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Ecological tribology

ECO-TRIBOLOGICAL CORRECT DESIGN: NEW DEMANDS OF CONTEMPORARY DESIGN

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ABSTRACT

Tribologically correct design is an important indicator of design quality and technical level of a product. The basic characteristics of such a design are minimisation of friction and wear to possible limits with simultaneous increase of degree of reliability and service life.

Ecologically correct design is a new aspect in systematic approach and methodological elaboration of design process. It is based on activities of identification of environmental aspects and their integration into the process of product design and development. The goal is continuous improvement of performances of product environment and interaction between environment and product.

Basic principles of tribological and ecological aspects of methodologically derived process of design are considered in the paper. In addition, an attempt was made to find the areas of common principles in the processes of product design and development.

Keywords: tribology, ecology, friction, wear, environment.

AIMS AND BACKGROUND

Design as reflective and creative process is, in the broadest sense, an intellectual project undertaken to satisfy certain needs in the best possible manner. Supported by scientific discoveries and laws, design is technical activity aimed towards development and manufacture of products.

The growing need for development of complex, high-quality products has broaden the list of demanded design characteristics as product evaluation parameters. In addition to conventional characteristics like function, shape, dimensions,

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material, ergonomic features, aesthetic features, technology and economy, there is larger and larger need for good tribological and ecological characteristics of design.

Tribologically and ecologically correct designs are new aspects of design process, and significant parameters of quality of a new product.

TRIBOLOGICALLY CORRECT DESIGN

Tribologically correct design is an important indicator of design quality and technical level of the product. Basic characteristics of this kind of design are minimisation of friction and wear to the possible limit with simultaneous increase of reliability level and extension of lifetime. Requirements are very complex and frequently incompatible with basic indicators of design quality, but they are necessary if we want to make the length of life closer to life of functional ageing of construction[1].

Tribologically correct design is a new aspect in systematic approach and methodological elaboration of the design process. It is a process of refinement of methodological design and computer-aided design – the concept based on application of tribology and tribological knowledge in the design process.

Tribologically correct design begins already in the construction planning phase in which important tribology knowledge is applied taking into account different aspects and influential factors. With certain limitations, general function of a system and tribological aspects must be connected with the following relations:

- system – environment – tribological processes,
- input and output values – tribological processes.

Forming of the construction is centrally positioned phase in which adopted conception is refined, construction revived and mostly made ready for the beginning of production.

Tribological approach to the phase of forming of the construction means application of available tribological possibilities with the final goal of gaining tribologically correct elements and structures. Tribologically correct means minimising friction and wear to the possible limits. Selection of shapes and dimensions, as well as meeting the other proclaimed features and characteristics of the construction, means achievement of satisfactory quality of all tribomechanical systems (TMS) that make-up the formed construction[2].

Tribologically correct forming of construction is best achieved by application of ‘tribological regulators’. Tribological regulators are all elements and possibilities for regulation with which appropriate action is taken on the structure of tribomechanical system (TMS). In contrast to influential factors that have multiple meanings, tribological regulators are unambiguously determined and their basic

