Engineering of Needs (Eon): The Role of Identifying and Analyzing Needs in Engineering and Engineering Management

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Abstract. The article presents the author’s thoughts on important issues that in the contemporary engineering is the identification and description of needs, which are the starting point for creating new products, technologies or services. In classical terms, the need to create new or improve existing technical means in the process of meeting needs were considered primarily in terms of technology. The current state of knowledge in the field of engineering knowledge and technology, and above all a clear tendency to expand the traditional area of engineering activities for the non-technical problem fields, generate new problems both in terms of the tasks performed by modern engineers, as well as the requirements for the system of training of students of technical universities oriented preparing them for the role of modern engineers. The author presents in the article some thoughts, as well as some proposals, to use—for the modern sense of identification/recognition of the needs of engineering—methods and tools from the field of technical diagnostics.

Introduction

The problem, or even the area of problems, of human needs is as old as the existence of our species on Earth. It could be evidently possible to discuss these problems in many contexts, like religions (the Buddhism concepts of the interdependence of human desires and human suffering) or philosophic (for instance, the Maslov’s concepts of classification/gradation of needs). When we study the history of human activities through centuries or even millennia, we can also state that the people were always determine to do a lot (may be, to do everything) striving to meet their needs. This is clearly visible in a variety of attempts to analyze and describe human behavior. As a spectacular example of this approach can be treated, for example, the biblical story of the Garden of Eden, from which the first man was banished for attempting the realization and implementation of his needs (in this case: the need for power and knowledge).

Even in the examples cited above clearly demonstrates the complexity of the undertaken in this study the issues and a set of issues related to the concept of the need (desire) and the aim to meet its. This set of issues contains the need itself, the desire to meet it, and measures and means to fulfill this desire. Taking about the problem of the need itself, it will be understood in this study as the set of questions: how do describe the need, how to recognize (identify) it and—last but not least—how to meet it?
Obviously trying to answer these questions we must consider existing restrictions. In this study the natural generator of such restrictions are limits on the volume of written text, and—as in this case—time to present the keynote speech during a scientific conference. Evidently, such limitation should be concerned with the knowledge and skills of the author. Therefore, it was decided in this study to limit considerations—at the first level restrictions—to activity mainly related to the needs of the material type (products and technologies) and actions associated with this type needs. Complementing this limitation is that we assume that in this study will be considered by the present time and its conditions (with possible references to the future). In the contemporary world undoubtedly important, perhaps dominant, role is played by the production and sale of goods. These goods are in the vast majority of manufacture comprising a significant contribution to engineering. We are constantly growing and objectively redundant supply of such goods, determined by many factors, forces striving for manufacturers to produce goods more attractive for a potential recipient, which may—but need not be—to ensure a good position in the market and, consequently, the corresponding level of sales in conjunction with conviction buyers the superiority of the product over competing products. Even these few sentences above indicate again the magnitude of the problem area, which is the framework of this study. Therefore, at this point it is necessary to drastically reduce again the type and number of issues whose discussion will be the canvas for the content of the next part of this study.

So that, the “second level” limitation is associated with the assumption that in this study will be discussed almost exclusively technical aspects of above indicated phenomena/processes, without considering aspects of economic or social origin.

**What Does Mean “Engineering of Needs”?**

Accepted in the above introduction the "technical" limit in the considerations focused on needs also refers to really wide range of issues related to the successive steps of a process, in which the product is designed, constructed, manufactured and used in accordance with the intended use. The model of such a process proposed and developed many years ago in the works of Professor Janusz Dietrych [1]. In accordance with this concept, the process contains successive types of engineering activities: \( rp \) — recognition of needs, \( pr \) — conceptual designing, \( ks \) — constructing, \( wt \) — manufacturing (production) and \( ep \) — operating with manufactured product. Due to the arrangement of process steps according to the time sequence, the model was treated by her as the creator of the technical picture of the “life” of the machine or device (see Fig.1).

![Figure 1. Model of the process of formation/creation of a machine (technical device). ([1])]()
(containing a choice of the optimal solution), constructing (understood as the development of technical documentation), manufacturing and transfer of produced technical means to use (operation) are or should be implying on the stage of recognition of needs.

A key element of thoughts of the creator of the discussed model was the assumption that observations related especially to the use of the finished product, but also the earlier stages described sequence of activities, form the collection of information/knowledge as a basis for the reformulation of the previously described needs. In other words, the elements of the modeled process are forming a specific, closed loop (see Fig.2). This assumption implies some significant consequences.

