ERGONOMIC DESIGNING OF OFFICE FURNITURE IN CAD SYSTEMS

Jerzy Smardzewski, Sebastian Beszterda
Department of Furniture Design, August Cieszkowski Agriculture University of Poznań, Poland

ABSTRACT

Analyzing functionality of software for furniture industry it can be concluded that so far not all groups of furniture have been parametrized and catalogued in the form of computer aided design programs. Non-standard or multifunctional furniture more difficult to parametrize and manufacture constitute a considerable technological gap in this respect.

The objective of this research project was to develop a parametric application for the AutoCAD® environment assisting ergonomic designing of constructionally complex office furniture. Specifically, the project consisted in developing a computer program generating selected constructions of reception counters.

The developed computer program constitutes a virtual tool useful in the process of designing and production preparation of non-standard or multifunctional furniture taking into consideration all functional and ergonomic requirements. Simultaneously, the elaborated computer program constitutes the kernel of an expert system dedicated to office furniture designing.

Key words: furniture, computer, ergonomics, design, technology

INTRODUCTION

Modern office furniture forms a fairly specific, constructionally and functionally noticeably distinguishable, group of furnishings, which are expected to fulfill appropriate safety standards and comfort requirements. These requirements are associated not only with their construction, safety or ergonomics of the workstation. The notion of the use comfort can be widened up to mean a certain kind of mental comfort resulting from being in the presence of an object having a specific form and affecting our mind in a definite way.

Ergonomics found its way to offices primarily as a result of investigations on work efficiency in industrial enterprises and, although the principal objective of those studies was improvement of labour effectiveness, their outcome was rationalization, standardization and, consequently, dehumanization of office space [4]. However, experience of designers of the last three decades followed a completely different route. It turned out that movement restriction of workers to minimum was not always good and did not necessarily have a positive influence on human health. In addition, at present, designers appear to abandon a monotonous structure of office space and avoid equipping them in almost identical furniture. Today one of the most important characteristics of offices is their functional flexibility and lightness, possibility of easy adjustment to ever changing requirements. Spaces, which meet these expectations, are often referred to as multifunctional offices [4].

One of the most stimulating challenges at present is designing of multifunctional furniture [6]. The main difficulty is that one piece of furniture should take into account a number of functional-practical requirements frequently at odds with one another. Reception or hotel counters or cashier stands illustrate well the difficulty. These types of furniture fulfill primarily their function as work facilities but, at the same time, they serve other functions, e.g. they are used to store handy documents, office accessories and, sometimes, serve as dinner tables. In addition, this type of furniture, on top of their characteristic functional dimensions resulting from anthropometrical measurements, should also take into consideration dimensions of office equipment and allow them to be plugged in as well as interconnected. It is also essential to plan and distribute properly individual appliances and any additional elements of equipment so that they do not stand in the way but, at the same time, are easily accessible.

Computer **A**ided **D**esign and **C**omputer **A**ided **M**anufacturing programs are very well suited for this type of design and production. The existing systems applied in furniture industry aid,

to varying degrees, the designing and manufacturing processes beginning with assisting in the creation of the design itself and ending with completely integrated systems of production control which form part of company management systems. Obviously, such tools must, first of all, be helpful for designers and engineers so that the generated piece of furniture fulfills the expectations of the customer and, additionally, complies with appropriate requirements of European standards. Moreover, a good tool should also attempt to optimize or, at least, automatize construction-technological tasks releasing the designer from arduous calculations and cutting down the number of choices to essential minimum.

When analyzing functionality of software for furniture industry it can be concluded that there are still groups of furniture for which proper parameters and catalogues have not yet been prepared in the form of computer aided design programs. They include non-standard or multifunctional furniture, which are more difficult to manufacture and prepare their parameters. Reception, bank, various types of hotel and lounge furniture are among the most attractive and challenging objects of investigations for informatics specialists. This is an area, which poses many problems but, at the same time, opens considerable room for development of new furniture creations and arrangements.

RESEARCH OBJECTIVE

The objective of this study is to develop a parametric application for AutoCAD® environment which would aid ergonomic designing of constructionally complex office furniture. In particular, the study will focus on the preparation of a computer program, which will generate selected constructions of reception counters.

The cognitive objective of the study is to develop an expert designing system of reception counters, which will facilitate elaboration of finished product documentation even for designers with very little experience.

METHODOLOGY OF THE STUDY

Below the authors present basic requirements and assumptions, which were applied in the course of the elaboration of the computer program, which is the objective of this study. Some of them are of compulsory nature – they must be fulfilled in order to manufacture a correct, safe and complying with European and Polish standards product, others are optional, adopted by the authors to narrow down and specify the scope of work.

FUNCTIONAL AND PRACTICAL REQUIREMENTS

The object of the computer program to be developed is multifunctional reception furniture assumed to be used in any office of public domain. The following requirements were taken into account when elaborating the program:

- Functional dimensions of office furniture directly associated with their utilization and resulting from anthropometrical measurements of mature Polish and European population according to [14, 15].
- Functional dimensions of office furniture indirectly associated with their utilization according to [17, 18].