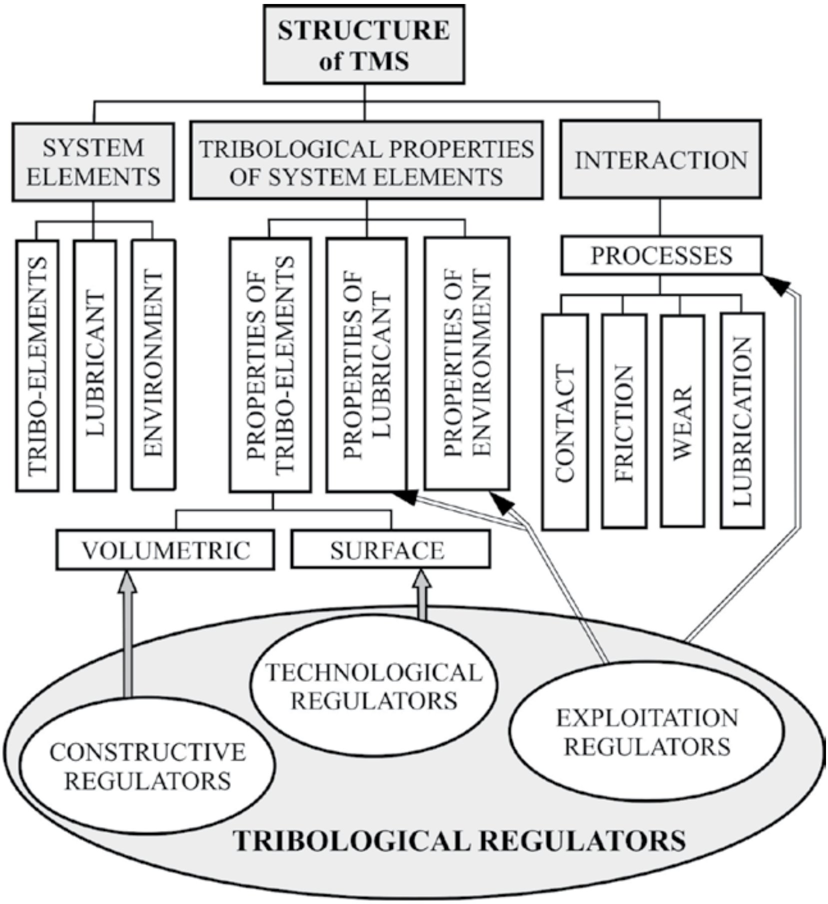

Fig. 1. General scheme of tribological regulators effects on the system structure

task is to minimise negative effects of numerous factors on friction and wear. By influence of tribological regulators on system elements, tribological characteristics of elements and quality of structure of tribomechanical systems are improved.

Tribological regulators, may be features (shape, material, etc.), but also regimes (exploitation, processing, etc.), or contact surface modifications (topography, coatings, etc.). In any case, tribological regulators carry a sign of a 'good choice' and use of available possibilities in the phase of tribological forming of the construction[3-5].

Figure 1 shows a general scheme of tribological regulators action on the structure of tribomechanical systems, where the regulators are divided into three major groups: construction regulators, technological regulators and exploitation regulators. By raising the level of tribological features of the systems elements using the corresponding group of tribological regulators, desired tribological processes are urged and tribologically correct construction is realised.

Finally, tribologically correct design ends with the phase of detailed design in which construction is definitely revived and necessary features are built in.

DESIGN AND ENVIRONMENT

The last decade of the second millennium and of the 20th century is characteristic, among other things, by special interest for environment that came into attention both of scientists and politicians, but also of experts from different areas and almost of any individual – inhabitant of our planet.

There are many definitions of environment, but their essence is the same: environment is all that surrounds human being (organism) with all mutual relations and interactions. Environmental factors that are necessary for organism during the lifetime and that may have negative effect on organism are called vital factors (ecological factors).

Environmental science is new multidisciplinary synthesis and complex scientific field that unites several scientific fields. It is expected to help development and realisation of conception of sustainable development adopted by international forum of the European Union (in 1990) and the United Nations on the Rio Summit (in 1992).

Sustainable development as an idea, term and approved concept, means such development that would provide the use of natural resources and created goods in a way to enable 'satisfaction of needs of current generations without endangering the future generations in meeting their needs'.

Products of human work originate from needs. Noticing the need, the human thinks with what and how to satisfy that need. Observed in that way, design is, in the broadest sense, intellectual project undertaken to satisfy certain needs in the best possible manner.

The human is very large and significant factor for environment. At the same time, he is the act and the part of nature, but also a being that greatly influences changes in nature. His desires to satisfy his needs are understandable, but it is his bigger and bigger duty to protect the environment and to develop the accepted concept of sustainable development. The idea on ecologically correct design in the process of product development was conceived on these bases.

Ecologically correct design (eco-design, design for environment, green design) is a new aspect in systematic approach and methodological work out of the design process, based on activities of recognition of environmental characteristics and their integration into the process of product design and development. The goal is to continually improve environmental factors, but also to integrate the environment and the product.

