high quality data obtained from the regular operation and maintenance of existing machines. This is one of the most important reasons for collecting, storing, and analysing such data.

The first type modernisation process is the regular way of the development of technical objects (and the technosphere). Its proper functioning may often determine the company's competitiveness on the market.

The second type modernisation process seems especially important to the practical issues of machines operation and maintenance. Obviously, it cannot be classified as a part or a kind of a maintenance process, but it may be conducted in practice by the regular servicing staff and in the circumstances offered by a regular maintenance workshop.

Modernisation processes of both types may be conducted at the same time, as is often observed.

Every modernisation process should be carefully planned (designed, cf. [2]) before it is conducted. That is one of the reasons for modelling such a process, and in particular, using the praxiological models. Another important issue is the analysis of the results of the modernisation process, which allows one to evaluate the decisions made during its designing. The results of the evaluation should allow one to develop better modernisation technologies.

The proposed models could and should be further developed in order to obtain more sophisticated models for machine modernisation processes designing. They also may be constructed in more complex ways (cf. [12]) in order to take into consideration more aspects of the modernisation processes. Such an activity may lead to the formulation of new methods and/or standards.

Considering some difficulties that occur during modelling a number of actions performed in a particular sequence in time, the praxiological chain model should be developed in order to introduce the passage of time into such a model.

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