The program takes into consideration basic functional dimensions of office furniture intended for work or for storage of different articles in accordance with the Polish standard [14] and

dimensions of office worktables in accordance with the European standard [15]. With regard to dimensions of computer furniture, the authors used the latest Polish [17] and European [18] legal regulations.

The authors assumed that the program should constitute an expert system prompting the user what characteristic reception furniture dimensions are optimal and, at the same time, comply with appropriate standards. The system should recommend correct solutions without excluding solutions differing from standards leaving the user a certain degree of freedom.

ERGONOMIC REQUIREMENTS

Ergonomic requirements are connected with the above-mentioned functional requirements, since sticking to them favours ergonomics of the workstation. In addition, general construction requirements according to [16] determining safety and functional requirements of constructions were also taken into account. The program also assumes that some requirements will be selected automatically, while others will have to be selected by the user, e.g. how to choose the rounding of work boards and, possibly, with what parameters.

CONSTRUCTION ASSUMPTIONS

A program, which generates reception counters, cannot fulfill all construction expectations of the user because possibilities are practically unlimited and it is impossible to predict all possible solutions. That is why the authors chose to focus on several basic constructions leaving considerable room for their diversification through determining the shape and profile of work boards, shape and distribution of internal elements of the level raiser, occurrence of shelves and partitions as well as additional elements such as: shelf for the keyboard, support, side covers. Basic types of construction and possible variations are shown on Figure 1.

Fig. 1. Basic possibilities of creating and diversifying of the construction
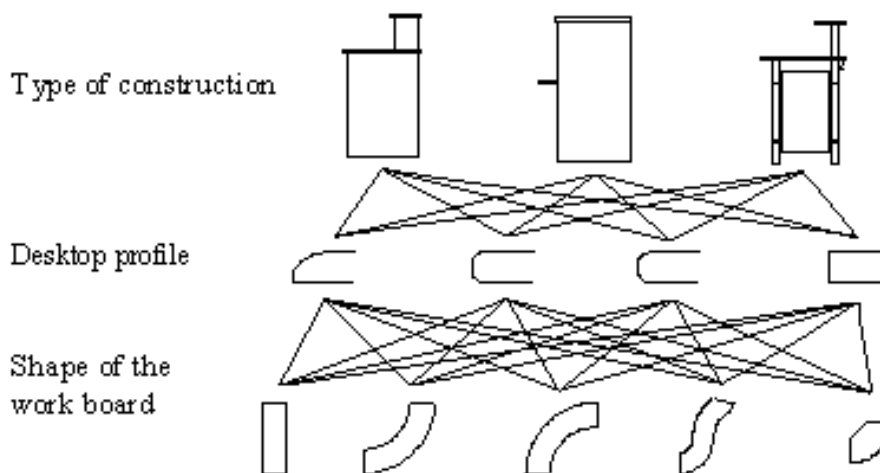
Construction type 1 – a reception counter with a level raiser is a typical solution for receptions, secretariats that is intended, basically, for work in a sitting position allowing work characteristic for the above-mentioned rooms.

Construction type 2 – a counter intended for work either in a sitting or standing position. This solutions is recommended particularly for hotel or bank use because it is characterized by inaccessibility into the inner space from the side of the customer.

Construction type 3 – this is a frequent combination of wood-derived materials with other materials which forms a reception counter on a support. This solution can be used in many places, especially in secretariats, reception hall. In addition, when manufactured without a level raiser, it can be used as an ordinary table.

Spatial generation of reception counters assumes the distribution of elements as in a real finished product but it does not specify places and number of connections, fittings and connectors, support elements and accessories. Obviously, it would be possible to include these in the program, too as well as to expand the program to include additional constructions and possibilities but this would exceed the framework of this study.

The program should allow generating reception counters which are constructionally correct without allowing incorrect constructions.

TECHNOLOGICAL ASSUMPTIONS

Bearing in mind the characteristic purpose of reception counters, it was assumed that they should be manufactured from laminated chipboards with work surfaces from materials of increased resistance to wear and chemical agents. The use of chipboards finished with natural veneer was not excluded. In the case of curvilinear counters with a small radius for the front or protection board, the use of materials which can be modeled easily, e.g. plywood, HDF board intended for bent and glued elements or even plastics was required. A counter construction, which employs a pipe framework, often combines metal with desktops from either wood-derived materials or plastics.

Spatial modeling should also allow obtaining information that can be useful for production control, i.e. a list of elements, their dimensions and surface. In future, this will allow to make a list of panels, determine material requirements and calculate costs. It was, therefore, assumed that, in the course of generation, each element would automatically get its own identification index, while its dimensions would be obtained and calculated directly from the drawing.

ALGORITHM AND PROGRAM CODING

The block diagram of the program algorithm spatially modeling reception counters is shown in Figure 2. Having prepared the program algorithm, the authors than decided to translate it into the program language appropriate for the selected CAD program. The application which was the objective of this work was intended to work in AutoCAD® 2000 environment in which the program could be adjusted to the requirements of the user employing the AutoLISP language and developing new system commands.