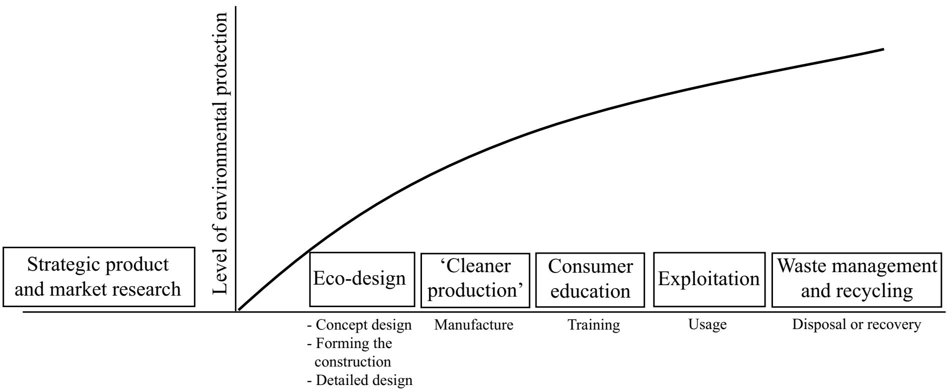

Fig. 2. Conceptual representation of environmental protection in the process of product development

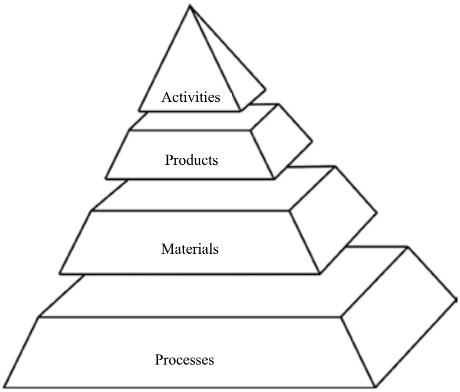

Fig. 3. Environmental priorities

Product development as a process includes all activities related to gaining and processing of information from design to recycling of a product. Really, these are the activities during the life-cycle of any product[6].

By respecting the generally accepted phases of the life-cycle of the product, the position of eco-design in conceptual representation of the environmental protection in the process of product development may be presented by Fig. 2.

The position of eco-design in generally proclaimed environmental protection and improvement of vital factors may be presented by a pyramid in Fig. 3.

Processes at the base of the pyramid point to adoption of 'clean production' processes, where the products are made with ecologically correct technologies. It is the easiest, but the least effective option in conception of environmental protection. Materials in the structure of the pyramid point to the use of eco-friendly materials in product manufacture. The third option, the products, is the advanced option based on recognition of environmental characteristics and their integration into the design process. The highest option, the activities, involves changes in the existing production and consumption, but also the changes in conscience of society and individuals[7].

According to the statement that design is a very complex process, with large number of interconnected phases, tribologically correct design, as the aspect in methodological elaboration, passes through several identified phases (Fig. 4).

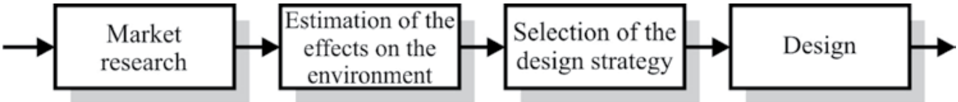

Fig. 4. Basic stages of eco-design

Global strategies of product development are (long-term) plans for achievement of the given goal, taking into account the existing state and situation. Observed in such a manner, the strategy of ecologically correct design is the plan for achievement of three basic goals:

- improvement of vital factors,
- environmental protection, and
- sustainable development.

Basic elements of such defined strategy are:

- selection of ecologically harmless materials,
- rejection of toxic and dangerous materials,
- selection of 'clean production' process,
- achievement of maximum effectiveness of energy use during manufacture and using of the product,
- achievement of maximum effectiveness of usage of water during exploitation,
- design oriented towards minimisation of mechanical losses (increase of mechanical efficiency).

It is good to note that ecologically correct design is not a special phase in the design process, but constituent part of methodologically developed activity. At the same time, obligation should be noted to use the life-cycle as an instrument of eco-design that reflects in correct interaction product environment during whole life-cycle.

DESIGN, TRIBOLOGY AND ENVIRONMENT

Tribologically correct design, as the segment of the design process, aimed at minimisation of friction and wear on carriers of elementary functions and ecologically correct design, as the segment of the same process, has a series of common features. They interlace and complement each other, frequently with ambiguous goals, and aim at the same goal defined by the features of quality construction.

Figure 5 presents interconnections between tribological regulators as elements of forming of tribologically correct construction and strategy of ecologically correct design[1,2].

