Paper number: 8(2010)3,188, 215 - 221

HIGHER LEVELS OF MODELING BASED ON INVENTOR SOFTWARE

Mr Rade Vasiljević*
IRC NIC A.D., Užice

In this paper, the higher levels of modeling were analyzed, which are in machine design and analysis products one of the most complex and most demanding phase. At this phase, an engineer-designer spent a lot of time in a matching of parts and defining the required constraints. On the one aspect, shortening this time is not achieved by either using today powerful software tools, while, on the other aspect, further increases without the existence of explicit procedures. To optimize the needed time in modeling the higher level of incorporation procedure is proposed in the form of structural diagrams. A software solution Inventor was presented in a systematic way. Special emphasis was given to higher levels of modeling. Solving higher-level modeling, using Inventor, illustrated on a concrete example of assembly.

Key words: higher levels of modeling, Inventor, assembly, matching, constraint

INTRODUCTION

Mechanical design and analysis of products is unthinkable without the support of modern software solutions today, [6]. Computer support contributes to the efficiency and effectiveness of industrial production, [5]. This is the result of a growing number of increasingly powerful and specialized software packages such as Inventor, Ansys, SAP2000, Catia, Solid Works, Pro Engineer, ADAMS and others. The list of software solutions, which are increasingly dominant place occupied by solutions from CAD.

Students of mechanical engineering and mechanical engineers-designers usually successfully master the use software tools to parts modeling, but the problems appear in the phase modeling of higher levels of incorporation or assembly. This fact is established and in paper [2].

In general, a technical system is consisted of n components, where n≥2. Modeling process for complex systems may consist of three logical phases:

- modeling of parts,
- modeling of subassemblies and assemblies (integration of parts and standard machine elements into higher levels incorporation), and
- modeling of main assemby (integration of parts, standard machine elements, subassemblies and assemblies into higher levels incorporation).

In the second and third phase of modeling complex systems are defined by the kinematic relations, and constraints in terms of:

- alignment of area,
- alignment of edges,
- alignment of axis,
- alignment of working points,
- defining the desired motion between two components, and
- identifying the relationship between the transient path fixed component and the component that moves along the path.

Each part can be assigned the appropriate number of freedom degrees and thus the degree of displacement or deviation part of the adjacent parts. It is very important to correctly define the constraints in the phase of high-level modeling. Number of constrations should be both, sufficient and minimal. The achievement of this requires, a model assembly or model of any of its parts can be used as a substitute for a physical prototype.

In the following subtitles of this paper will first

"IRC NIC" AD, Nikole Pašića 38b/IV, 31000 Užice; rvasiljevic@ptt.rs

be presented the theoretical basis of higher-level modeling in Inventor, and then the same ilustrded on the example of the assembly of performed solution of electromechanical two post lifts. Finally, on this basis will perform a appropriate number of recommendations and conclusions.

GENERAL CONSIDERATIONS INVENTOR

Today There are a large number of software solutions that offer powerful tools for modeling high-level application today. In paper [2], shown two contemporary software solutions, CATIA V5 and Solid Works. In this paper the problem of modeling the higher level of incorporation will be presented at high-end software solution Inventor, Autodesk company. Autodesk is the world's leading manufacturer of CAD software, [1, 4].

Inventor software package is intended for the design and analysis products on the computer. At the time of paper writing the Inventor has arrived version 2011, [1]. It enables automate the design, construction and calculation. Based on a system for modeling assemblies solids (3D) and technical documentation creating (2D).

The importance of Inventor, as well as other software solutions from CAD group, is contained in the creating of 3D geometry. Inventor is a hybrid modeler that combines solid bodies and surface. In the structure of Inventor are two separate modules for creating 3D geometry:

- Part Modeler - enables parametric modeling and editing of solid bodies and surfaces, and
- Assembly Modeler - enables the design of mechanical assemblies and creating of specification, expanded screening etc.

