COMPETENCE OF THE DEVELOPMENT ENGINEERS FROM ASPECT OF FUTURE TECHNOLOGIES

Aleksandar MILTENOVIĆ1, - Milan BANIĆ1
1 University of Niš, Faculty of Mechanical Engineering, Niš, Serbia

Preliminary note

Abstract: Companies are today forced, due to growing market competition, to put on the market quality products with numerous innovations. Consequently, they have to implement new ideas and to solve complex problems and tasks in a short period of time. In order to realize this, it is essential to have quality staff. Engineers with university education must be prepared to use new opportunities and future technologies and applications that are responsible for products and manufacturing processes. Innovative thinking and work are crucial for education of engineers. Engineers are those who develop, compute and experiment, plan and manage the flow of the economy. Topic of this paper are future working areas of engineers, that are largely determined by the future technologies.

Key words: engineer, education, technology, future

1. INTRODUCTION

It is considered that the organization is successful if it offers something that solves the problem to the others. It can be a product or service. The success of the organization is based on the fact that such a solution "has" and it is offered to the market. It does not matter whether this solution exists for thousands of years or is the result of spontaneous inventions or ingenious ideas to achieve the success of the organization through the development process that must meet the requirements of the customer. The key to the success of an organization is the development of products that could meet as much as possible the demands of the customer. Marketing and realization of products are equally important and must be mutually agreed upon.

The development is a decisive factor for the transformation of research potential and experience in the company's success. In this way, existing potential and knowledge through the product development are transformed into competitive products and profits. The development is a creative task which is systematically creating a new product. Product development allows companies to offer customers attractive products. Knowing new technologies and the constant use of innovations provides a base for the conquest of new markets. Companies that do not develop and improve their products quickly lose their position in the market. In order to realized such a responsible position it is essential that companies have university educated staff with appropriate job competencies.

2. CHANGES AND CHALLENGES THAT ARE SHAPING FUTURE SOCIETY

Our civilization owes its present appearance to advances in technology and engineering capabilities to allow the application of technical achievements in different spheres of social life. Relying on scientific knowledge and recognizing the needs of society, Engineers have shaped the world we live in and enable the continued progress of science and society, relying on scientific knowledge and recognizing the needs of society. Today's society is increasingly taking on the characteristics of the knowledge society, where all processes in human activities depend on the knowledge and skills based on knowledge. In this context, it is very likely that the three most important tasks in the knowledge society are: problem identification, problem solving and exchange of ideas.

One of the important tasks of engineers in the future will be to help society by adapting new advanced technology to their needs. In this sense is necessary to identify the trends that dominantly shape the future society, politic, economy, environment, technology and market.

Fundamental changes and megatrends in future society:

1. Globalization - the creation of a single economic, political and cultural space on the planet where people, ideas, goods and capital are free to circulate. Globalization as a process is not new and it takes place for centuries, but its full expansion experienced the advent of the Internet. Information and communication technologies have led to a shortening of the duration of the cycle in commerce, banking and manufacturing. Increase of frequency of this cycles creates the impression that the world is decreasing and accelerating.

2. Networking. Internet makes it easy to reach out to like-minded people around the world. People are less familiar, and more and more connected through social networks like Facebook, Twitter, LinkedIn or YouTube. In this moment (September 2012) Facebook has a little bit less than 1 billion active users.

3. Human population growth. Predictions are that from the current 6.9 billion people in 40 years, world
population will grow to over 9 billion people. Changes that occur by growth of world population is very difficult to track because they lead to very rapid change and great challenges.

4. Preservation of harmony between humans and the environment. A series of major natural disasters in the last 10 years (global warming, climate change, wildfires, earthquakes, rapid extinction of plant and animal species) caused that the need for sustainable development to become one of the dominant forces that shape the future.

The influence of the above mentioned megatrends are reflected in:

- Dramatically increased dependency of "all against all";
- Increasing mobility and migration of the population;
- Individualization of lifestyles;
- Easier access to knowledge;
- Reducing barriers to entry into new businesses;
- Increased competition;
- Search for talent all over the world.

