Mechanical Engineer as a Technical Problem Solver

AN APPROACH TO TEACHING MECHANICAL ENGINEERING COURSES AT THE UNIVERSITY LEVEL

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Abstract **- Engineers work in a real world. Mechanical engineers in everyday business have to solve technical tasks and their responsibility spans from the concept and the technical design to manufacturing and commissioning - often under the time pressure and in stress conditions. Therefore the engineering curriculum needs to be reviewed; the future engineers need mutual language to solve technical problems in a more effective way. This kind of approach to teaching mechanical engineers is demonstrated in two case studies. The first one is an individual approach in classes called "Technical Problem Solving ", based on technical system analysis and optimization. The classes are based on the "Theory Of Inventive Problem Solving" (known as TRIZ), with an original approach to the first stage of the solution – how to define and understand a technical system as an abstract model for further optimization. The second case study demonstrates team cooperation on the project "High Capacity Bucket Elevators".**

Index Terms - mechanical engineer, technical problem solving, TRIZ, technical system

INTRODUCTION

Engineering creates products, services and knowledge integrated in infrastructures that are essential for business and prosperity of humankind.

Dynamical trends towards the high complexity of machines (mechatronics, systems engineering), new materials (material engineering, nanotechnology) and mass and global production (integrated and simultaneous engineering) influenced the university curriculum of engineering in regards to structuring knowledge. Even though there are new dynamic developing engineering branches (bio-engineering, enviromental-engineering, etc.,) the mechanical engineering plays the role of the system integrator in most business projects.

SYSTEM APPROACH

At the beginning, the students (usually group from 6-12) are involved in the general concept of the system approach, focused on the answering the questions and giving the motivation:

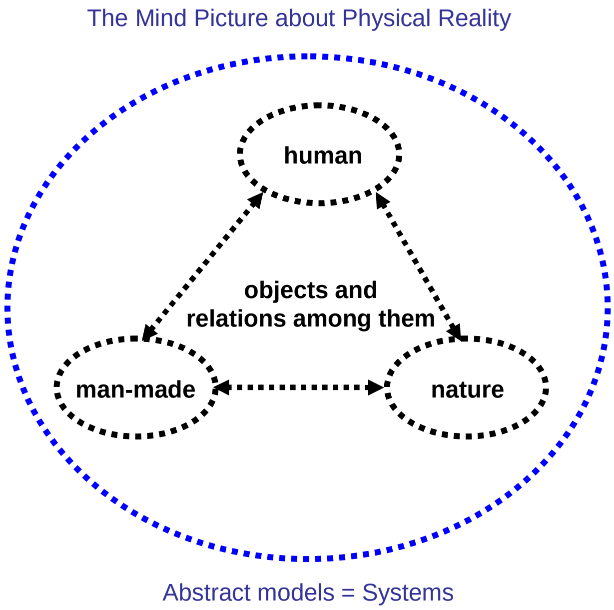

FIGURE 1
THE GENERAL STRUCTURE OF SYSTEM APPROACH

- **What is the system ?** We use the definition "System is an assemblage , real or abstract, comprising a whole with each and every component interacting and related to another one (see figure 1).
- **What is the task for an engineer and the task for a scientist ?**
  The tasks for engineer is to create an engineering work for the customer, at best to protect it by the patent –on the other side, the scientist´s task is to create, find and prove new knowledge and publish it with priority (see figure 2). The interfaces between the engineer and scientist are mostly critical for a succsesful project (to deliver an engineering work to a scientist or to deliver new knowledge to an engineer).
- **What is the project ?**
  We define it by means of the triad Technical Specification ←→ Costs ←→ Terms. This scheme showed to be useful for the mutual focus on an engineering design project.
- **What is the team ?**
  We define it by a sentence " There is no team without mutual goal and no mutual goal without team" as the sum of individual contributions with synergy effect on the team level.