In addition to these modules, which relate to the title of this paper, the structure of Inventor are the following modules:

- Sheet metal modul - enables the design of plates and automatic unfolding of surface,
- Weldment Assemblies - enables the welded assemblies creating,
- Frame Generator - enables parametric 3D modeling and editing of steel structures using standard profile,
- Drawing Layout - enables technical documentation creating, automatic dimensioning, drawing different note, the symbols in accordance with industry standards (ISO, DIN, BS, ANSI, etc.)
- Presentation - enables animations mounting subassemblies and assemblies creating,
- Inventor Studio - enables animation and photorealistic images creating,
- Library - contains a library of over one million standard machine elements by various industry standards (ISO, DIN, BS, ANSI, etc.)
- Design Accelerator - enables a large number of mechanical calculations and contain mechanical manuals over one million standard machine elements,
- FEA - enables the calculation assembly according to the method of finite elements,
- Dynamic Simulation - enables the dynamic simulation of assembly or mechanism,
- Tooling Suite - enables working with plastic parts and automated design tools for molding plastic
- Pipe / Tube - enables parametric modeling of pipes, hoses and connections,
- Harness / Cable - enables parametric modeling of cables and wiring, and
- IDF - enables a IDF file inserting with information of printed circuit boards and printed circuit boards modeling.

Inventor, based on the created 3D geometry of the parts, enables composition and analysis of products using its virtual prototype. Using the model thus obtained, can be analyzed the product before making his prototype. By using Inventor software package, engineers-designers can very quickly identify errors and omissions on the model before the phase of production and thus eliminate unnecessary investment.

TOOLS FOR HIGHER LEVELS IN MODELING INVENTOR

Assembly is a group that consists of one or more components of the design, where components can consist of parts or subassemblies, [3]. Assembling elements into an assembly in Inventor software package is implemented under the same principles which is used at the montage of a physical prototype. This software package offers tools for matching an engineer-designer to provide support for its work with higher levels of modeling. Tools matching enables the positioning, fixing and limiting components in the assembly, ie. define the interrelationships between the components in the assembly. It can also enable motion freedom.

The first step to getting assembly is appropriate components grounding. Mainly, a base component or components that can not be moved in relation to other components is landed. In the second step can be implemented matching through Place Constraint tool, figure 1.

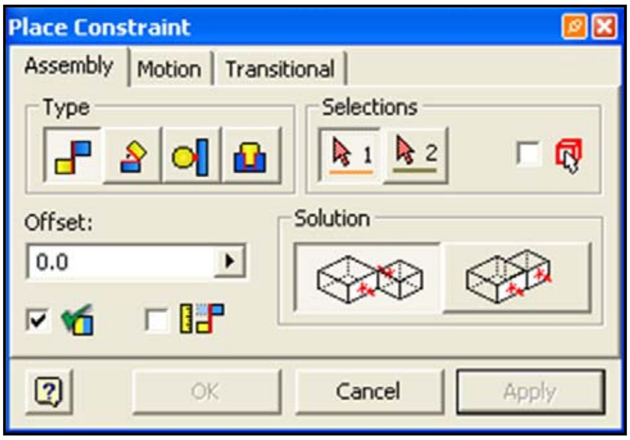

Figure 1. Tools for matching in Inventor (Active card Assembly)

Card Assembly, figure 1, is the most commonly used and it enables paired, angular, tangential and constraint insertion. Options from this card are Mate, Angle, Tangent and Insert. Using these options exercised constraint assembly. These limits define the place or position of components and fixed components in space. After the assembly constraints, constraints of motion are executed.

Card Motion, figure 2, defines the desired motion between two components, using the specified scale and orientation. Options from this card are Rotation and Rotation-Translation. Constraints of motion are present to components that rotate and move together (gears, racks, belt drive, bearings and carriers, wheels and lift tracks etc.). These constraints define way the motion of mobile components in relation to other mobile or fixed components (for example, defines whether the two gears moving in the same or opposite directions). Eventually, other types of constraints from the card Assembly apply (for example, attaching the tops of two gears).

Card Transitional, figure 3, enables us to identify the relationship between the transient path fixed component and the component that moves along the path. A simple example to illustrate the constraints of the transmission is the movement of the movable cylinder along a fixed path (for example, roller and a tooth). The aim of transmission constraints is to determine how mobile component should follow a certain path. Eventually, other types of constraints from the card Assembly apply (for example, attaching the roller and the top teeth).