![Figure 2. Cyclic nature of the process of responding to needs.](image)

First of all, the relation between the phase of operating with product and phase of recognition of needs is of special meaning: set of observation from exploitation and maintenance processes creates the background for starting the recognition of needs in a “next cycle”. In the next cycle as mentioned above, the identified needs should lead to “new or significantly modified” product, process or technology. We can see here the reference to the idea of innovation in its technological aspect.

Next, the position of recognizing, describing and analyzing need is leading in the analyzed process. It is possible to state, that the “quality of recognizing needs” determines – finally – quality of a final product. We can find here a similarity with the classic rule of informatics: “garbage in, garbage out”. In this point it is also worth to be pointed that the cyclic model of process of responding to needs can be applied not only for analyzing processes of formation/creation of machines (technical devices). This approach can be useful also for the analyzing engineering activities focused on creation or development (improvement) technologies or technical services.

If we accept such a cyclic nature of the model of engineering activities it will lead us to further conceptual consideration. In contemporary times, the meaning of the term “engineering”, defined as – for example - in [3]: “Engineering is the application of mathematics, empirical evidence and scientific, economic, social, and practical knowledge in order to invent, innovate, design, build, maintain, research, and improve structures, machines, tools, systems, components, materials, processes and organizations”, shows its multidisciplinary sense in a full dimension. There is also a lot of using this term in the manner which is sometimes treated – especially by representatives of “pure” technical sciences - as an overusing (like “social engineering” or “data engineering”). The intention of this paper is to keep the technical sense of the concept with a focus on non-technical connotations in the selected area of activities of engineering.

In the literature we can find many proposals to classify areas of engineering activities, usually by type of end product or service produced in a specific area of engineering. The author
of this study has also proposed in his earlier publication [2] a formal operation, which can be treated as a “dividing” the engineering tasks (seen as a complex set of activities focused on creating product or service) on some separate parts. In this case, the proposed classification is associated with the model shown above, the process of responding to needs.

In particular, it is suggested to consider four sub-areas in this meaning:

1) **Engineering of recognizing needs** (“Engineering of Needs”)
2) **Engineering of designing and constructing** (it seems to be reasonable to consider the activities dealing with abstractive parts of engineering together)
3) **Engineering of manufacturing** (“Engineering of Production Processes”)
4) **Engineering of products’ operation** (“Engineering of Exploitation and Maintenance of Technical Systems”?)

It is assumed that this study should be treated as the first attempt to develop the concept in its first part, i.e., the concept of “Engineering of Needs”. In successive part of this paper, the author presents his (evidently subjective) thoughts concerned with the presented concept and tries to illustrate them by some results of research. Of course, in these considerations the stages in the process of responding to needs which occur subsequently to step to recognize the need should also be taken into account. Relationships between the first and subsequent stages are certainly much more extensive and complex than is consistent with the schematic model shown in Fig.1 or 2. For example, in the stage of conceptual design (“pr”) it is assumed in the process of responding to needs that the possible technical solutions responding to the need identified and described in the stage “rp” should be subjects of optimization. The evident questions to be answered are: how to describe the need and how to find criterion (or criteria) for the optimizing procedure? May be, the criteria should form the output of the stage of “rp” and – consequently – an input to “pr”? These are the first, but evidently not the last questions to which answers should be sought in the consideration focused on the Engineering of Needs.

**Subjective Review of Problems to be Solved in “Engineering of Needs”**

Let’s begin the consideration focused on the concept of identifying, describing and evaluating needs as an element of engineering activities from posing a basic (“classic”?) set of questions:

1) **What** (is the matter of our consideration)?
2) **Why** (this matter is worth to be considered)?
3) **Who** (should (ought to) be engaged in)?
4) **How** (to solve practical problems concerned)?

The answer to the first one of above question seems obvious: the subject is the need understood in the technical sense. But when we try to consider this question in more detail, for instance: we try to describe activities concerned with the need, it can be stated that the above question can be answered in at least two variants.

First one of these variants (see **Fig.3**) is a direct consequence of the model of responding to needs as a part of the process of continuous development and improvement. The need is implied by the observation of existing/functioning machines, technical processes and/or services. In this approach, the activities associated with the need lead to the improvement of existing solutions. We could say that – in such a case – the need is “given”: still exists but is analyzed concerning new information, evaluated and improved. In general, the set of criteria formed in this stage and applied in the stage of conceptual design is not subject to significant modifications. This variant
of our model is – for instance, adequate for considering a process of technical innovation based on “significant improvement of existing solution”. We can call the variant of the discussed process, as shown in Fig.3, passive due to the lack of an active interaction of performers to input of the process.