Fig. 2. Block diagram of the program generating reception counters
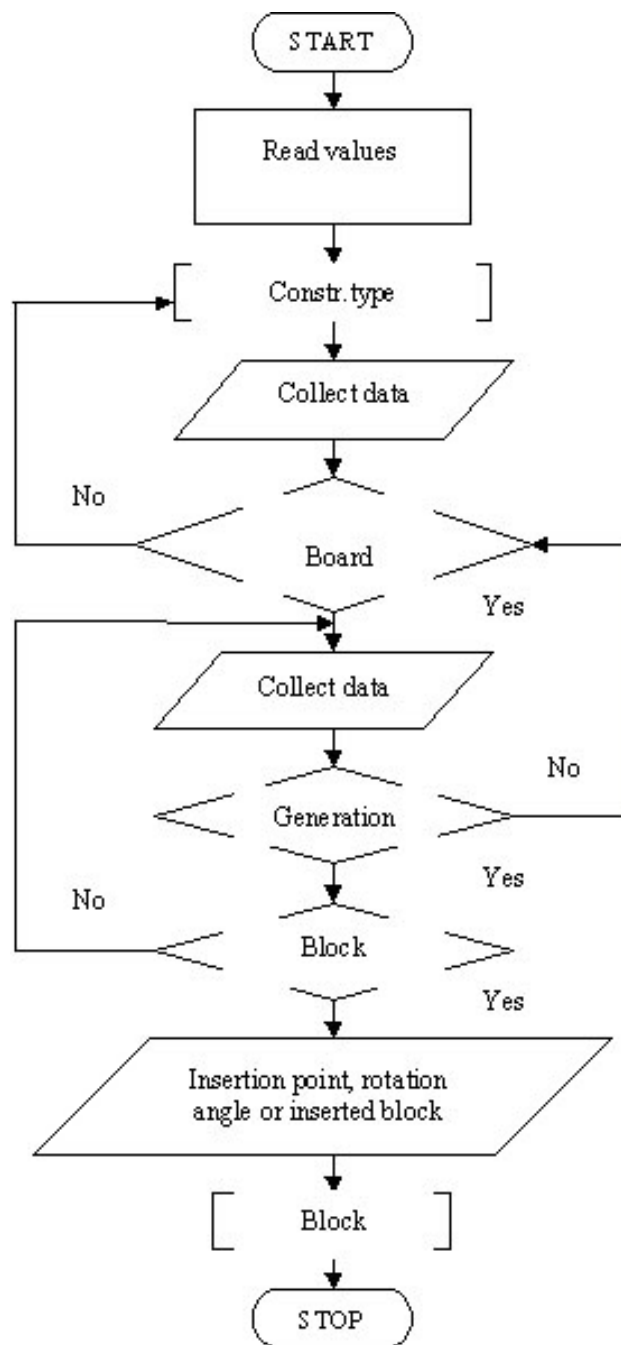
The access and control over AutoCAD® objects can be gained from the level of each application, which acts as an Automation controller. AutoCAD® program interfaces include: Mechanism ActiveX®, VBA, AutoLISP®, VisualLISP™ and ObjectARX®. The type of interface used by the user depends on the requirements of the application and experience in programming. Therefore, the AutoLISP language [13, 23] was chosen as the language of programming. VLISP® represents a new LISP generation for AutoCAD® offering new possibilities and language extensions for interactions with objects using ActiveX® [12, 24]. Thanks to this, is possible not only to create and alter AutoCAD® objects but also to access Windows® applications such as: Microsoft Excel®, Word®, and Access®, which facilitates exchange of data.

The final form of the application program prepared for AutoCAD® was a complex VLX file, which is a set of several LSP files, and files defining DCL dialogue windows (Fig. 3). This type of file has several advantages, among others, all functions and variables defined in this file are formally accessible for other applications, program code is compiled to binary form, which increases the rate of reading in, and the file can be removed from memory releasing resources.

Fig. 3. A fragment of a definition of a dialogue window

```
baza
:dialog{label="Lista lad i elementów";
    :boxed_row{label="Lista lad:";
    :list_box{key="lad_lst";
                width=17;
                height=6;
                fixed_width=true;
    }
    :column{width=50;
            fixed_width=true;
    :row{
    :text{label="Indeks";}
    :edit_box{
            key="indeks";
            edit_width=14;
            is_enabled=false;
    }
    :text{label="Ilość ";}
    :edit_box{
            key="ilo";
            edit_width=5;
            is_enabled=false;
    }
    }
    :row{
    :boxed_row{label="Opis";
    :text{key="opis";
        height=2;
    }
    }
    :button{label="&Podświetl";
            key="light";
            fixed_width=true;
    }
    }
    }
    }
```

Additionally, for comfort of potential users, an installation program for Windows® environment was added which copies all essential files into a selected catalogue and writes all the necessary data into the Windows® register.

PROGRAM INSTALLATION

The program was prepared as one installation file called "setup.exe". The installation of the program consists in activating the file and following installation instructions. The installation

program copies program files into a selected catalogue, adds an access path in the system register, creates an uninstall command and adds the application name "Reception counters" to the group "Add-Remove programs". Additionally, optionally, the installation program creates shortcuts in the Start menu, shows the "readme.txt" file and adds program menu to AutoCAD®.