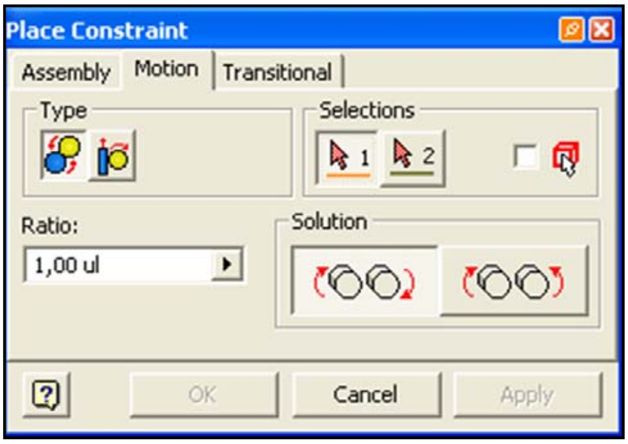

Figure 2. Card Motion tools Place Constraint

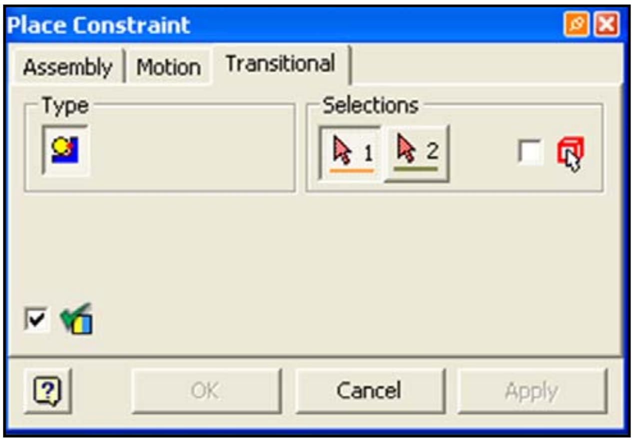

Figure 3. Card Transitional tools - Place Constraint

During the modeling of higher levels of incorporation, it is important to analyze the constraints and errors. Number of components in the Browser tree Inventor is conditional and depends of the function of the assembly. On the one hand, each components in match defines the appropriate constraints, while on the other hand, the components were losing some of their freedom of movement. Number of constraints of one component should not be higher than the minimum and necessary. Any redundant constraint can cause problems in the process of analysis of products (simulation analysis, static analysis, dynamic analysis, etc.) Overextended constraints are marked and can be seen in the Browser tree Inventor. For the analysis of constraints the Drive Constraint option is available in Inventor, which, among other things, can detect collisions. Components involved in the crash are identified and will be displayed on the detection of a collision.

PROPOSAL PROCEDURES FOR HIGHER LEVELS IN MODELLING

To have students of mechanical engineering and mechanical engineers-designers in addition to the successful mastering of software tools for parts modeling, successfully mastered and software tools for higher levels of modeling and assembly modeling is necessary to define problems in the modeling of higher-level incorporation.

Problems in modeling of the higher level of incorporation occur for the following reasons:

- insufficient knowledge of the function of parts and subassemblies into assemblies or subassemblies and assemblies in the main assemblies,
- needed knowledge and skills for successful modeling of higher levels of incorporation are not always at the appropriate level,
- examples of modeling high-level of incorporation in the instructions and literature are simple, as is the case in the papers [2] and [3], and
- operating procedures for the successful modeling of higher levels of incorporation are not explicitly defined in the instructions and literature.

One of the possible solutions of mentioned problems, the general procedure a modeling higher level of incorporation in the form of structural diagrams is proposed, figure 4.

In order to avoid design errors that may arise during the modeling high-level of incorporation, it necessary to constantly take preventive measures and carry out necessary activities according to the most logical order.

Verification of the validity of the proposed procedures for modeling the higher level of incorporation can best be shown on a concrete example of the product, so that it will be done on a concrete example of assembly in the following subtitle.