Tribo-technical materials are certainly important regulators of tribologically correct construction today, with high resistance to wear and small friction coefficient even with insufficient lubrication, but with whole series of other complex features.

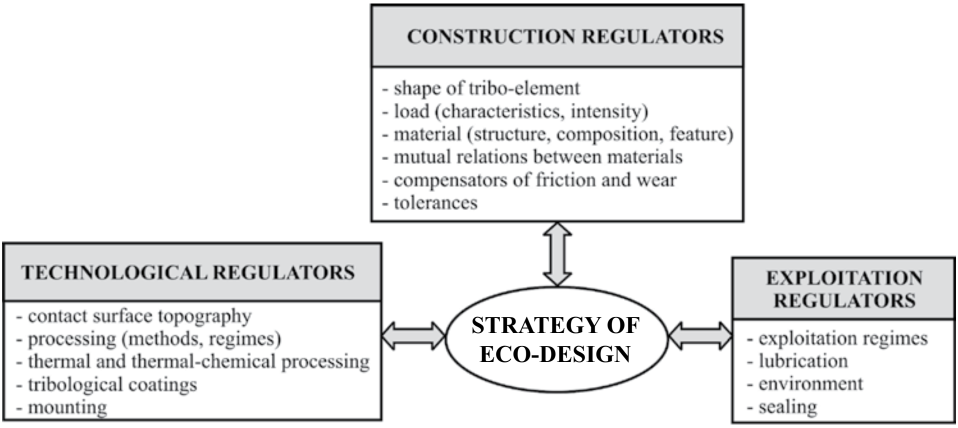

Fig. 5. Strategy of eco-design and tribological regulators

Ecologically harmless materials, as elements of eco-design strategy, are materials with the following features[8]:

- good 'communication' with the environment,
- easy disposal,
- easy and harmless recycling,
- easy workability and forming,
- easy and harmless disposal.

Materials from the corpus of eco-design strategy are also materials:

- from a reach resource, and
- less demanding regarding energy consumption necessary for extraction and refining, etc.

It is obvious that material, as an element of ecological strategy of design, is connected with other elements (energy and 'clean production', first of all), but also with other regulators of tribological aspect of design. Eco-tribo-technical materials, materials with good tribological and ecological features, are perspective and future.

Energy, as important input and output quantity of every machine system, is significant element of strategy of ecologically correct design. At the found of proclaimed strategy, there is reduction of energy consumption both during manufacture and during exploitation of the product.

Reduction of energy consumption may be achieved by direct and indirect savings. Direct savings are more significant and may be classified according to importance in the following groups:

Primary savings: reduction of friction, the increase of mechanical efficiency. To achieve these goals, construction regulators (shape of tribo-elements and compensators of friction and wear), technological regulators (topography of contact surfaces) and exploitation regulators (lubrication, sealing) are available.

Secondary savings: smaller frequency of replacement of worn-out and damaged parts of the construction, in other words prolongation of operating life of machine systems. The most efficient way of achieving these savings is application of tribologically correct design in systematic approach and methodological elaboration of the design process.

Tertiary savings: smaller consumption of energy needed for extraction and processing of materials necessary for production of parts that should be replaced.

Indirect savings of energy are in reduction of investment costs for prolongation of operating life of machines and machine elements.

Lubrication is defined as process of separation of coupled surfaces of the body in relative motion with a layer of some kind of lubricant. Lubricant is referred to as any substance that separates, fully or partially, body surfaces in motion and reduces friction and wear. Lubrication and lubricants are important tribo-technological-exploitation regulators. In addition, they are carriers of toxic and dangerous matter. In the concept of tribo-ecologically correct design, lubricants with good tribological characteristics and with 'positive' effects on environment should be selected. From the aspect of strategy of ecologically correct design, environmental protection is achieved by:

- selection of lubricants acceptable for environment,
- prolongation of lubricant replacement period,
- selection of lubricants with minimum fire and explosive capabilities,
- selection of lubricants with capability of multiple regeneration, total use and harmless disposal and destruction.

CONCLUSIONS

Tribological and ecological features are new parameters of product quality evaluation. They are realised by tribologically and ecologically correct designs as new aspects in systematic approach and methodological elaboration of design process. They possess a series of common fields in product development strategy which basic task is to achieve three basic goals: reduction of product development time, improvement of product quality and reduction of product price.

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