PROGRAM ACTIVATION

If, during the installation process, the program menu was not added to the automatic reading in or, because for other reasons, menu is not available after AutoCAD® activation, the "Reception counters" (Fig 4.) program can be accessed in either of the following two ways:

- Reading in of the "lada.vlx" file from the "lada.mns" file (a new unfold menu "Reception counters" will appear), files "lada.mns" and "lada_auto_utils.vlx".
- Reading in of the partial menu from the "lada.mns" file and adding to the top menu unfolding strap "Reception counters"; "lada.mns" and "lada_auto_utils.vlx files will be read in automatically and program commands will be registered.

The next action that should be undertaken is to select the appropriate command from the menu (Fig. 5) or to write in the command in the command line.

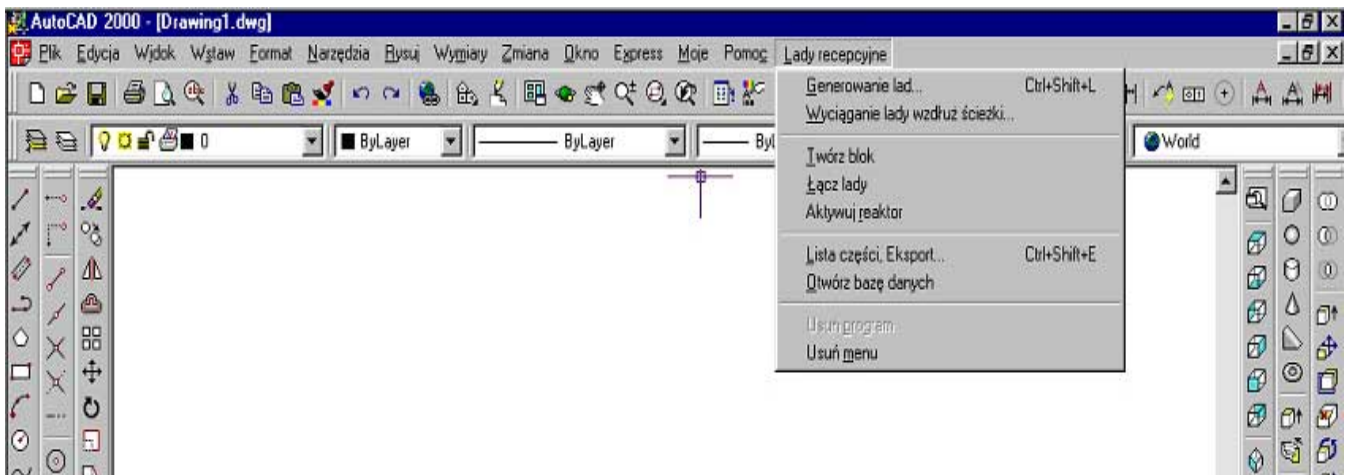**Fig. 4. Unfolding menu of the "Reception counters" in the top menu**

Fig. 5. Menu "Lady recepcyjne"
(Reception counters)

DESCRIPTION OF PROGRAM FUNCTIONS

- Counter generation (Generowanie lad) – command LADA activates dialogue windows defining details of spatially modeled counters, generates and creates blocks.
- Draw counters along path (Wyciąganie lady wzdłuż ścieżki) – command LADAP allows generating counters on the basis of a path defined by the user with full possibilities of defining details, as in command LADA in the dialogue window.
- Create block (Twórz blok) – command MBLOCKL creates and re-defines blocks from the existing objects according to the system of block management; gives indexes (possibility of making lists of defined blocks, picking data about elements). This command is particularly useful to create new pieces of furniture normally unavailable from the application.
- Join counters (Łącz lady) – command JOINL allows close combination of counter blocks on the basis of added data (characteristic points and angles).
- Activate/Deactivate reactor (Aktywuj/Deaktywuj reactor) – the command activates/deactivates the activity of the reactor responsible for the automatic activation of the function merging counter blocks after block insertion (command "Insert" or draggin block from another drawing). This menu position changes depending on the status of reactor.
- Remove program (Usuń program) – removes the "lada.vlx" program file from the memory of a given drawing. The command is available when the file is read in.
- Remove menu (Usuń menu) – removes menu "lady" from the group of AutoCAD® menu.

PROGRAM DESCRIPTION

Once the command was selected from the menu or command LADA written into the command window, a dialogue window appears (Fig. 6) in which the user is to select the type of counter construction.

After selecting the first button, the following dialogue window will appear.

**Fig. 6. Selection of counter construction**

Details of the construction are to be selected in the dialogue window (Fig. 7) picking values from the list, moving the slide, clicking the image button or writing in the value in the edit window. The sequence of field fillings is optional and default values are also acceptable.

