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FACULTY OF TECHNICAL SCIENCES
ADEKO - ASSOCIATION FOR DESIGN, ELEMENTS AND CONSTRUCTIONS

KOD

Konstruisanje • Oblikovanje • Dizajn

2010

PROCEEDINGS

THE 6TH INTERNATIONAL SYMPOSIUM ABOUT FORMING AND DESIGN IN MECHANICAL ENGINEERING

6

29 - 30 SEPTEMBER 2010, PALIĆ, SERBIA

NOVI SAD, 2010

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KOD 2010

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Dear Ladies and Gentlemen, respectable Colleagues and Friends of KOD,

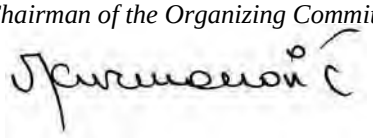
It is a real pleasure and great honor for me to greet You on behalf of the Organizing Committee of the Sixth International Symposium about forming and design in mechanical engineering – KOD 2010. This year, symposium KOD takes place in Hotel Prezident in Palić, Serbia on 29th and 30th September 2010, and I would like to thank You for participating in it.

As we all know, the basic goal of this event is to assemble experienced researchers and practitioners from universities, scientific institutes and different enterprises and organizations from this region. Also, it should initiate more intensive cooperation and exchanging of practical professional experiences in the field of shaping, forming and design in mechanical and graphical engineering. Having always present need for making more effective, simpler, smaller, easier, noiseless, cheaper and more beautiful and esthetic products that can easy be recycled and are not harmful for environment, the cooperation between specialists of these fields should certainly be intensive.

Sixty nine articles, by authors from thirteen countries, are published in this Proceedings. It could be more papers, but the recession is everywhere, so also in publishing papers and proceedings. However, published papers are very interesting, so that means these topics have potentials and have to be further researched.

Thank You for coming in Palić to take part in symposium KOD 2010 and for Your interesting articles. I wish You success in Your further researching and great fortune and happiness in personal life.

Prof. D.Sc. Siniša Kuzmanović, Eng.
Chairman of the Organizing Committee of KOD



Palić, 29 September 2010

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Faculty of Technical Sciences, ADEKO

PARAMETRIC MODELING APPLIED IN WOOD FURNITURE MANUFACTURING

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Dragan MILČIĆ
Miroslav MIJAJLOVIĆ

Abstract: *Product shaping is an important phase of the design process. Theory of product shaping is scientific discipline which studies approaches and methods applied in product development. Theory is applicable to the parts and assemblies as well. Part and assembly modeling is final operation of shape forming process. That is the phase when product gets its final, defined 3D shape. Compute Aided Design (CAD) technologies which support parametric part modeling as a support to the design process, give following advantages: time necessary to design family of similar parts is significantly shorter and quality of products is the same or better than during design part by part. This paper gives a glance on parametric modeling and its application in wooden furniture manufacturing.*

Key words: *CAD, Parametric Modeling, Wood Furniture Manufacturing*

1. INTRODUCTION

Design process is a process of transformation of an idea to a project what is a basis for production. The main goal of the design process is to find optimal solutions considering every aspect of a product and to fulfill all demands tied to the manufacturing, exploitation and recycling. The product has to be market concurrent as well.
Product shaping is an important phase of the design process. Design and shaping theory, as applied scientific disciplines, investigate structure and shapes of systems and methods of optimal shape forming. Tools for shaping process realization, computer based technologies based on hardware and software for visualization of results is in the scope of investigation within shaping theory, as well.
Product modeling is final phase in the shaping process. To geometrically model a product means to define product's shape in 3D model.
Modeling of a product is achieved in several levels, accordingly to its structure and complexity. If we consider part as a primary unit of complexity, several parts, functionally connected represent preassembly or assembly. Several assemblies functionally and structurally connected make a group or a machine. CAD technologies, following the previously mentioned logic enable:

- Part modeling,
- Assembly creation
- System creation.

To create new system, modern engineers use CAD technologies which give them 3D virtual models of products. This completes modern design process and eases further phases of product development. Parametric modeling can even ease even more the product development process, especially for similar parts/assemblies/systems – different families of parts/assemblies/systems.