In this sense it is necessary to correctly set up the experiment of modeling the higher level of

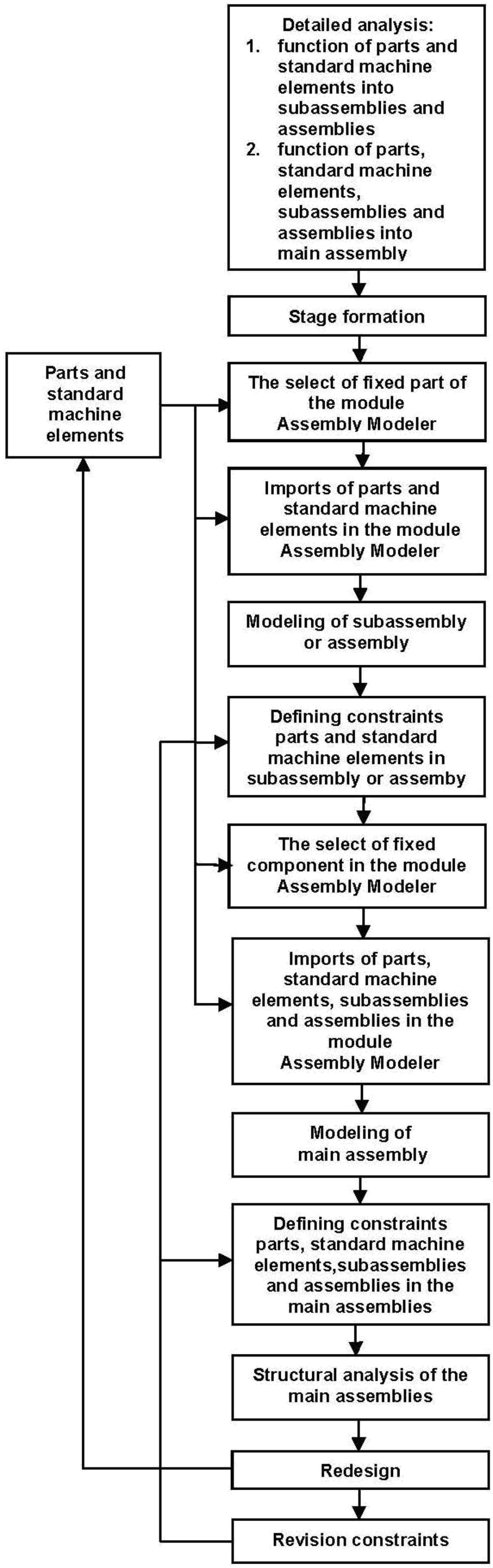

Figure 4. Structural diagram modeling higher levels

incorporation of selected example of the assembly. For the implementation of the experiment Inventor specialized software package is planned in this work, which is discussed in the preceding subtitles.

EXAMPLE HIGHER LEVEL MODELING

Verification of the validity of the proposed procedures for modeling the higher level of incorporation into the Inventor software, is demonstrated for electromechanical two post lifts. To illustrate this example, the materials and results from the paper are used /6/. The experiment used a software package Autodesk Inventor Series 10.

In the first part of the experiment, according to the proposed procedure modeling the higher levels, activities prior modeling electro-mechanical two post lifts were first carried out.

In the first activity, the author of this work was made the analysis of performed the solution of electromechanical two post lifts manufacturer "Universal" from Banja Luka, the type of DB2:

- principles of operation of electro-mechanical two post lifts or higher levels of incorporation, and
- the place and function of each element in the electromechanical two post lifts.

In second activity, based on previous activity, the formation stage carried was out.

In the second part of the experiment, modeling electromechanical two post lifts was conducted.

In the first phase of modeling, the discussed products, parts were modeled and standard machine elements were selected. The proposed procedure leads to the possibility of redesigning parts in case of changing parameters.

In the second and the third phase to approach the modeling of higher-level incorporation.

In the second phase was conducted modeling assemblies electromechanical two post lifts. In this paper the modeling phase assemblies is shown an example of a higher level assembly of the threaded pair electromechanical two post lifts.

The first step is carried out functional analysis of higher-level assembly of threaded pairs electromechanical two post lifts and defines the appropriate parts and subassemblies of the same assemblies.

The second step, the first fixed component is selected and imported into the Assembly Modeler, and then imported the free components into Assembly Modeler. For a fixed component is selected threaded screw, while the imported components as a free mobile carrier console. Figures 5 and 6 shows the models of threaded screw (part) and mobile carrier console (subassembly) which form one of the possible variants of the decomposition of assemblies threaded pair electromechanical two post lifts.