Fig. 7. Details of the side profile of the first construction
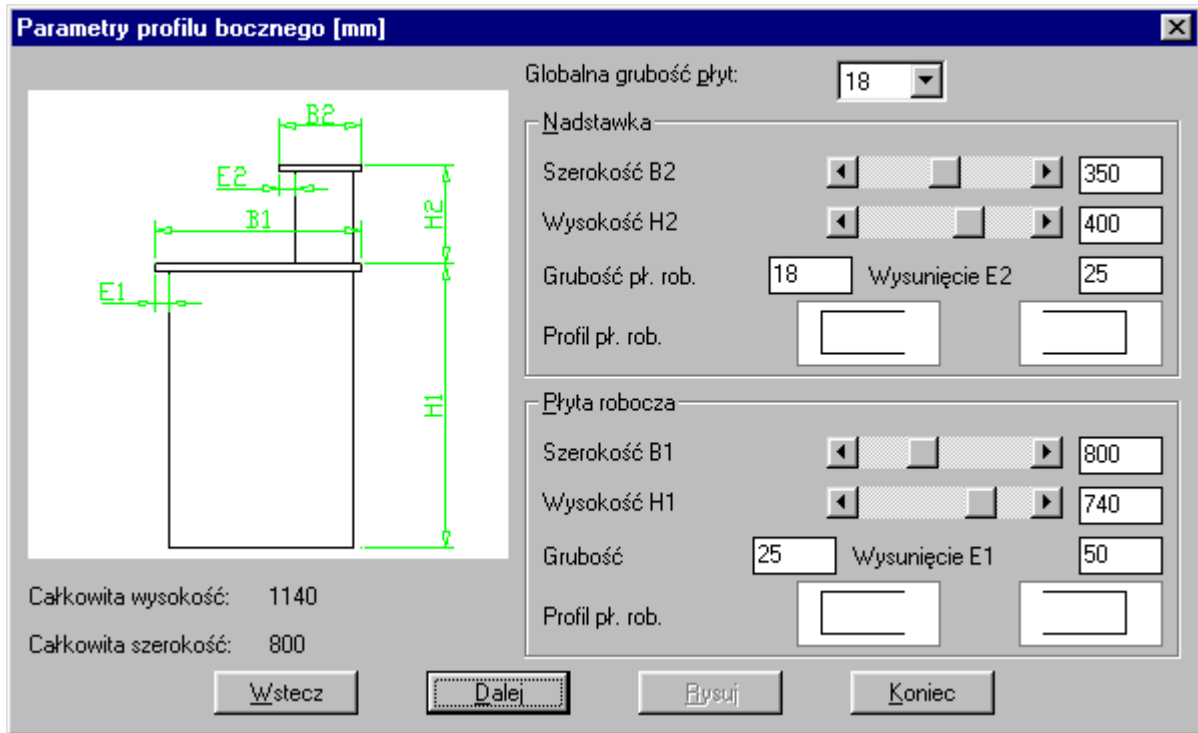
The dialogue window "Wybierz profil płyty" (Pick board profile) (Fig. 8) allows selecting the edge shape of the work board and determines its parameters. The slide changes depending on the selected profile showing the shape and characteristic dimensions which can be defined. Appropriate values are to be written into two edit fields; alternatively, default vales should be accepted. The window also services the error controls, so when incorrect values are written in edit fields, an error communiqué will appear next to OK button.

Fig. 8. Work board profiles
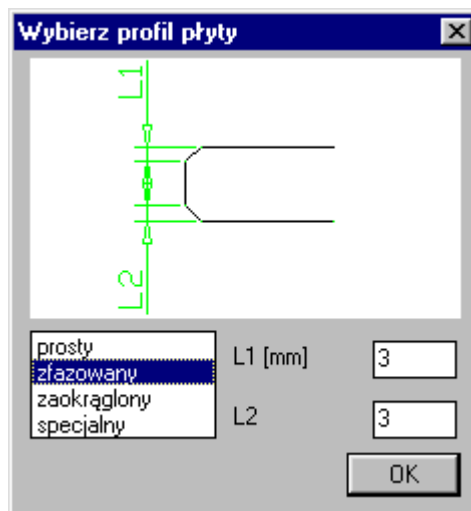
In order to precede, after determining all details in the fields of the dialogue window (Fig. 7), the user is supposed to select button Dalej (Precede). This will allow selecting numerical values, which will be stored in global variables. The current window will then close and the next one will appear (Fig. 9).

The remaining buttons of the dialogue window allow picking the following commands:

- Wstecz (Move back) – return to the dialogue window (Fig. 6),
- Rysuj (Draw) – define top profile (Fig. 10),
- Koniec (End) – finish work with the application.

Fig. 9. Selection of the shape of the work board
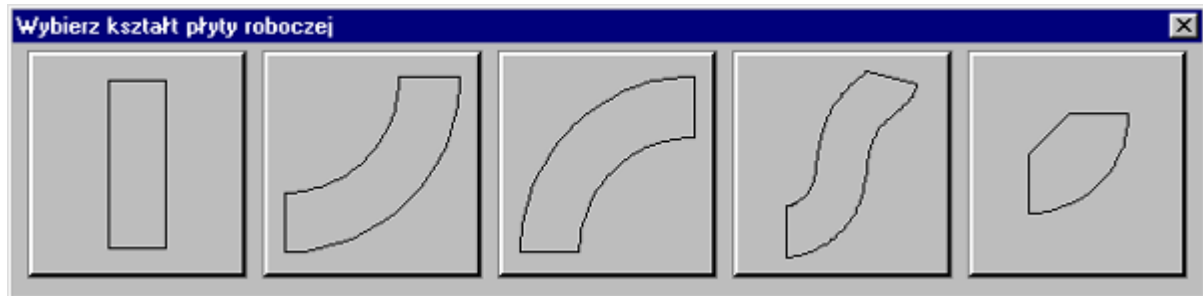
The choice of, for example, the second button to the left will activate a dialogue window (Fig. 10) in which it is necessary to specify the last parameters of the modeled reception counter.