2. PARAMETRIC MODELING

Process of realistic 3D models creation, models that are replicas of real model, is called modeling. Modeling can be done in any CAD applicative software. CAD models give materiality and realistic picture of a real product. The level of realism depends from the class of the CAD application that is being used for modeling.
CAD applications have been introduced to the engineering branch in the early 1970s and they were simple replacement for the drawing boards. Further development of CAD applications enables to engineers to create 2D Fig.s and use previously created Fig.s as standard elements taken from the database. In the early 1980s, fast development of computers has backed up development of first CAD applications that were capable to work with 3D wireframe models. These models are first steps of modeling – virtual product design.
Higher level of modeling is parametric modeling. Prerequisite for this parametric modeling is existence of adequate CAD parametric kernel. Parametric form is based on the functional dependency of dimensions between similar parts – from the same family. Parameters are properties directly involved in shape and size of a product – dimensions. These parameters are called geometrical parameters of shape. Some number of dimensions (for example: height, width and length of the furniture) represent undependable parameters and they do not consider other parameters of a product. These parametric values are calculated, chosen or demanded and they are main constants of a product. The other group of parameters is group of dependable or tied parameters that are mathematically tied to some other parameters, which might be dependable or undependable.
However, even thou parameters directly involve on geometry and shape of a construction – product, their existence is important for other properties of a product, as well. This statement puts all parameters in some of the following groups:

1. parameters tied to the functionality of a product,
2. parameters tied to the strength and stiffness of a product,
3. parameters tied to the position of a part in a system,
4. parameters tied to the standards.

If product development consists of work with elements and assemblies with significant structural complexity full parametric dimensioning of a system is very difficult and sometimes impossible to do. Complete parametric dependency (and modeling) between parts/assemblies/systems is then, required only with not so complex structures. The more appropriate and much easier to use principle is partial parametric modeling. Application of this principle demands parametric modeling of basic part, assemblies or subsystems that have functional importance or they are expected to be modified periodically. So, parametric modeling can be defined as: complete or partial.

One of the biggest advantages of parametric modeling is possibility of quick dimension change what mostly results in shape change, as well. This property of parametrically modeled parts is widely used for family of similar parts creation. Simple change of values in one or more parameters results with new dimensions, new shape and/or new position in an assembly. This ability is very useful for modeling panel furniture, as well for standard elements quick modeling – elements like: gears, bolts, nuts, bearings are. Modern CAD applications have implemented modules that easily develop or implement already modeled standard parts.

2. MODELING IN WOOD FURNITURE MANUFACTURING

Parametric modeling of wooden furniture is very useful approach in furniture manufacturing since schemes and models used in this area are similar and belong to a family of similar parts. Wood based panels for furniture manufacturing are delivered as 2750-2800 mm long and 2070-2120 mm wide, depending on the manufacturer of wood panels. For further furniture manufacturing it is necessary to prepare these panels to adequate dimensions. Common usage of these panels is usually below 90% what makes them more expensive then they are. Manufacturing program of a furniture factory is usually adjusted to a single wood panel's manufacturer, but unexpected contract canceling between them might be a problem if furniture factory is not capable to quickly transform existing documentation according to the proposal of a new panel distributer. One way to prevent delays in work of such a factory is parametric modeling of parts and assemblies.

It is a powerful service for the panel-based furniture that is typically manufactured by CNC machines. We first build a digital 3D model with all the parts required to build the actual product. We then use this model to generate subsequent manufacturing data and drawings for precise and fast production. 3D virtual models are developed in some CAD application (Inventor, SolidWorks etc.) and they have numerous applications (Fig. 1). These models can give final – technological documentation, lists of parts, and numerous details such are: price of a product, mass, density, volume etc. For example, furniture factory must make a business proposal in a few hours and parametrically modeled parts and assemblies can ease that problem and make a proposal possible in a few minutes. Price, as a prime factor of any proposal, is given in seconds. Development of montage schemes is crucial in furniture design process as well. Furniture should be home friendly and every buyer has different taste for his living space. Parametric modeling can provide fast adjustments and buyer can easily give brief overview to a manufacturer what does he wants to see in his home. 3D renderings give realistic images of furniture. Developed models can be converted into the STEP or IGES files and easily used in any other application, such is 3D planner – used for living space planning.(Fig. 2).