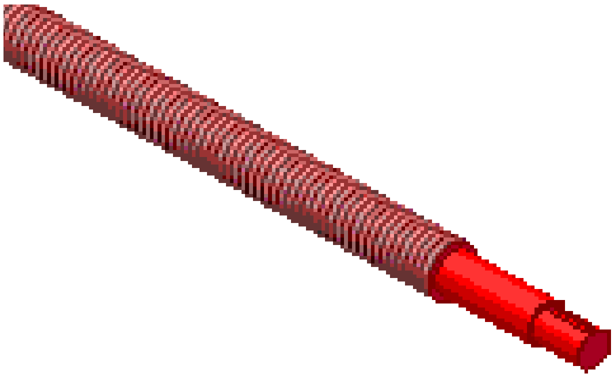

Figure 5. Threaded screw - part

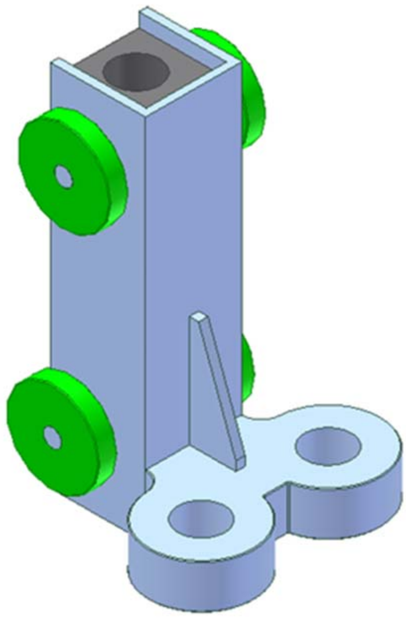

Figure 6. Mobile carrier console - subassembly

In the next step, using a tool for matching and definition of constraints was formed the final model of the assembly of threaded pairs electromechanical two post lifts, figure 7.

The analysis of constraints of modeled assembly threaded pair in Inventor, using options Drive Constraint. Revealed the overextended constraints are removed.

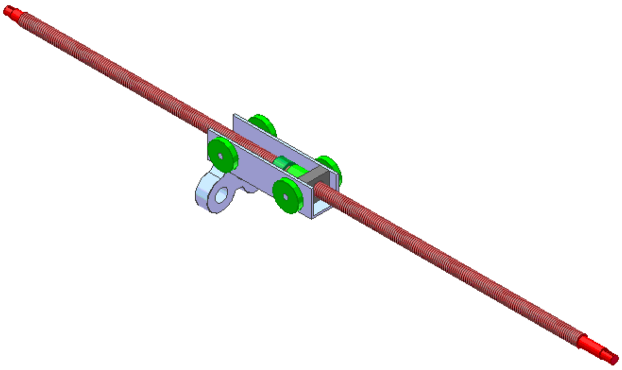

Figure 7. Assembly of threaded pairs

By analogy, using appropriate tools for matching and definition of constraints, were other assemblies modeled.

Furthermore, the modeled assembly threaded pairs are first used to model higher-level assembly of the driving and following columns, and then the main assembly of electromechanical two post lifts. Some examples of complex matching of higher levels of incorporation components for the assembly of electromechanical two post lifts are:

- contact the wheels mobile carriers consoles and columns,
- belt drive,
- chain drive, and
- connection between console and mobile carriers console.

The third phase was carried out modeling of the main assembly of electromechanical two post lifts. The first step is carried out functional analysis of a higher level of incorporation of the main assembly of electromechanical two post lifts and defined its corresponding angles parts, subassemblies and assemblies. In the second step, the first fixed component is selected and imported into the Assembly Modeler, and then imported into the free components Assembly Modeler. The base lifts is selected for a fixed component. Free list of imported components consisted of the further components: driving column, following column, telescopic console, electric motor, driving pulleys, following pulleys, sling etc. Because of the limited space of this paper, figure 8 shows the final model of the main assembly of electromechanical two post lifts.

In the final step of this experiment is an analysis of the constraints of the main assemblies model in Inventor, using option Drive Constraint. Revealed the overextended constraints are removed.