Negative trends of development of society:

- Irrational consumption as model of lifestyle in "developed countries". If all the people in the world live on this model, the Earth should be increased by 40-60 times.
- Waste and inability to recycling. The percentage of products that can not be recycled is growing. Around the cities in the world are growing mountains of waste. Our civilization has become a "civilization of garbage".
- Unlimited right to remuneration. The total value of all shares on the planet is limited. At the same time money is limited. This causes the illusion of unlimited growth of money, regardless of the value on the planet. Consequence is the global financial crisis.
- Continuous growth. Stable state of nature is a state of equilibrium, and unstable is uncontrolled growth. Between these two states must be established correlation to regain equilibrium.
- In 2020 the society will be dominated by knowledge, exceptional mobility and competitiveness. Knowledge is the key and only resource that is increasing by its using and sharing. It is difficult to preserve and protect knowledge because its rapidly losing value in the market and is not subject to known procedures and methods of management. Every 7 to 10 years of knowledge doubles. Modern communications and information technologies contribute to a very rapid expansion of knowledge. But on the other side knowledge very fast becomes obsolete. The diagram in Figure 1 shows that the level of knowledge obsolescence in the last 100 years has accelerated 10 times. At the beginning of the 20th century, it was necessary to pass 40 years that the level of knowledge falls by 50%. Today (2012) the period is 4 years. This is especially important for product development.

3. FUTURE TECHNOLOGIES

The word technology comes from Greek τεχνολογία (technología); from τέχνη (téchnē), meaning "art, skill, craft", and -λογία (-logía), meaning "study of-". The technology involves the skills, knowledge and ability of humans to create, develop, produce, and put to use the products to meet the diverse needs - both material and nonmaterial. So technology is a set of activities that result in creating a value, regardless of whether they are products or services. The technologies of future are considered technologies that are going to play an important role in future. Approximate future list is as follows:

- Biotechnology and genetic engineering
- Artificial intelligence
- Laser technology
- Aerospace technology
- Nanotechnology
- Optical technology
- The use of renewable energy sources.

3.1. Biotechnology

Biotechnology is the common application of a biology, biochemistry, microbiology and process technologies for their industrial use. Biotechnology deals with the application of biological processes, organisms and systems for industrial production (food, pharmaceuticals, agriculture, energy, mining, chemical industry, service industry).

The discovery that a hereditary trait can replant in the structure of genes (DNA) of other species has led to the development of genetic engineering. Genetic engineering is of great importance in human health, agriculture, forestry and food production. These are opportunities to increase production of raw materials, energy and food while preserving the natural environment as well as production of new and better drugs.

3.2. Artificial intelligence

Artificial intelligence, as part of computer science, is focused on developing a program (software) that will allow computers to behave in a way that could be characterized as intelligent. Therefore, the artificial intelligence is a scientific field which explores how to
create a device that could successfully do the jobs that are currently better done by the humans.
About intelligent machines can be talked with the advent of the first computer "Electronic Numerical Integrator And Computer" (ENIAC), that was invented in year 1945 by Mauchly and J. Presper Eckert. In the beginning, computers were primarily used to perform mathematical operations, but it was soon recognized that they have much greater capabilities. Already the first results in the application of computers pointed to the possibility of a computer with the exercise of certain intellectual abilities. Today the operational systems that can autonomously perform complex tasks, such as only humans were capable of doing. Very often these systems perform such tasks even more successful than humans. Mechanical systems with computational and mechatronic subsystems can work independently, to govern themselves and to produce other products, freeing the humans and monotonous physical labor, leaving him to work on the more complex and creative tasks.
The main directions of artificial intelligence are:
- The study of natural intelligence (knowing brain function, brain function modeling, simulation of human behavior, reactions and reasoning).
- Achieving intelligent behavior using different approaches, which can not be found in natural systems.
According to the method of problem solving using artificial intelligence can identify three main approaches:
- neural networks
- modeling of evolution and
- heuristic programming.
According to the type of problem solving artificial intelligence can be divided into the following systems:
- systems for solving human common tasks:
- systems for solving formal tasks:
- systems for solving expert tasks.
From the standpoint of education and areas of future engineers are most expert systems for solving tasks, they are present in the following activities:
- Product development, designing,
- fault finding, production planning,
- scientific analysis and diagnostics,
- recognition of shapes and images,
- industrial process control,
- Monitoring of medical devices,
- autonomously moving vehicles (land and water),
- autopilots,
- Management satellites,
- Monitoring installation,
- detection of oil wells.