Fig.1. Application of 3D parametric modeling

Fig.2. Furniture from a program KIKI

In children, living and bed room primary furniture can be described as a member of a family:

- lockers,
- commode,
- show case,
- wardrobes,
- closets.

Analyzing the manufacturing program KIKI of manufacturing factory Jela, city of Jagodina, it is concluded that redesign of an existing program is

necessary. Several facts have given the proof for this conclusion:

1. decrease of selling,
2. hard manufacturing,
3. non optimal constructive decisions in products,
4. large number of different panels involved in manufacturing process,
5. usage of démodé materials, colors etc,
6. design changes on the market.

After an analysis, list of demands has been created:

1. to redesign program KIKI but there should be no visual change comparing to the existing program,
2. to satisfy ergonomic demands,
3. to decrease number of different panels in the program to ease the manufacturing,
4. to find new model for edge curving and increase shock adsorption of elements,
5. to design new type of support that will increase stability of complete furniture even on a rough background,
6. to include new mounting for all elements to get more stabile furniture,
7. to equalize length between masks and floor, wings, back, left and right panels and diverting verticals in the closets,
8. to input corpus drawers as a replacement for 3 different panels in a drawer,
9. to ease montage, to avoid hammering of the back sides,
10. strictly to take care about limitations in manufacturing, logistics and manipulative packages of furniture.

3. ELEMENTS REDESIGNING

Old program had furniture which had single and different floor panels and roof panels for every variation of furniture. Panels were totally different – geometrically and dimensionally. Equalization of both panels has decreased number of different panels in manufacturing what has resulted to increase of the manufacturing series and productivity increase (Fig.s 3 and 4).

Fig.3. Ceilr of the element P5

Old program fad furniture with left and right back planes. Redesign of both planes has been done and now all of the wardrobes have only one panel (Fig. 5). New model has back panel drilled in raster of 32 mm with holes ∅5 mm and depth 12 mm. They are used for mounting of clams, sliders, drawers and side ribs. User is able to change the shape of the furniture or remove parts of the wardrobe that doesn't need. Variant solutions are given in Fig. 6. Wardrobes can have some elements that belong to the closets or commodes and various types - drawers and wings.

Fig.4. Floor of the element P5

Fig.5. Back side of the closet

Fig.6. Variant solutions of wardrobes

Application of new mountings called “quick feet” has given the increased stability of complete wardrobe and eased montage. After this redesign, only one person in montage is needed to complete the biggest wardrobe (Fig.7).