On the left side of the window, the slide shows the shape of the counter and characteristic dimensions. Bellow is the section Długość łuku (Length of arch), and it informs about the current length of the arch (inner and outer) of the work board.

Fig. 10. Details of the top arched profile
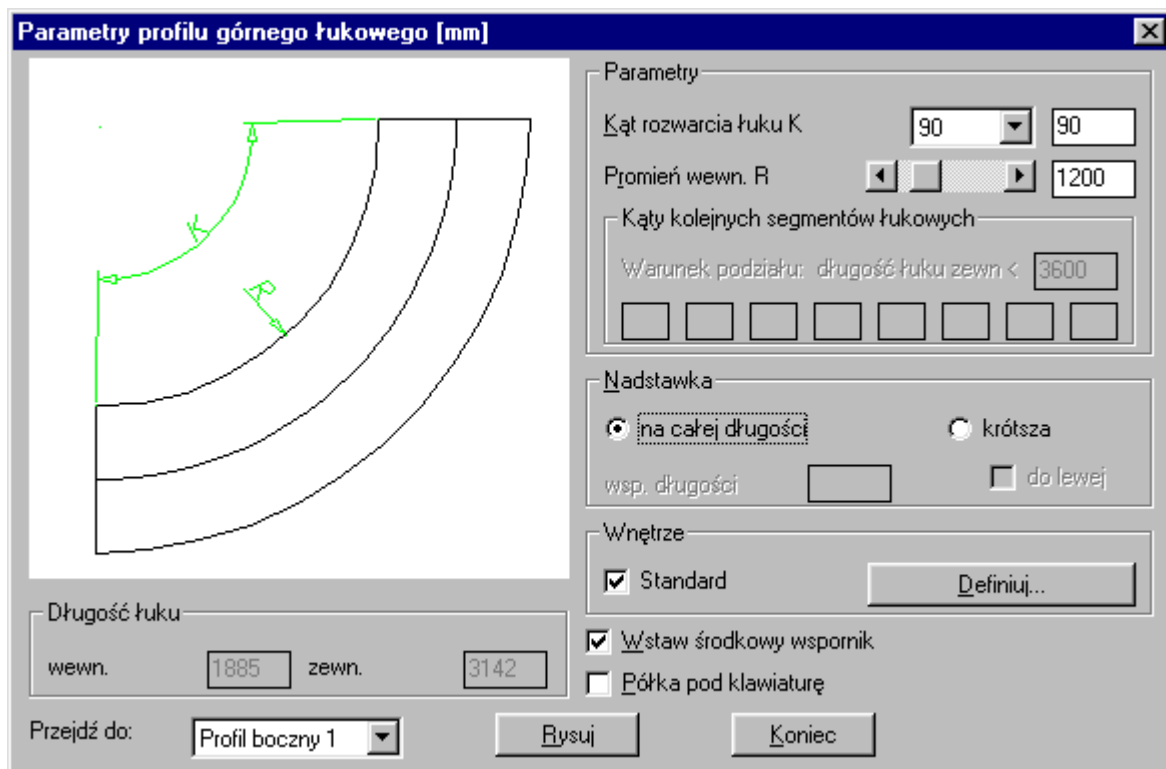
After generating the reception counter, the user can see the result of the program operation on the AutoCAD® screen and can accept the result and select either the Twórz blok (Create block) button or Wstecz (Go back) button in order to go back the previous dialogue window.

After selecting Twórz blok (Create block) button, the program asks the user to give optional description, creates block and asks to indicate the point of insertion or (when a block has already been inserted into the drawing) indicate the block into which it is to be adjusted (Fig. 11, 12).

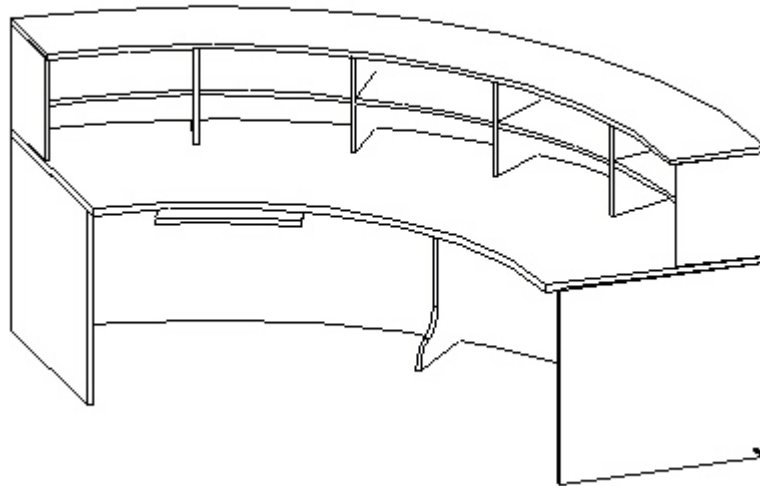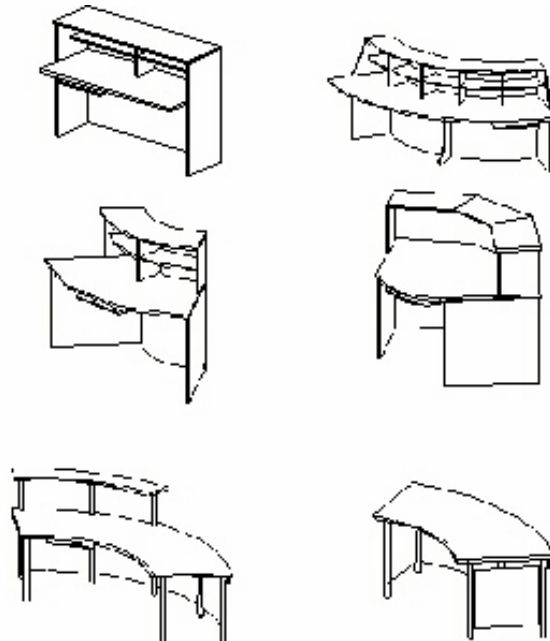**Fig. 11. A reception counter generated on the basis of the above description**

