# Geometry and engineering graphics in engineering education illustrated by example of advanced 3D modelling course.

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***Abstract* – The authors will present the process of students' education in chosen faculties of Silesian University of Technology in the field of descriptive geometry and engineering graphics. The education of engineers in this field covers at first the „classical" descriptive geometry and technical drawing principles. The study of broadly defined geometry is continued during the advanced solid modelling courses, when the latest systems used in creation of virtual models of real objects, such as Autodesk Inventor, Catia and others are utilised. Examples of students' projects are given. These projects were aimed at acquiring skills necessary to created three-dimensional virtual models of real objects. Other examples will also be given, showing complex objects projects, where the goal was to attain the ability of discerning positions of different objects in space in relation to each other.**

*Index Terms* – geometry and engineering graphics, 3D modelling, students' projects.

## COURSE CONCEPTION

Descriptive geometry and engineering graphics are among the basic subjects taught in many faculties of Polish technical universities. In Silesian University of Technology these subjects are obligatory in almost all faculties. The curriculum covers lectures, practical exercises in drawing and projects done using computers and CAD software. In some faculties the study of geometry includes training in generation of virtual models of real objects, using software such as Autodesk Inventor or Catia. Here we can cite the example of Katedra Transportu Szynowego (Department of Railway Engineering) of Transport Faculty. This Department works in close co-operation with Ośrodek Geometrii i Grafiki Inżynierskiej (Centre for Geometry and Engineering Graphics) in the field of advanced solid modelling. The students of Silesian University of Technology Transport Faculty are able to participate in a Catia software training course, utilising previously already acquired knowledge of descriptive geometry. The course is carried out during 3rd year of study, lasts 120 hours and is organised during vacation. It is free and non-obligatory. The course is run by well-trained university staff in specially adapted computer laboratory.

The course's goal is to provide students and future engineers with skills necessary to employ appropriate software used to create three dimensional virtual models of real objects. These skills will be useful in their future professional career, helping them to create virtual prototypes of technical devices or architectural objects and buildings as well as household objects used in everyday life. These skills will be most helpful in developing professional ambitions in many branches of industry, artistry and art. English version of Catia software is used during the course and this provides the students with additional advantage, since they may be easily employed in any foreign company in Poland or other EU country.

Catia software training course is also useful in preparation of projects in many other subjects undertaken during the graduate studies as well as during preparation of M.Sc. theses.

The skilful use of almost unlimited possibilities of creating virtual prototypes of real objects provides modern engineer with ability of overcoming many design barriers. Nothing restrains the imagination and ingenuity and design conceptions may be verified at a minimum cost, since the necessity to construct many prototypes or run experimental tests may be, to some degree, eliminated. There is no doubt that the use of virtual prototypes of machine elements, devices, vehicles of buildings must not be the sole basis in design. However, the ability to construct virtual prototypes shortens the design time and decreases the overall costs of the project.

## BASIC EXERCISES

The students learn to use Catia software, using already acquired knowledge of descriptive geometry. First exercises start with creation of three-dimensional models of simple solids (FIG.1.). These exercises are aimed at acquainting students with Catia software interface, getting them to know program commands, its possibilities, its direction for use and showing that all steps taken during creation of 3D models are founded on the descriptive geometry and maths principles. The initial exercises must also result in acquiring skills necessary to define positions of virtual objects (or their

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elements) in space relative to each other (coaxiality, coplanarity, parallelism, perpendicularity and the like).

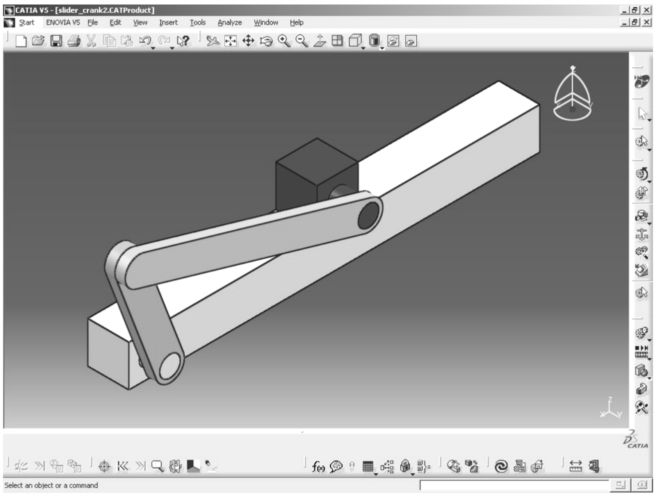


FIGURE 1.
EXAMPLE OF BASIC EXERCISES

### INTERMEDIATE EXERCISES

The next stage in learning Catia software covers modification of elements of basic solids and creation of complex shape solids. Students use line segments, arc segments, planar sectors, to create solids and Boole operations with solids. They also get to know engineering processes used in manufacturing the modelled elements. It is indispensable to the modern engineer to be aware of the requisites of production process. The almost unlimited possibilities of virtual design of new objects are limited by production requirements and restrictions.

This phase of the course results in participants' working out virtual models of devices, machines, vehicles and everyday life objects elements (FIG.2.).