![Figure 3. Activities aimed at processing the needs (variant 1).]

In the second variant (see Fig.4) we should assume that need, treated as a factor in initiating engineering action, may not necessarily be linked directly (or: linked in a “full-scale”) to the existing solutions to technical problems. For instance, the new view on the need can be effected by a new technical solutions (new machines, devices, other elements of technical systems) that are “technically” available at that moment. This situation is well illustrated by the research focused on using alternative technical solution for the needs of a class of services as introduced in [4] (conversion of Man-operated Aircrafts by Unmanned Aircraft Systems). In this case, it assumed that contactors (“performers”) of the process are actively seeking new opportunities to meet the analyzed needs, as opposed to the first variant. This variant of the process of identifying needs can be defined as active or - taking into consideration the conditions discussed in the next paragraph - partially active.

![Figure 4. Activities aimed at processing the needs (variant 2).]

Referring to the innovation: this variant of our model seems to be adequate for considering a process of technical innovation based on “implementing completely new technical solutions”. Perhaps as a separate variant of the present process should be considered: the situation where the need is in some sense created. As a matter of fact, just such a variant of engineering of needs corresponds most fully above definition of the term "engineering" based on creative nature of engineering tasks. On the other hand, this case shows fully the meaning of the term
“multidisciplinarity” in modern engineering. The request of creativity should be addressed not only to “technical contractors” of the analyzed process, but also to other participants.

In this case, as the “input” to the process of responding to needs are considered – or should be considered – factors of various origin. Besides the possibilities of technical realization of the need, in this variant can and should be taken into account economic considerations (marketing?), Social, environmental, etc. In many publications we can find a “trace” of investigations related to eg. the possibility of quantitative assessment of the implementation of innovation [5] and to take into account in the process of engineering of ergonomic criteria [6]. In this variant, engineers/contractors engaged in the process of responding to needs are actively looking for opportunities to improve the technical method and means to meet the identified needs but also consult their activity with specialists from other areas.

The problem of identifying needs has in contemporary world very wide context. For example, the problem of searching for new opportunities (solutions) is undoubtedly linked with the contemporary vision of issues related to the availability of large amounts of data (“Big Data”). They appear in the literature concepts of using the approach “data mining” or to seek new, ready-made solutions, or to initiate research directions, aimed to obtain appropriate solutions ([7]). Probably, it is also a very interesting field of investigation as well as – mentioned in the next chapter of this paper – problem of including this sort of problems into programs of educating new engineers. In further perspective, a problem of managing the processes of EoN ought to be also seen as an important task of widely understood Engineering Management. The author of this paper also believes that the issue of engineering needs may be interesting problem area for R & D in the perspective of the so-called “fourth industrial revolution” (Industry 4.0 [8]). Moreover, the concept of the “Internet of Things (IoT)” is becoming more and more visible in scientific publications [9].

In this point of consideration, presented in this study, the author assumes that the first three questions formulated in the beginning of this chapter (what?, why?, who?) find (partially?) their answers. Therefore, let’s try to answer the last question: how to do “Engineering of Needs”. In all considered variants of activities belonging to EoN we can note the presence of two elements which are common:

I. Description of the need
II. Evaluation of the need

The first one of these questions refers to the placement of the recognition of a need in the whole process of responding to need: if we want effectively perform next steps (in this case: conceptual design) the need has to be described as clearly and completely as possible. In the earliest research (as presented for instance in [1]) the description of needs had been seen purely in technical meaning. In particular, it had been assumed that the description of a need can be treated as a specific set of four elements: input (I) and output (O) of created machine/device, intended manner of its functioning (MoF) and a form (FoFP) of the final product.

Undoubtedly, we can formulate here the question, in which order the individual components describing needs ought to be identified? Evident seems to postulate that the first step will be to determine the type and form of inputs and outputs, but the next step is not so evident. Shall we begin from a manner of functioning or from a general form of the product? A separate question is whether and how to evaluate the various components of the description of a need?

Evidently, when we will try to put this general idea into practice, a lot of practical difficulties may also be expected. Perhaps, the first on the list of such difficulties is the question of how to
describe a need (qualitative or quantitative?). Next, it is worth to consider carefully the problem of a degree of simplification in each particular case. It is evidently a dilemma: the degree of simplification is lower, the possibilities of considering a variety of concepts is more limited. On the other hand, very high level of simplification makes the description of the need too general. It seems that the problem of describing needs in the processes as discussed briefly in this study offer very interesting perspectives of further research.