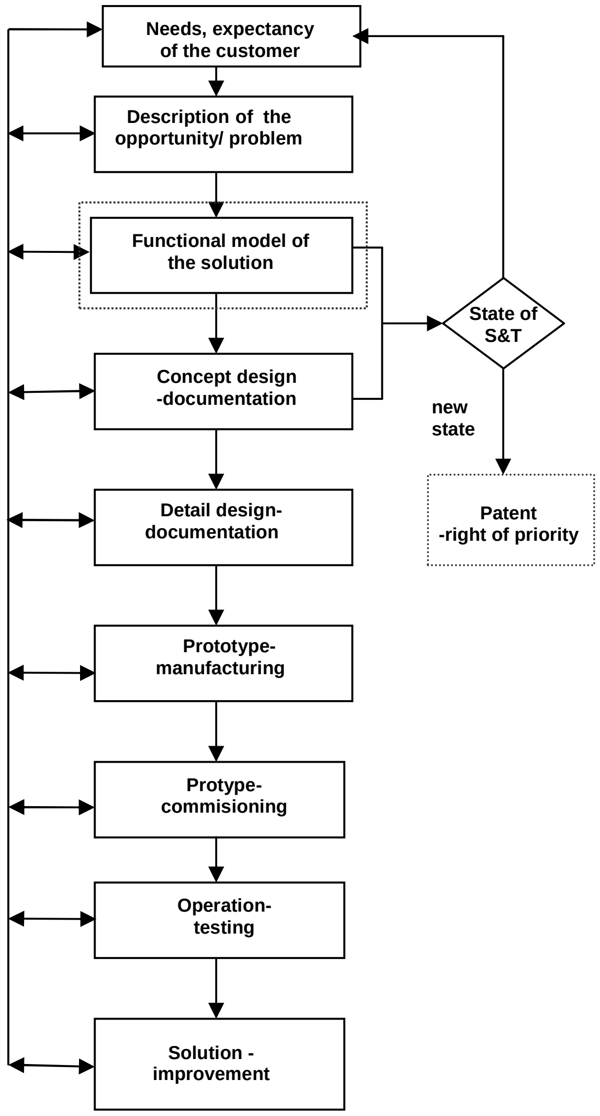

FIGURE 2
THE PROCESS OF ENGINEERING APPROACH

- **What is my mind and my perception ?**
We begin with the sentence : "Do you believe what you see, or do you see, what you believe ?" to show, that the individual reflection without appropriate feedback leads to subjective, non critical approaches. There is no good design without an appropriate criticality. During the course the principles known as Universal Intellectual Standards is applied, e.g. clarity → accuracy → precision → relevance →depth → breadth → logic. [1].We have a good practice to join the standards with system approach, especially for clarity of statements. But sometimes you need to overcome the paradigma of technical thinking, bonded on terms and categories specific for technical branches.

CASE 1: TECHNICAL PROBLEM SOLVING

The basic decisions about the quality of an engineering work are generated at the third step of the process – e.g. by functional modeling of the solution.

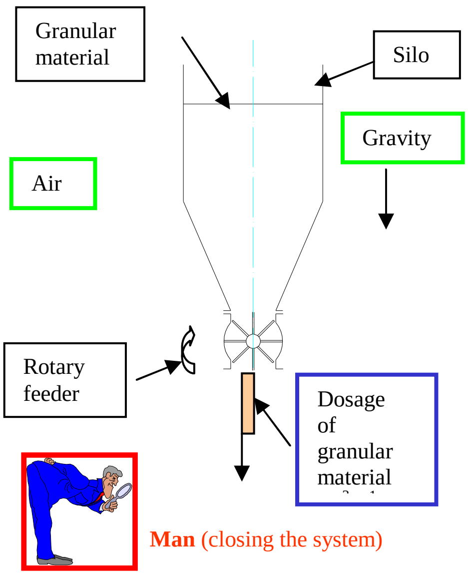

FIGURE 3
A TYPICAL DESCRIPTION OF THE SYSTEM COMPONENTS

The important instructions for description of the system components (see figure 3), are:

- Describe, what you see (things – objects –elements)
- Keep the hierarchy and the phase of the system
- By the first description the system will not include all elements, you will add / trim elements several times
- Your description shall include the enviroment , e.g. gravity, air,…
- On of the elements plays the role of "workpiece" ,e.g. element, which whole system creates, changes,…For the description –see Silo-system on the figure 3 - it is the dosage of granular material.

After description of the system components, the description of the functions, e.g. relations between components shall be discovered. Usually, these phase runs a little bit harder. One of the reasons is, that the relations are not so visible as the components. The causes of mistakes are usually coming from the mixture of various hierarchies and phases generated in the minds of solvers.

The instructions are:

- Draw the components and find the relations among them
- Keep in mind, that each relation shall contribute to the main function (purpose) of the whole system
- When the relation does not contribute to the main function of the system, than it is no function.
- Keep the laws of technical systems – e.g. the system have to be closed in order the energy and information can flow throughout the system. When it is not a situation , then adopt your system in order to fulfill these laws (see figure 4).

