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ENGINEERING DESIGN AS KEY AREA OF TECHNICAL BACKGROUND FOR ENGINEERS

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Abstract: The article identifies some areas of engineer's background, which are not sufficiently covered in curriculums of national universities. These gaps mainly relate to issues of clear understanding of real engineering and design processes, capability to apply system thinking approach to realization of engineering tasks, which is basis of systems engineering. Properly configured curriculums will allow students smoothly move forward from basics of engineering processes and disciplines up to Engineering Project Management.

Keywords: *Engineering Design, Curriculum, System Approach, System Engineering, Engineering Design Process, Syllabus*

Introduction. Up-to-date level of technical progress and intensive character of innovative processes in different areas of science and industry require from the specialists with engineering background capability for quick involving into complicated processes of engineering tasks realization, ability to switch over from one technical orientation to another one. These requirements can be achievable only in the case if engineer besides fundamental knowledge has clear understanding that engineering design is a process of system realization.

The basis for understanding of engineering design process shall be set up during study in university and be further improved in course of professional activity.

Lot of universities worldwide today propose to high school students innovative engineering curriculums, which are based on system approach to the engineering defining [1-5]. These curriculums provide flexible engineering foundation, do not prescribe specific modules but offer integration with wide range of other disciplines

Long-term experience of working in engineering company involved into real engineering and design projects of different size and complexity, allows the author to consider the process how just graduated engineers and specialists are entering into practice of routine engineering operation and are involved into execution of real engineering projects.

As a result of conducted analysis the areas of engineering qualification, where deficient attitude and imperfection of syllabuses in national universities are displayed in a maximum extent, are identified. These gaps in engineer's background could have serious consequences for professionals and need to be further compensated by experience gathered during practical work. So, it is essential for engineering syllabuses to ensure that by the time of professional activity commencement the engineer is in possession of main principles of systems engineering.

Systems engineering is an interdisciplinary field of engineering that focuses on how to design and manage complex engineering systems over their life cycles.

The main ideas of systems engineering approach relevant to engineers who supposed to work in engineering and design companies are mainly considered within the frame of this article.

Engineering design as system realization process. Engineering and design is a process with final goal to define architecture, components, interfaces and other characteristics of system or its parts. This process results in final design – integrated package of models, properties or characteristics presented in the form, which allows to carry out system realization. Engineering and design process along with analysis of requirements is a part of system overall life cycle, which is

called “system definition”. Outcome of this stage is input data which will be used during system realization stage.

System design is focused on presentation of system, which will correspond to established target, principles and intention. This process includes assessment and decision making regarding selection of system components, which meet the system architecture and confine themselves within prescribed limits.

At its core systems engineering utilizes systems thinking principles to organize this body knowledge. Issues such as requirements engineering, reliability, coordination of different teams, testing and evaluation, maintainability and many other disciplines necessary for successful system development, design, and implementation, become more difficult when dealing with large or complex projects. Systems engineering deals with work-processes, optimization methods, and risk management tools in such projects. It overlaps technical and human-centered disciplines such as industrial engineering, manufacturing engineering, control engineering, software engineering, electrical engineering, cybernetics, organizational studies, and project management. Systems engineering ensures that all likely aspects of a project or system are considered, and integrated into a whole.

As defined by International Council of Systems Engineering’s (INCOSE), systems engineering is based on following main principles [6-8]:

- Systems engineering is a discipline that concentrates on the design and application of the whole (system) as distinct from the parts and involves looking at a problem in its entirety;
- Systems engineering is an iterative process of top-down synthesis, development, and operation of a real-world system that satisfies, in a near optimal manner, the full range of requirements for the system;
- Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems.

Systems engineering signifies only an approach and, more recently, a discipline in engineering. The aim of education in systems engineering is to formalize various approaches simply and in doing so, identify new methods and research opportunities similar to that which occurs in other fields of engineering. As an approach, systems engineering is holistic and interdisciplinary in flavor.

Engineering design process as a subject for syllabus. Syllabus is considered as constituent part of mechanism for customization of engineering education in high school as well as a support structure to sustain and continuously improve engineering education in high school.

One of main concern to syllabuses for engineers in national universities is luck of clear understanding the principal distinctions between qualifications of engineer and designer [9-11].

Traditionally in practice of national high school the engineer’s syllabuses include lot of topics (descriptive geometry, technical drawing, etc.) which actually relate to qualification of designer, while many issues essential for engineering background (system thinking, problem definition, brain storming, backward design, systems engineering, engineering design process, etc.) are missed. Clear understanding and perception of engineering and design process is departing point in professional training for all engineers.

The engineering design process is a series of steps that engineers should follow to come up with a solution to a problem. Many times the solution involves designing a product (like a machine or computer code) that meets certain criteria and/or accomplishes a certain task.

Defining the problem is most important and difficult step, because only when a problem has been clearly and accurately identified, a process can be conducted properly.

“If you define problem correctly you almost have the solution” (Steve Jobs).

Engineering design process is different from the steps and approaches used in the Scientific Method. If your project involves making observations and doing experiments, you should probably follow the Scientific Method.

But if your project involves such tasks as designing, building, and testing of something, you need to follow the Engineering Design Process.

The steps of the engineering design process are to:

- Define the Problem;
- Do Background Research;
- Specify Requirements;
- Collect Input Data;
- Identify Concept Solutions;
- Brainstorm Solutions;
- Conduct Technical and Other Risks Assessment;
- Conduct Economic/Financial Assessment;
- Choose the Best Solution;
- Do Development Work;
- Validate Design;
- Build a Prototype;
- Test and Redesign.

Engineers do not always follow the engineering design process steps in order, one after another. It is very common to design something, test it, find a problem, and then go back to an earlier step to make a modification or change to your design. This way of working is called **iteration**, and it is likely that your process will do the same.

All steps of design process above are essential as theoretical knowledge as well as practical skill all engineers shall be in possession. Actually, these items could be considered as self-independent topics of technical curriculum.

Technical curriculums shall be originated and structured so that to ensure the future engineer clearly understands as principles of overall engineering and designing process as well as details of its separate constituent parts, like:

- Final goal of design;
- Input Data (Design input);
- Main and additional design requirements;
- Design methodology;
- Quality assurance and quality control for design process;
- Final product (Design output);
- Tools and criteria for design verification and validation

Understanding of engineering and its core disciplines. Students of high school will come to understanding of increasingly complex content and concepts of modern engineering scinces through the learning, practicing and applying main principles of engineering design, thinking and skills for solutions of complex technical tasks up to concepts of Engineering Project Management, which consolidates project management skills incorporating multidisciplinary contributions.

Modern engineers should realize that any engineering task should be considered and analyzed from the point of close interrelation and interdependence of all engineering disciplines. So, irrespective of selected area for future specialization all engineering syllabuses should include introduction into main engineering disciplines, such Mechanical Engineering, Civil Engineering, Electrical Engineering, Computer use in Engineering, Bioengineering, Industrial & Manufacturing Engineering. Only through the clear understanding of main concepts and principles of these areas of human expertise high school students can come to well-grounded and deliberate decision about direction for their further engineering specialization.

Conclusions. Modern curriculums proposed by national universities for engineering background besides fundamental knowledge in areas of science should ensure that engineers are in possession of methods and approaches of Engineering and Design process based on system thinking principles.

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