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# Computer Aided Design System and its Acquisitions for the Professional Literacy of Students

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***Abstract***

The contribution is focused on features and functionality that program Autodesk Inventor can provide to the user with the emphasis on link between study and practice. Modules of this program can be used in all phases of design and technological process that means from modelling in 3D space through creation of assembly and relevant drawing documentation to the strength and dynamic analysis of proposed components and mechanisms.

*Keywords:*
Bicycle frame
Computer Aided Design and Manufacturing
Mechanical Engineering
Professional Literacy

## 1 Introduction

Nowadays, when the use of information and communication technology is becoming an everyday part of our lives, is this trend increasingly implementing also in the field of engineering. Using of CAD applications in the pre-production stage of mechanical engineering is currently almost commonplace of every company. Knowing how to use the CAD systems is gradually becoming a prerequisite of almost every expert in engineering. Software products such as SolidWorks, CATIA, and Autodesk Inventor are the most widely used in terms of experience of staff and not least in terms of historical development of Czech companies in recent years.
Based on this fact included the Department of Mechanical Engineering at Institute of Technology and Business in České Budějovice the subject as Computer Aided Design I and II and Computer Aided Manufacturing to the category of mandatory subjects. The need to link the students with production sector has now become one of the necessary conditions for subsequent employment of graduates. Priority task of the our university is the effort to enhance the professional literacy of students in response to the current state of industrialized practice as well as efforts to develop their professional skills during their studies, thereby facilitating students success on the labour market. As it is obvious from the titles of subjects, their priority is, so that the designer can create all the necessary documentation in the comfort of his own personal computer and not to have spent long hours in front of the drawing board. Currently, both of the subjects are being taught on the department for four hours per week by exercising. Through the solving of various projects, the Department of Mechanical Engineering is trying to engage students into solving tasks in connection with the manufacturing sector. One of

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the projects was to design fully functioning prototype of a bicycle according to the certain criteria. As the main criterion by the development has been the design and model of the bicycle frame.

## 2 Computer Aided Design system Autodesk Inventor

The abbreviation CAD stands for Computer Aided Design. It incorporates all the applications that are primarily used for creation and editing of geometry of products, spatial 3D models and manufacturing documentation. Many CAD systems can be extended with additional features making them a comprehensive developed ambience. This may be extensions for specific purposes such as simulation and strength analysis. Among advantages of CAD systems can be included libraries of standardized and user-defined components that can be constantly added. The main advantage of CAD applications is the big time saving that must be dedicated to graphical processing of design or editing of components.
The aim of today´s leading manufacturers engaged in development of CAD applications is to enable users the comprehensive management of product life cycle in production sector, which aims on increasing the productivity and reduction of production costs. In other words, the aim is to facilitate CAD systems and simplification of routine work of designers by modern methods and elements that expand the structure possibilities, not just of the drawing documentation, but also the possibilities of creating the geometric objects and subsequent design of other technological parameters. This system can be linked with other systems such as CAM systems or Computer Aided Manufacturing. These systems are able to generate code for control of NC machine. Among typical applications can be included: AutoCAD, Autodesk Inventor, Solid Edge, SolidWorks, and CATIA.
Autodesk Inventor is one of the bestselling CAD application for engineering of 3D design in the world. The program can be divided according to the considered issues in modelling and creating of drawing documentation on individual blocks. When creating a new file, Inventor gives users the possibility to choose from multiple variations of basic blocks. Specifically. The types of new files are as follows: component file (*.ipt), assembly file (*.iam), drawings file (*.idw, *.dwg) and presentation file (*.ipn). Program Autodesk Inventor can be described as a software that is primarily intended for productive designing of new products. Creation in the program is based on the use of elements of parametric and adaptive modelling. These characteristics greatly facilitate the creation and modification of components. The primary advantage of inventor is the ease of use, efficient creation of highly complex components and assemblies that could mean in manufacturing sector the fast operator training and subsequent transition to modelling of components.

## 3 Computer Aided Design from the perspective of acquisitions for students

The educational process of this subject takes place in classrooms of the university that include the computer software. As the suitable software for the education was chosen the ambience of Autodesk Inventor. This selected program, thanks to its extensions module can significantly affect the legitimacy and applicability in practice. We are speaking about modules that are used in every phase of design and technological process that means by the modelling in 3D space, through the creation of the proposed components and assemblies.
The vast majority of the students of the department are high school graduates with the focus on engineering or other related fields, certain knowledge and habits from drawings in various computer programs has been already adopted. In addition to their knowledge that each of them should have acquired by using CAD systems is the knowledge of at least basics from technical drawing. The education of the subject throughout the semester consists in familiarization of students with basic knowledge and skills of using Autodesk Inventor in its latest version released in 2015.
In the initial hours of the subject students familiarize with the ambience, using of the program and program settings. Progressively, the procedures of basic parametric modelling are being explained and discussed. Once students are familiar with the basics skills of program use, we proceed with drawing of simple 2D sketch. Subsequently on incurred sketches, students will try multiple forms of dimensioning, bonds and using of axes and points. Whereas the design of 2D sketches is in ambience of Autodesk Inventor very important, we assign great importance to mastering of the skills and habits of students. By activities, that are associated with the designing of 2D sketch is also necessary the knowledge of at least basics from technical drawing.