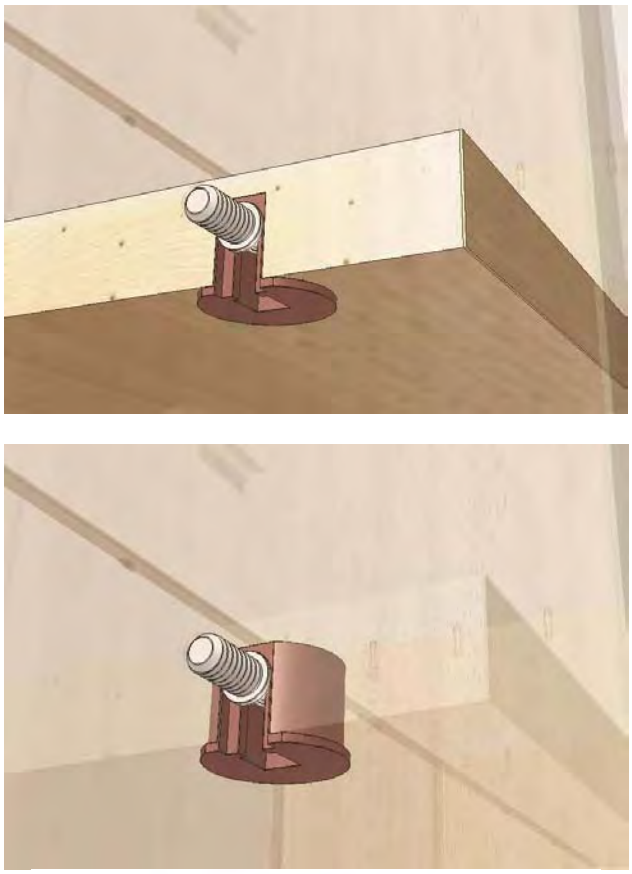
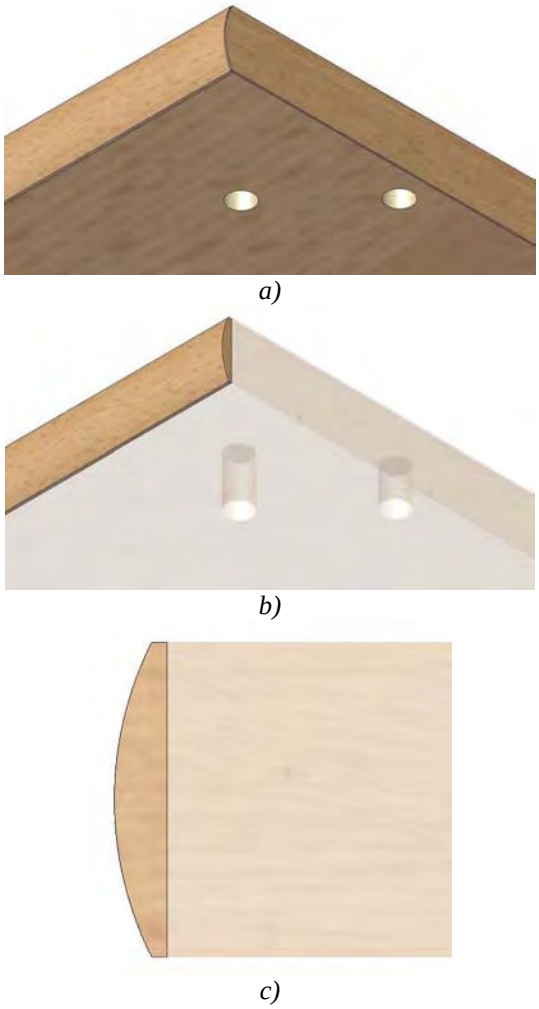


Fig.7. New mounting for carrying – “quick feet” applied to the all parts of a wardrobe

Shock sensitivity of surfaces with rounded edges (with soft material as an absorber, width 0.45 mm) is improved with application of new material, width 3 mm (Fig. 8). This material is made of PVC, layered with foil of décor which is applied in corpus. It is easy to manufacture, fabricate during furniture manufacturing. No leg for the furniture has been developed that enables easier montage and adjustment of parts (Fig.s 9 and 10).



a)

b)

c)

Fig.8. New material for edges, soft contour and application to the floor panel
a)top view of the floor panel; b) soft contour on the floor panel; c) section view of the soft contour

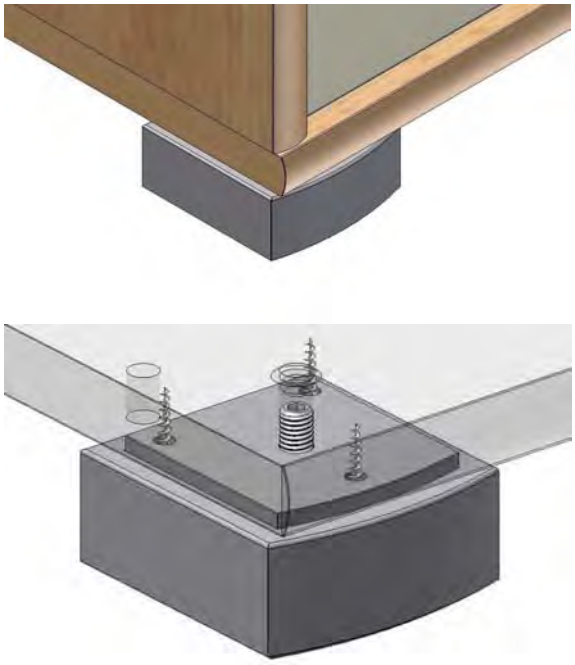


Fig. 9. Model of the leg

Fig.10. Complete leg

In order to ease montage, no nailing has been used for back ribbing (Fig. 11).

Fig.11. Back view of the element

4. PARAMETRIC MODELING OF THE PANEL FURNITURE

There are several types of wooden panels in corpus manufacturing program (Fig. 12):

- floor of the roof,
- back sides,
- separating verticals,
- separating horizontals,
- divisions,
- wings (application with glass),
- masks.