Fig. 12. Examples of construction generated by the program

A special way of creating reception counters is the option of generating them on the basis of the path defined by the user (command LADAP). The user first defines the path of dragging

by drawing the outer edge of the work board on the AutoCAD graphic screen in the form of an object of LINE, ARC, (LW)POLYLINE, ELLIPSE or SPLINE type. Next he indicates it, the program checks the correctness of the path and activates the dialogue window similar to the window in Figure 12. This window allows determining features of the level raiser, its inside, additional elements. An example of a counter generated on the basis of an elliptical arch is shown in Figure 13.

Fig. 13. An elliptical arch and a reception counter generated on its basis
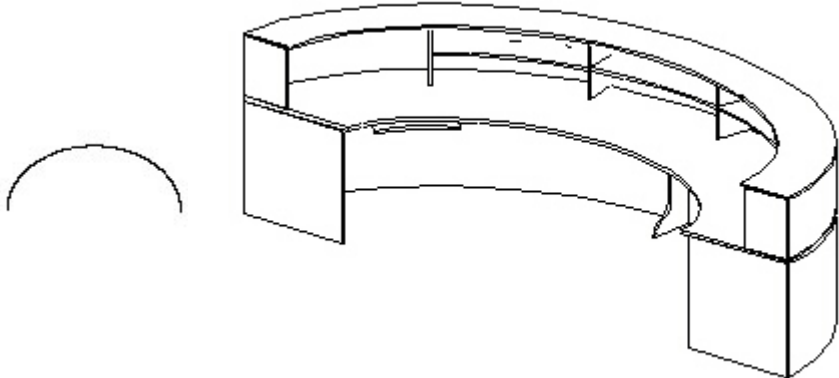
Figure 14 shows a corner of a room to be used as a secretariat. On the basis of requirements and possibilities, an outline (red line) of a reception counter was designed (including encircling of a column). On the basis of this path, a reception counter was generated (Fig. 14).

Fig. 14. An example of a built-in of a corner in a room generated on the basis of a path
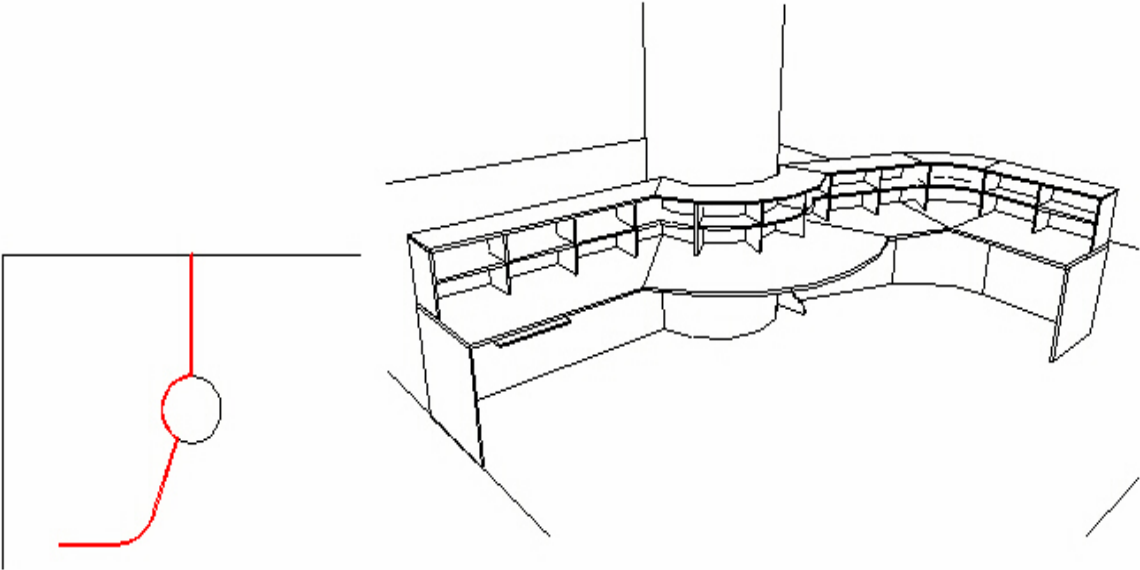
EXAMPLES OF SETS OF RECEPTION COUNTERS

Generated pieces of furniture are easy to set into optional arrangements depending on requirements, place in which they are to be used or method of work. Below, some examples of such arrangements are given (Fig. 15, 16).