The importance of the mastering of designing of sketches will be demonstrated by students in other functions of the program such as extrude, loft, drag. Validation whether all this features were acquired by students will be done by the final assignment. Once student had acquired basic features of the program and is able to design components, we proceed to the assembly design. By the assembly designing. Students become aware of multiple ways how to put individual components into assembly and how can components bond together. In addition to the bonding possibilities, students will learn how to create welds on already designed assembly.
The last issue that the subject includes is the production of drawing documentation. This section is devoted considerable attention, since the proper drawing documentation is one of the most important tasks in engineering practice. Autodesk Inventor provides many possibilities of creation of manufacturing drawings and that's why it is given the significant attention to this issue in subject syllabus. Our effort in education in this issue was mainly focused on the drawing documentation of already designed components by students on previous exercises and also in this way we tried to repeat the already acquired knowledge.
One of the outcomes is also the preparation of the final assignment which is oriented to the design of a fully functional model of bicycle. Students´ task is to create and design the assembly of bicycle using the knowledge acquired during semester. The basis for design is to model the bicycle frame itself on which students practice their skills in using the program. The subsequent task it to design other components such as handlebars, saddle, wheels, pedals etc. If student has all the components designed, he is finalizing the design of a bicycle by composition of an assembly.
By designing of an assembly, he must ensure to have a perfect bonds between each components. Form and content of the assignment achieved success and for large group of students we managed to attract even greater interest in this subject.

**Fig. 1:** Sample of designed assembly of bicycle model

Particularly by designing and modelling this type of the bicycle frame, student must have provisionally design the underseat pipes by rotation and thus preserve the stability of a fixed size, thus preventing the shifting of planes to unwanted positions. Once student had designed the underseat pipe, he started a new report in which it was inserted as an initial component. From location of this component, all other components unfolded, such as other pipes, axes, composition of head and not least the handle for the wheels. Most of the elements were designed to derive from the base of the shaft while it was necessary to meet the suggested geometry. It referred the set of bonds that have been prepared to link up to each other according to the specification of changes to the original part. As long as the assembly will not meet the standards of a particular strain, it would be very simple to change the size of all of the components included in assembly. In essence, this would mean, that by changing of one dimension could be ensured that all used pipes would change to desired thickness. Finally, in this case the corrections have been avoided, as the designer (student) was using his rich experience by the design and his estimation was ultimately quite precise and accurate.

## 4 Benefits from the connection of theory and practice

The main outcome of education of subject Computer Aided Design was to design a hybrid frames for bicycles for riding in urban areas, for sports or recreational purposes. By designing the frames it was required to apply

the knowledge not only from the field of engineering, but also from the field of ergonomics. The shape of bicycle frame must be based on linking the effort for perfect rider position with technical, technological and material possibilities. By designing the frames was also necessary to assume, what is the target group of costumers. For example, when designing a men´s bicycle frames, it is necessary that the frame has mostly irregular pentagon shape, but to the above mentioned pentagonal shape of frame should not be approached dogmatically and mainly due to the use of modern materials and technologies, which in the future may mean a clear change in the shape of the frame.

An important factor in the designing of the frames is also suitably selected material. By analysis of the currently most widely used materials, we have determined that as a material for the production of a frame may be used steel, aluminium, titanium, magnesium, scandium and carbon. From the above mentioned materials according to our needs was chosen the aluminium as the most appropriate material. This decision was mainly due to its characteristics such as low weight and high rigidity. The density of aluminium is 2700 kg/m3, which is about one-third of the density of steel, the tensile strength of the aluminium alloy is up to 700MPa, a value similar to that one of low carbon steel. The disadvantage may be its higher price and low elasticity. These drawbacks ultimately proved to be less significant in comparison to the frame, for example of carbon fiber or titanium.

The subsequent task was to design other components such as handlebars, saddle, wheels, pedals etc. If students had all components designed, the final task of the bicycle design was to assemble components into the set. By creating the assembly, students had to keep in mind the creation of perfect bond of every component. The form and content of the assignment did achieve the success and we felt students were attracted by the subject. Following this fact, currently at the Department of Mechanical Engineering is undergoing a project that is aimed at ensuring to have the proper production areas for production and construction of bicycle frames.