3.3. Laser technologies

Laser technologies are mainly based on the use of devices - the laser. The term "laser" originated as an acronym for Light Amplification by Stimulated Emission of Radiation. A laser is an optical device that emits a coherent beam of photons. In contrast to the light emitted from common sources such as light bulbs, laser light is usually monochromatic, i.e. only one wavelength (color) and is focused in a narrow beam. The beam is coherent, which means that the electromagnetic waves are in the same phase and they extend in the same direction. It is composed of excitation systems, resonator and active environment that fills it. It was discovered in the U.S. in the 1960.
Considering the nature of the medium that is used to produce laser light, lasers are divided into:
- solid state lasers,
- gas lasers,
- semiconductor lasers,
- liquid lasers,
- hemical lasers,
- dyes lasers and
- free electron lasers.
Laser technology is used in:
- medicine (ophthalmology, laser surgery, break up kidney stones, treatment of tumors),
- measurement techniques (measurement geometry, surface testing, spectroscopy, holography)
- Industrial Production (cutting, drilling, welding, soldering, hardening, control procedures),
- traffic (exhaust gas control, radars, traffic control, safety sensors)
- Trade / Industry (coding, laser printers, laser scanners, microanalysis)
- communications (fiber optics, telecommunication systems, integrated optics, computer systems),
- energy / environment (environmental controls, combustion control, meteorology, the study of fusion)
- Education / Entertainment (CD, laser displays, video equipment).

3.4. Aerospace technology

Aviation and space technology is part of the engineering research and traffic technologies, which includes aircrafts, spaceships and satellites. Development of these systems includes technical, scientific and environmental aspects. Successful realization of this task requires the optimal integration of subsystems and components in the whole system. This integration includes:
- Development of lightweight aircraft structures
- Development of an optimal aerodynamic shapes,
- Development of new constructions of propulsion systems (engines),
- Development of systems for energy supply, control, data transfer and communication,
- Development of subsystems of basic equipment, which should provide function and stability,
- Development of new systems that have to fulfil the requirements of space technology,
- Development of a navigation system.

3.5. Nanotechnology

This term comes from the Greek word nanos (νος) which means "dwarf" or something tiny, invisible. Nanometre as derived unit of measurement of length is 1 nm = 10^-9 m, that is a nanometre is one billionth of a meter.
Nanotechnology is an interdisciplinary science that includes physics, chemistry, biology, materials sciences, as well as a wide set of engineering disciplines. The term nanotechnology is a synonym for science and technology.
As a science, nanotechnology studies physical, chemical and biological properties of molecules and atomic particles. As the technology it is applied to the researches of these sciences including various engineering disciplines for material production and functional systems with particular and unique characteristics. As an engineering discipline, nanotechnology refers to the techniques and products that include structures of nanometre dimensions in the range of 1 to 100 nanometres, especially those that transform matter, energy and information using nanometre components with precisely defined molecular features.

3.6. Optical technologies

Optical technologies encompass physical, chemical and biological axioms and technologies for acquisition, enhancement, creation, transmission, measurement and use of light. It is considered that optical technologies are foundation and prerequisite for the development of other technologies and their application in the future. They are also a prerequisite for the realization of many innovations in the 21st century. Optical technologies are primarily applied in information and communication technologies. But they are also used in biosciences and medicine, energy and lighting, in the industrial development of macro and micro structure of industrial sensors, etc… It is anticipated that with the optical technology the new products such as ultra-powerful microscopes, light computers, advanced solar cells, multi-sensors, etc. will be developed.

3.7. Magnetic levitation train

Magnetic levitation train is a new type of rail vehicles, where the force of gravity is balanced by magnetic force, so that the train in motion hovering over the guideway forms of T. Magnetic repulsive force rises train above the guideway at a very short distance, so that it levitates and during the movement of the train there is no contact between the train and the ground. This mode of operation is called magnetic levitation. Drive train is done by a linear motor. Name of the trains in the English-speaking world is maglev from magnetic levitation. In German-speaking countries, the term „turnsrapid” which comes from the Latin „trans” meaning above and „rapidus” meaning fast. Magnetic levitating train is a train system of new technology designed to speed 300 to 500 km/h. Technically this system can achieve higher speed. It is primarily intended for passenger service, but can also be used for container freight.

Contactless and electromagnetic techniques of these trains have a number of advantages over conventional trains. The noise in these trains is small, does not pollute the surrounding environment and they are energy efficient. Maintenance and operation of these trains is more profitable than conventional ones since there is no contact during the movement.

Conventional trains with wheels reached their limits in terms of speed, and due to the contact with rails, there is lack a high-wear especially at high speeds. The disadvantage of magnetic trains is that their construction of a new train route is very expensive.