Fig.12. Model of commode with 2 wings and 2 drawers

A single corpus element has corpus and color. One corpus is considered to consist of: floor roofs, back sides, separating verticals, separating horizontals and divisions. All of them are made in décor of beech, light ash, oak and sweet cherry.

Every element has its length, width and depth.

Manufacturing program considers raster between drilled hole of 32 mm precisely defined with the distance of masks and edges from the roof floors and separating horizontals. For parametric modeling of these elements, it is important to accept several standard heights of elements that will fulfill functionality and ergonomic criteria.

Width of elements is defined with the model of furniture: if it is one winged, two winged etc. Two winged furniture can be a variant with separating vertical or without it. If we use the separating verticals, that makes six possible widths of corpus elements. If we consider the orientation of the wood it can be said that width of the panel is the length of the floor panel.

Depth of the furniture gives functionality. Program has two options. So, lockers, commodes and show cases have smaller depth while closets and wardrobes have greater depth. Depth determines the width of the floor, back side, divisions, separating horizontals and separating verticals.

Parametric model generation is possible on 2 different ways. First approach uses a template of the model created in CAD and systematic parameters are read over dll files by the CAD application.

Another approach uses Microsoft Excel file as a database where parameters of the model are inserted .Previously modeled basic models of furniture, parametrically connected one to another are already in the M. Excel. After start of the CAD application, in this case Autodesk Inventor, CAD connects to the M. Excel file, starts a template of the model and updates it according the data from the Excel.

For parametric modeling of the furniture, it is used second approach. Since every element has its dimensions in the table (Excel) (Fig.13) these are the main parameters necessary for modeling.

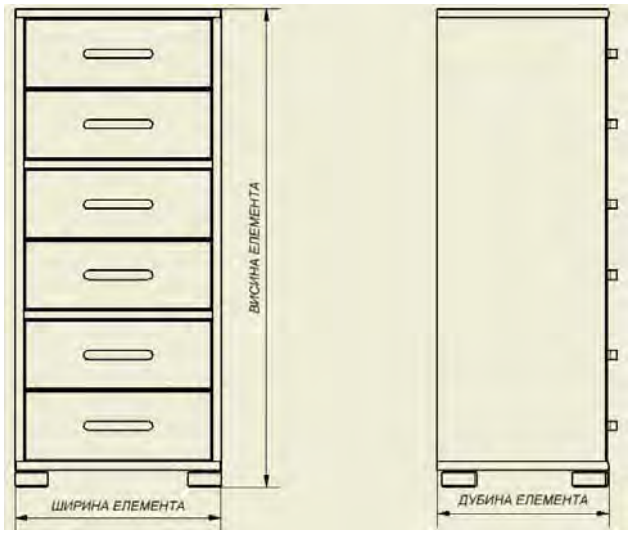


Fig.13. An example of the furniture

For quick exchange and program adjutancy with new cutting schemes (for panels) 3 parameters are used: length, width and depth (Fig. 14).

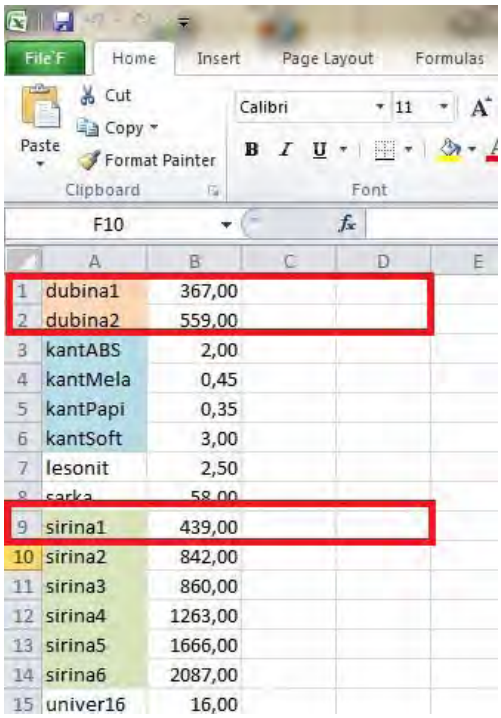


Fig.14. Basic parameters

Checking the adequate parameters it is possible to choose characteristic parameters of the furniture. These parameters are responsible for further manipulation of the furniture data. Fig. 15 gives and example how parameter exchange involves the shape of the furniture and its elements.