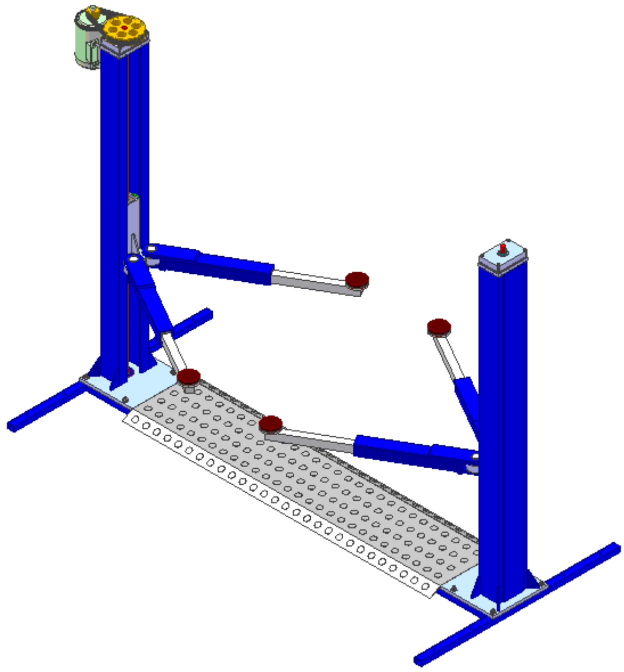

Figure 8. Main assembly of electromechanical two post lifts

The validity of the created model electromechanical two post lifts, and therefore the validity of the proposed procedures for modeling the higher level of incorporation, confirmed the following activities:

- simulation analysis of assemblies and main assembly the electromechanical two post lifts,
- import 3D geometry electromechanical two post lifts the program ANSYS and the formation of finite element model, and
- static and dynamic analysis of finite element model formed.

During the experiment is shown:

- modeling high-level incorporation was done according to the most logical order,
- problems have not reported in the phases of modeling the higher level of incorporation,
- modeling of higher levels of incorporation worked effectively, and
- performed parts, assemblies and the main assemblies were adequate substitute for a physical prototype.

CONCLUSION

The software package Inventor, modeling the higher level of incorporation according to the proposed procedure, illustrated by the example of electromechanical two post lifts. For the illustrated example, the proposed modeling concept proved to be effective and based on that in this paper strongly recommends the same concept to model higher levels of incorporation with other assemblies.

First, based on the exposed examples of modeling a higher level of incorporation, which is also an experiment, it was shown that the phase of modeling conducted two activities, matching components and definition of constraints, which can accomplish separately or simultaneously.

Further, during the implementation of this example it is shown that errors can occur and the collision which further block the simulation analysis on the model. Guidelines for their detection and removal are given.

The existence of various kinematic relations and complex interactions between the columns and the mechanism for lifting, assembly of electromechanical two post lifts seems relevant to the verification of the proposed procedure.

For more complex products and assemblies, based on the experiences of the authors of this paper, there may be special cases when the tool suite Inventor, and other software solutions in the CAD group, do not support defining complex kinematic relations between its components. It will be necessary to resort to artificial definition of working references to pairs of components (for example points, lines or surfaces).

From these conclusions, which are the results of the conducted examples, derive the appropriate advice and recommendations that may be useful to students of mechanical engineering and mechanical engineers-designers which are dealing in product modeling.

REFERENCES

1) http://www.teamcad.co.rs
2) Krsmanović, C., Anderla, A., Rafa, K. (2008) Procedures and Methods of Mating and Constraints Definition in Computer Aided Assembly Design Processes, Journal of Mechanical Engineering Design, 11(1), 31-44
3) Madsen, D. (2003) Autodesk Inventor 5/5.3, Belgrade: Cet Computer Equipment and Trade.
4) Perišić, S. (2009) Prelazak u višu klasu, PC PRESS, 15 (158), 94-97
5) Stojković, M., Trajanović, M., Korunović, N., (2005) Računarom podržano projektovanje pneumatika, Istraživanja i projektovanja za privredu, 3 (8), 19-32
6) Vasiljević, R. (2009) Dinamička analiza elektromehaničke dvostubne dizalice, Mašinski fakultet Beograd

Paper sent to revision: 29.09.2010

Paper ready for publication: 10.11.2010.