Table 1. Field of work of future engineers in terms of future technologies

<table>
<thead>
<tr>
<th>Future technologies</th>
<th>Goals</th>
<th>Challenges (problems)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biotechnology and genetic engineering</td>
<td>Analysis and modification of genetic material Analysis and modification of proteins Analysis and modification of metabolites (small molecules) Manipulation of cells to a variety of applications The application of information technologies in the analysis and storage of biological data</td>
<td>Ethical issues Synthetic biology Tissue engineering and therapy treatment at cellular level Gathering and application of stem cells Pharmacogenetics Development of therapeutic vaccines Nanomedicine (delivery of medicaments and genes, biosensors, biomaterials - implants, in vitro diagnostics) Manufacturing of industrial crops Genetically modified animals and crops Cloning Nutrigenomics and nutrigenetics New and improved approaches to industrial biotechnology (biocatalysts and enzymes) Manufacturing of bioethanol, biodiesel and bio butane</td>
</tr>
<tr>
<td>Artificial Intelligence</td>
<td>Biorobotics Developmental robotics Ubiquitous computing Artificial life and multi-agent systems</td>
<td>Theoretical understanding of behaviour Achieving higher level intelligence Automated design methods (artificial evolution and morphogenesis) Moving into the real world</td>
</tr>
<tr>
<td>Laser technology</td>
<td>Development of high energy lasers Development of weapons and defence systems Development of new particle accelerators Development of lased induced nuclear fusion Vertical-cavity surface-emitting lasers Centralized clocked lasers</td>
<td>Consumer safety Beam coherency Increase of energy output diode-pumped solid-state lasers Fibre lasers Optical cooling</td>
</tr>
</tbody>
</table>

4. DEVELOPMENT TRENDS AND COMPETENCE OF DEVELOPMENT ENGINEERS

In the future, the work of engineers will be multidisciplinary and interdisciplinary. It will include the complete product life cycle, from the product idea, through its concretization through development of specific innovative products, manufacturing, distribution, exploitation and finally recycling. The engineers must be able to create a new or improve existing products, through creativity, innovation and fascinating technologies and place it on the market. For the realization of these tasks engineers must have the knowledge of available technologies for successful creation and development of products, taking into account the available material and energy resources and environmental protection.
Because of this, engineers must expand their professional competence in the field of economy, work processes and quality assurance. In the frame of this interdisciplinary and partial work processes the additional qualifications in cooperative social behaviour with management and communication skills are required. This of course requires the development and implementation of relevant plans and programs in the field of education. Engineers in the development must have the wide knowledge and be oriented towards the products and the processes.

Orientation to the products means comprehensive education of the engineers in the field of sciences and engineering to create new or further development of existing technical products. This primarily applies to activities related to defining the product profile, finding existing technical products. This primarily applies to engineering to create new or further development of products.

Orientation to the products means comprehensive processes. Knowledge and be oriented towards the products and the development and implementation of relevant plans based on the simulation of realistic loads and boundary conditions, which are often empirical. High integration of multiphysical software tools for modelling and simulation of the behaviour of the product in exploitation, and a substantial increase in processing capabilities of modern computer systems, have enabled that the design process in the product development is based on the simulation of realistic loads and boundary conditions, that is the real physics of the product. Above approach significantly increases the quality and reliability of products.

### Table 1. Field of work of future engineers in terms of future technologies (continued)

<table>
<thead>
<tr>
<th>Future technologies</th>
<th>Goals</th>
<th>Challenges (problems)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace technologies</td>
<td>Development of micro reactors</td>
<td>Development of efficient propulsion systems</td>
</tr>
<tr>
<td></td>
<td>Development of lab on chip</td>
<td>Price</td>
</tr>
<tr>
<td></td>
<td>Surface engineering</td>
<td>Resilient materials and designs</td>
</tr>
<tr>
<td></td>
<td>Development of flexible displays</td>
<td>Design of lightweight aircrafts</td>
</tr>
<tr>
<td></td>
<td>Development of polymer LED displays</td>
<td>Development of systems for energy supply, control, data transfer</td>
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<tr>
<td></td>
<td>Catalyst materials</td>
<td>and communication</td>
</tr>
<tr>
<td></td>
<td>Optical and opto-electronic materials</td>
<td>Development of navigation systems</td>
</tr>
<tr>
<td></td>
<td>Organic electronics and organic opto-electronics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>New magnetic materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biomimicry and biomimetic materials</td>
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<tr>
<td></td>
<td>Nanobiotechnology</td>
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<tr>
<td></td>
<td>Superconductivity</td>
<td></td>
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<tr>
<td></td>
<td>Composites and &quot;multimaterials&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intelligent textiles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Materials for medical applications</td>
<td></td>
</tr>
<tr>
<td>Optical technologies</td>
<td>Manuaturisation, energy efficiency and manufacturing of devices</td>
<td>RTD costs</td>
</tr>
<tr>
<td></td>
<td>based on optical technologies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Further development of basic photon technologies (lasers, photodetectors, LED, optical fibres, etc.) and their application in medicine, biology, communications, detection, measuring and manufacturing</td>
<td>Simplification of design</td>
</tr>
<tr>
<td></td>
<td>Evolutionary improvement in optoelectronic devices</td>
<td>Scaling of interconnects</td>
</tr>
<tr>
<td></td>
<td>Quantum-well modulators</td>
<td>Development of interfaces between optical and electronic circuits</td>
</tr>
<tr>
<td></td>
<td>Clocking and Synchronization</td>
<td>Silicon circuits integration technologies</td>
</tr>
<tr>
<td></td>
<td>Silicon-based optoelectronic devices</td>
<td>Receiver circuits and low capacitance integration of photodetectors</td>
</tr>
<tr>
<td>Fuel cells and alternative energy sources</td>
<td>Replacement of existing batteries and generators</td>
<td>Absence of appropriate practical optomechanical technology</td>
</tr>
<tr>
<td></td>
<td>Replacement of combustion principles of fossil fuels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nuclear fusion</td>
<td></td>
</tr>
</tbody>
</table>