Fig.15. An example: element K22-S defined with parameters given in table – width and depth

Parametric modeling eases the changes in technological documentation of a certain part of the furniture what is the main goal of parametric modeling in manufacturing of the wood furniture.

Fig.s 16, 17, 18, 19 give examples for the lockers, commodes, wardrobes and closets. Numerous variants are made and converted into adequate model capable to be inserted into 3D planner and further more used for custom development. Buyer can create his own children's room, bedroom, without even coming to the factory. Parametric modeling has enabled virtual world to improve realistic word without increasing the price of the furniture.

After analysis of the market, management can easily change parametric modeled furniture and adjust the factory to the new market demands.

Fig.16. Lockers

Fig.17. Commode

Fig.18. Chases

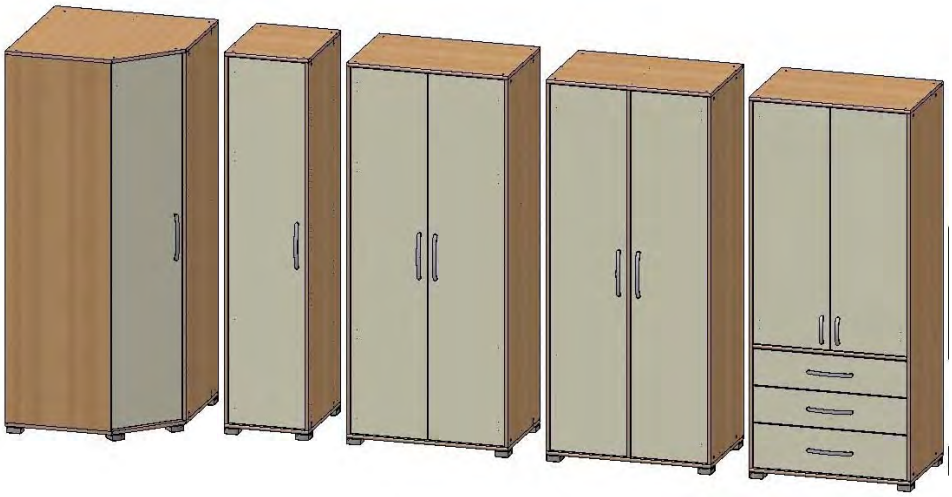


Fig.19. Wardrobe

5. CONCLUSIONS

Usage of CAD drastically decreases the time necessary for the design process and direct influence on the design process increases the quality of the system. Parametric modeling put its advantages to the design process and helps engineers of every class and type get better products.

So, the biggest advantages of the parametric modeling are:

- It saves money since there is no need for the probe manufacturing (0 series). Errors and difficulties can be seen on the virtual model and simulated.
- Better, easier and faster optimization of the process and products.
- Easy and fast solution change during design process.
- Designer can easily redefine and change construction if product manufacturing process changes.
- Easier and simpler work on technological documentation creation.
- It is easy to create family of similar parts that differ one from another only in dimensions,
- It is easy to determine the price of every part or an assembly. If we pay attention to the application on the furniture manufacturing it is important to note that price is calculated as a price per surface. It is important to determine the surface that has been used what is not so easy to do without virtual models.

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The first symposium about design in mechanical engineering KOD 2000 was organized on May 24th 2000 in Novi Sad. The second symposium KOD 2002was held on May 22nd 2002 in Novi Kneževac. The third symposium KOD 2004 was organized on May 19th 2004 in Novi Sad, and the fourth symposium with international participation KOD 2006 was held on May 30-31 2006 in Palić. The next symposium was organized as international event on April 15-16 2008.
There were 21 papers on KOD 2000, 36 papers on KOD 2002, 43 papers on KOD 2004, 79 papers on KOD 2006 and 103 papers on KOD 2008.
This year, there is some recession as every where, so 69 papers are published in the Proceedings of KOD 2010. The paper authors come from 13 countries. Most of the papers come from Serbia - 35 papers and Romania- 14 papers. There are 5 papers from Belarus, 4 papers from Slovakia and Slovenia, 2 papers from Bosnia and Herzegovina, and by 1 paper comes from Bulgaria, Croatia, Czech Republic, Hungary and Macedonia.

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