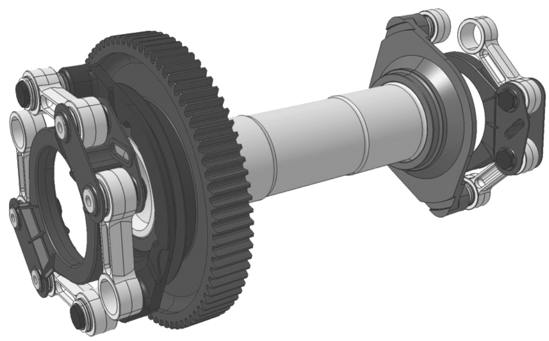

FIGURE 2.
INTERMEDIATE EXERCISES EXAMPLE

The course instructors prefer team work. The students group is divided into teams working on separate elements of the whole object. Putting together the results of different teams' work, the virtual model of a complex object is created. At this stage crucial decisions related to the object are taken. The participants receive technical specification of existing object. On this basis the virtual models of separate elements are generated, different teams co-operate and adjust their work. The subsequent phases of the project are also co-ordinated and agreed on.

Working together gives many opportunities of exchanging experiences, co-ordinating project strategies and collective solving of problems arising from e.g. possible mistakes in technical specification. Co-operation skills are indispensable to team work and are acquired by the students during the monthly training course. These are of course necessary for the engineer undertaking work in design office.

### ADVANCED EXERCISES

The next stage of the training is aimed at forming the ability of perceiving the objects' positions in space in relation to each other. Here the different separate objects (created during the preceding work) are assembled. They utilise geometrical relations (coaxiality, coplanarity, parallelism, perpendicularity of the axes and edges, constant distances etc.) in order to create complex virtual models of real objects (FIG.3.).

During this phase verification of different elements of complex objects is done. The elements created by different student groups are collected and assembled. Ability to determine positions of solids in space defined by cartesian co-ordinate system makes possible object assembly. Without doubt the skills acquired during the descriptive geometry course are among the most important factors here, since they are requisite in spatial imagining of 3D objects represented by 2D drawings.

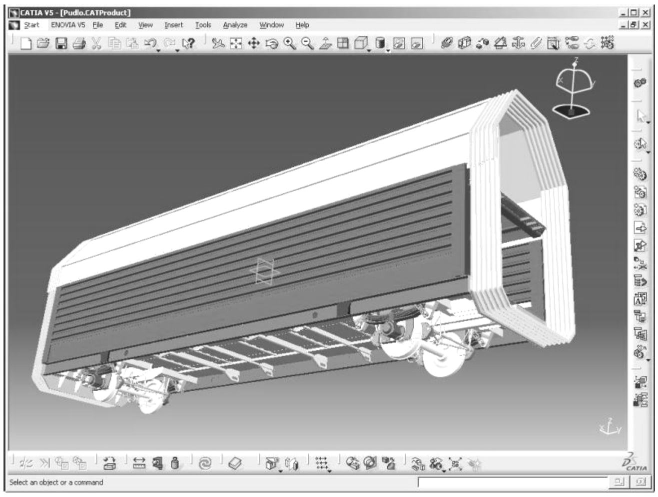


FIGURE 3.
EXAMPLE OF ADVANCED EXERCISES

### ADDITIONAL POSSIBILITIES

3D virtual models of real objects may be used in different analyses. Complex models are utilised in functional analysis (checking the proper operation of a mechanism, machine or vehicle). Catia software makes possible simulation of assemblies and complete models operation of real objects (FIG.4.). At this stage the participants must be able to associate skills and knowledge acquired during the courses of descriptive geometry, mechanics and others.

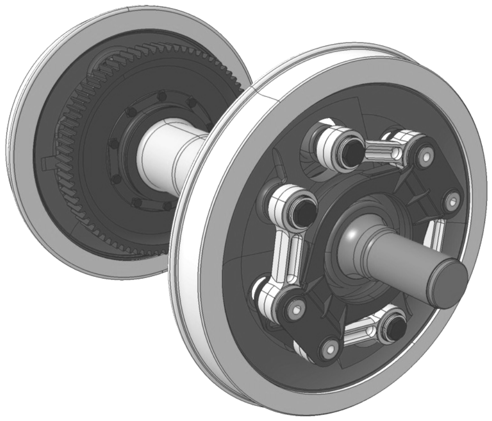

FIGURE 4.
EXAMPLE OF FUNCTIONAL ANALYSIS

Virtual models of real objects may be also used in different strength (FIG.5.) and kinematic analyses.

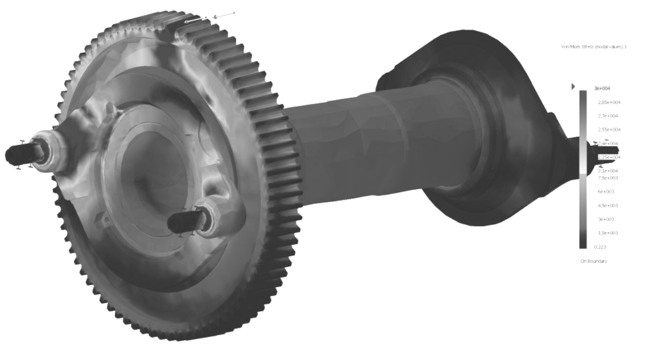

FIGURE 5.
EXAMPLE OF STRENGTH ANALYSIS

The course's participants, i.e. future engineers use the generated models of real elements to run strength analysis. At this stage they are able to check whether the designed element fulfils strength requirements. If not, then the design process must start anew. The geometric parameterisation of the models makes possible fast and effective dimensional changes so that they meet strength conditions.

## CONCLUSIONS

Basing on skills and knowledge acquired previously during maths, descriptive geometry and other basic subjects' courses the participants of advanced course of solid modelling learn how to use modern CAD software. The CAD software makes possible searching and finding new solutions to the problems and allows for their fast multi-criterial verification, with criteria ranging from safety considerations to cost-effectiveness.