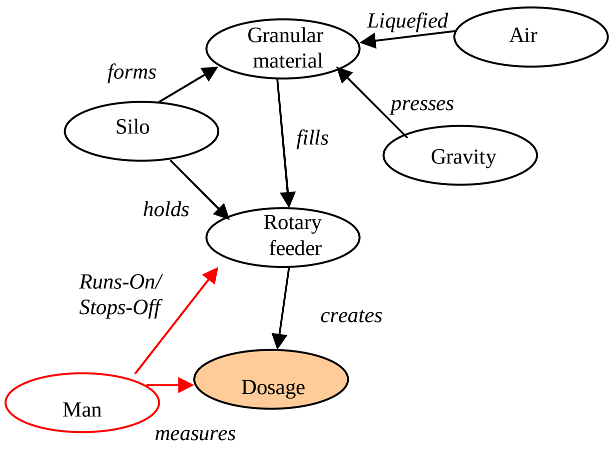

FIGURE 4
A TYPICAL DESCRIPTION OF THE SYSTEM FUNCTIONS

CASE 2: PROJECT "HIGH CAPACITY BUCKET ELEVATORS"

The goal of the project was to hand-over the practical design experience to the group of students (6-12) during the summer and winter semestres. Further the concept of integrated engineering was applied and working mechanical parts (buckets) were designed with respect to granular material behaviour.

When you see the process on the figure 2 the only chance is to fulfill most of the steps, e.g.:

- To find a customer/ theme
- To create the team (all students are sharing the same project)
- To motivate the team
- To manage the project
- To transfer science –knowledge into the project
- To design concept documentation (during winter semester)
- To design detail documentation (during summer semester).
- To keep the communication with the customer and inside the team
- To simulate prototyping, operating by the close cooperation with the customer

For lecturers these approach requires more energy and preparation for courses. Also the conflicts on the interfaces among team members could occur. As a whole, the positive evaluation from side students,customer and lecturers were signed at the end of the project

The following figures 5,6,7,8 document several steps of the project solution.

FIGURE 5
THE EXPERIMENTAL RESULTS OF GRANULAR MATERIAL BEHAVIOUR ON THE HEAD OF BUCKET ELEVATOR WERE TRANSFERRED INTO THE PROJECT SOLUTION , [2],[3].

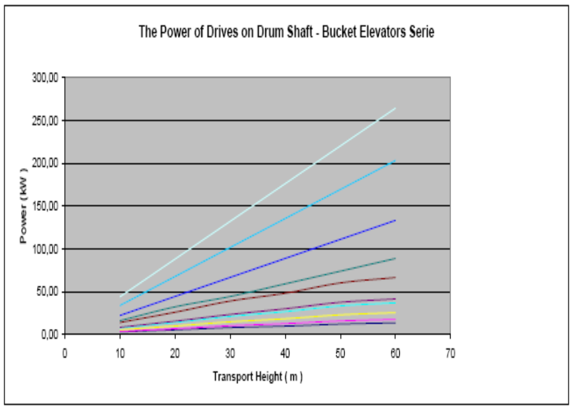

FIGURE 6
THE POWER OF DRIVES FOR THE WHOLE RANGE OF TRANPORT HEIGHTS AND CAPACITIES WERE CALCULATED:

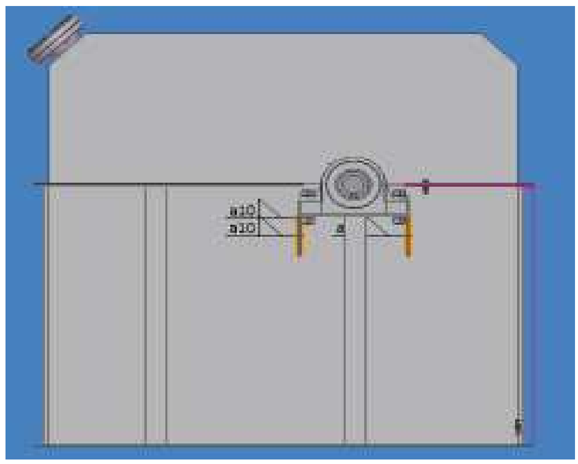

FIGURE 7
THE FUNCTIONALITY WAS FIXED INTO THE CONCEPT -3D MODELS

FIGURE 8
THE PROTOTYPING AND OPERATING WERE CLOSE COOPERATE WITH THE CUSTOMER

CONCLUSION

The above described integrated approach to teaching mechanical engineering courses at the university level was practiced for the last 2 years with the positive evaluation from the students, lecturers and external firms from industrial branch. It brings more professional experience on the students and improves their creativity and motivation for innovative engineering solutions.

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