As to the second of the above indicated problems it is worth asking what the purpose of the assessment of needs in discussed area of tasks? The answer to this question can be given in many different positions, eg. economic (cost effectiveness of satisfying the need?) or sociological (what social effects could cause satisfying this need?). According to the general assumption of this study, attention will be paid here mainly to the technical aspects. Even from so limited point of view, the evaluation of needs offers also many interesting aspects, like:

- technical realisability all stages of the process to meet the need,
- possibility of obtaining appropriate (required?) reliability and durability,
- evaluation of environmental impacts,
- evaluation of social impact.

After determining the problems to be solved, it would be at this point to introduce a set of ways and means (tools) which can produce such solutions. In the opinion of the author of this study, there is currently no unified (and coherent) methodology to solve the above problems, and hence result - ready to use “tool-box”. Potentially, the tools already used in modern engineering, such as the methods of forecasting ([10]) or scenarios ([11]), offer interesting opportunities also for discussed here task area. Thus, it seems that also the problem of evaluating needs in the processes as discussed briefly in this study offer very interesting perspectives of further research.

Subjective Review of Problems Concerned with the Concept of “Engineering of Needs”

Some of the problem areas, associated with the concept of Engineering of Needs, have al-ready appeared in this study, particularly in the previous section. These areas belong—first of all—to the “classic” Engineering, but are also associated with tasks of Production Engineering or, more generally, of Engineering Management. It is evidently not possible to make a full review of such problems in this short paper, so the author has decided to mention here briefly only some of them. This choice of problems is based on selected practical cases that have emerged in author’s earlier research.

Considering both the area of Engineering an Engineering Management, it is worth to mention in this place the problems concerned with computerized support of technical tasks. For instance, the practical experience with Computerized Maintenance Management systems (CMMs) shows, how important can be the suitable recognition and description of a need in conjunction with the so-called “human factor”. In the case of research project, described briefly in [12] and aimed at supporting water management in urban areas, the defining of needs as the basis for the creation of an information supporting system has been based on arbitrary decisions of experts.

When the final result of the project (IT supporting system) has started to be tested, it turned out that there were at least two areas of difficulty. Firstly, operators of water supply network were not prepared (even more mentally than "technically") to benefit from the support offered
by the system. In particular, they believed that their personal experiences are more trustworthy than the indication of the supporting system. It certainly had affected on decisions made during the operation: the decisions suggested by the system were not approved. Secondly, the final customers (consumers of water) were not properly prepared (educated?) to using the system. Appeared here well-known problem of redundancy in the functioning of systems supporting various activities.

Therefore, it seems to be reasonable to make one more step in extending models as presented in Fig. 3 and 4. The key element of such an extension ought to be taking into consideration – as the part of “input” in EoN activities – results of recognition in the area of a widely treated “human factor” (!). The extended scheme of EoN is shown in Fig. 5.

![Figure 5. Activities aimed at processing the needs (variant including “overtechnical” aspects of the problem).](image)

Both the problems mentioned above, i.e. the problem of adequate identification and description of needs, treated as an input to engineering activities or an input to planning in managing such activities, as well as the problem of adequate and sufficient education, appear also – for instance – in the case of the issue of Sustainable Development in various aspects ([13]) or in the wide field of Technology Assessment (TA) [2], [14].

In the opinion of the author of this article, taking into account the problems of engineering of needs in relation to these (and many others) would give very interesting results. In some aspects, these problem areas are independent and are properly tooling. On the other hand, nothing is as good as it could be. A stronger focus on proper preparation (defining) inputs should transfer into both made the given process more effective and its final outcome better.

**Conclusions**

As was assumed in the introduction, this study is intended to present a “first touch” of a concept of Engineering of Needs (EoN). Therefore, when more specific is problem or group of problems associated with this concept, more generally it is indicated in the text. The author shows here his
point of view as well as (evidently subjective) thoughts concerning both general and particular elements of this concept. He treats this study it as a kind of invitation of double nature.

One part invites to discuss about a general sense of such an approach. Second - if the answer of the first question is positive - it is an invitation to debate about detailed questions, including for instance the methodology being usable in the discussed field. Of course, the opening of other fields in such a debate is welcome as well.

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