Within this subsequent task, the research team devoted inter alia to the front fork suspension (Fig. 2). The suspension is provided by two hydraulic and one pneumatic chamber. The lower hydraulic chamber is a space between the upper shaft, lower shaft and sleeve. The upper hydraulic chamber is a space within the upper shaft (space under the spring during the compression and decompression of the spring area). Pneumatic chamber is a space in the bottom of the shaft, where the air can compress accurately to the measure of the slider a by this, it is possible to influence the pressure with the exact same way as the pressure in tires (assured by valve). This chamber is compressed by the movement of bottom shaft, while the upper shaft is stationary and thereby creating the pressure in the chamber.

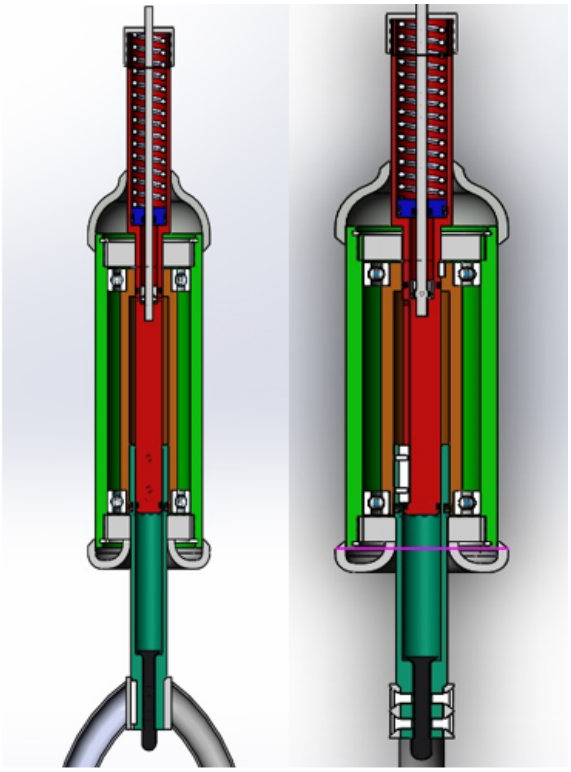

**Fig. 2:** Sectional view of central front fork dampening

The suspension can transmit torque and performs reciprocated movement of the bottom shaft to the top. Torque is provided by assembly that includes pen, sliding pen and by two ball bearings. Pen is placed between the upper shaft and sleeve. The sliding pen is assured within the bottom shaft and moving between the upper and bottom shaft, being in the oil bath. The assembly of the upper shaft, bottom shaft and the housing are not capable of carrying the torque. Therefore, the housing includes the ball bearings from both sides. The bearings defines the gap between the head and the housing and is secured on each side by sealing rings and lock nuts. Reciprocation is carried only by bottom shaft. This movement ensures the mounting in the hull and the upper shaft. The shaft itself is secured from below by the stop lock nut and hydraulic oil, so that the shaft could not exceed a range of functionality, depending on the compressibility of the spring and the air in lower chamber.

## 5 Conclusions

To summarize the key outcomes of multiple ongoing projects, we can state that we are holders of fourteen European industrial patterns dedicated to the bicycle frames. Also we have constructed and designed fully functional prototype of bicycle. The anticipated outcomes yet to come is the creation of portal that would provide the theoretical and practical support for students. It will include so called electronic textbook and exercise book, which would contain short tutorials on hand-outs and it will provide the practical support for students on our institute, later on at other universities through helpdesk or “costumer” support.
The main priority of the Department of Mechanical Engineering at the Institute of Technology and Business in České Budějovice is to prepare students to simply engage in a work process. One of the subjects, which assists students in the transition from school to work is currently the subject Computer Aided Design. Teaching of this subject has its narrow specifications. During the interpretation of subject matter it is also important to find the optimal way to interest and teach students. Thanks to the final assignment that included the design and construction of the fully functional bicycle, we can say that we managed to evoke the students´ interest in this subject. We can see this particularly on lessons which now include active discussion of all interested students to solve partial issues that they have with assignment. We believe that only by the active participation of students into solving issues can be achieved fully-fledged educational results.
Today´s using of CAD 3D modelling is a must for every mechanical engineer. This requirement has changed the approach to the problem of computer aided subjects at almost all schools involved in teaching mechanical engineering. It is important to pay attention on the increased possibility to link the knowledge acquired at lessons and the practice. Evidence that the objectives on our institute are fulfilled is the implementation of such assignment within the education of subjects Computer Aided Design and Computer Aided Manufacturing.

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