Special attention in education should be paid to the innovation management and analysis upon which the conclusion about the economic justification of future development projects can be made. Future development projects largely determine which technology development is expected in the future. They will not only largely define the future development projects, but also determine the field of work and operation of the future engineers. Table 1 show an overview of the expected future technologies with the goals and challenges, which can be seen now.
For the realization of those serious tasks it is necessary that the future engineers have an adequate education, focusing on areas that allow the acquisition of adequate working competencies. Jobs of designer engineer and management engineer are significantly different (Tables 2 and 3). While the designers engineers solve the technical and economic-technical problems in engineering management prevails solving organizational and economic problems.

**Table 2. Work day of design engineer**

<table>
<thead>
<tr>
<th>Time</th>
<th>Task</th>
<th>Problem type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.00</td>
<td>Discussion with the Head of Department about the structure of the product price - budget controls</td>
<td>economic-technical</td>
</tr>
<tr>
<td>8.30</td>
<td>Obtaining information from suppliers about the price of components</td>
<td>obtaining information</td>
</tr>
<tr>
<td>10.00</td>
<td>Preparation for installation of equipment</td>
<td>technical</td>
</tr>
<tr>
<td>10.20</td>
<td>Discussion of measures to improve the installation</td>
<td>obtaining information</td>
</tr>
<tr>
<td>11.00</td>
<td>Reordering of installation in order to optimize its</td>
<td>technical</td>
</tr>
<tr>
<td>12.00</td>
<td>Launch break</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 3. Work day of management engineer**

<table>
<thead>
<tr>
<th>Time</th>
<th>Task</th>
<th>Problem type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.00</td>
<td>Planning upcoming tasks</td>
<td>organization</td>
</tr>
<tr>
<td>8.20</td>
<td>Search for external partners for design. Telephone negotiations on hiring designers for 6 weeks</td>
<td>organization</td>
</tr>
<tr>
<td>8.30</td>
<td>The call from the refinery, &quot;the device completely destroyed.&quot; Budget control and drawings; study documentation.</td>
<td>communication</td>
</tr>
<tr>
<td>9.00</td>
<td>Searching for designers and installers that can be deployed immediately, to clarify the damage and to replace of components - Discussion on how to conduct client</td>
<td>organization</td>
</tr>
<tr>
<td>9.30</td>
<td>Discussion about the failed device with the seller, developer, producer, director: - Define the time of delivery devices and any penalties</td>
<td>organisation, economic</td>
</tr>
<tr>
<td>12.00</td>
<td>Launch break</td>
<td>-</td>
</tr>
</tbody>
</table>

5. CONCLUSION

Our world is shaped by engineers using scientific knowledge, technical advances and new advanced technologies in different spheres of social life. Today's society is increasingly taking on the characteristics of the knowledge society, where all processes and human activities depend on the knowledge and skills based on knowledge.

In the future one of the important tasks of engineers will be helping society to adapt new technologies to its needs. In this sense is necessary to identify the dominant trends that shape the future society, politics, economics, the environment, technology and market. Engineers in the development must be thoroughly educated and oriented towards the products and to the processes.

Education of future engineers must offer a set of knowledge, skills and competencies that will make them capable of strive and adapt to the changing environment. They adapt technology to current needs without breaking the natural balance. Future development projects largely determine which technology development is expected in the future. They will define the education, field of work and operation of future engineers. The paper gives an overview of the expected future technologies with the objectives and challenges, which can be seen now.

The engineer needs to do more than in the past, acknowledge its responsibility to society. He has to overlook the social, the political, the economic, environmental, and which has the ethical dimensions of his work.

**REFERENCES**