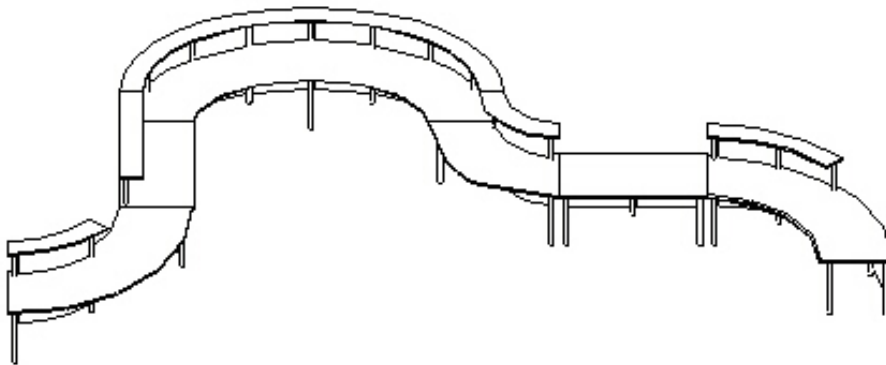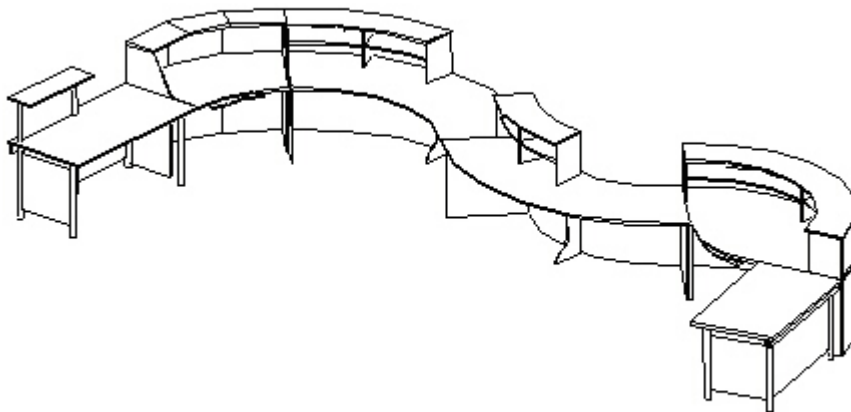**Fig. 15. A set of counters whose construction is uniform**

Fig. 16. A set of counters of different construction

SUMMING UP

The elaborated computer program constitutes a virtual tool useful in the process of designing and preparation of production of multifunctional furniture or furniture which is not typical

taking into consideration all functional and ergonomic requirements. AutoCAD® is the basic environment of the developed application which includes tools for object programming. Simultaneously, the elaborated computer program constitutes a kernel of an expert system dedicated to office furniture designing. The generated 3D model of a piece of furniture represents a complete engineer construction with parameter dimensions complying with requirements of European standards. Moreover, the program supplements the traditional AutoCAD® environment with a new, intelligent tool oriented towards office furniture designers and engineers. It can, in particular, be applied to design reception furniture or, after introducing appropriate adjustments to match requirements of a specific customer, to design almost any furniture employing complete service and database.

REFERENCES

1. Guideline of European Union about of work positions. 2001, Typescript. Chair Furnit. Design Agric. Univ. Pozn. [in Polish].
2. Visio – Vision of modern offices, 1999. Meble Plus 1: 34. [in Polish].
3. AutoCAD Visual LISP and ActiveX Help. Autodesk 1999.
4. Dzięgielewski S., Smardzewski J., 1999, Projecting of furniture in quality system ISO-9000. Przem. Drzewn. 3: 12-16. [in Polish].
5. Dzięgielewski S., Smardzewski J., 1995, Furniture. Project and construction. PWRiL, Poznań. [in Polish].
6. EN 527-1. Office furniture – office – working tables – dimensions. [in Polish].
7. EN 527-2. Office furniture – working tables – mechanical requirements of safety. [in Polish].
8. Grześkiewicz M., 1997, System of software for projecting, production and sale of furniture. Przem. Drzewn. 10: 1-3. [in Polish].
9. Małuszyński J., Kessel D., 1993, Elements of computer science. Seton, Poznań. [in Polish].
10. Mrozek J., 1999, Household office. Meble Plus 1: 26-29. [in Polish].
11. Skalski R., 1999, From industrial hall to friendly offices. Meble Plus 7: 24-27. [in Polish].
12. Smardzewski J., 1997, Computer aided of furniture design with base to certification of qualities systems requirements of norms ISO 9000. Scientific session on theme "Certification in furniture industry". Poznań. [in Polish].
13. Smardzewski J., 1998, Parametric library of office furniture - together with production order generator. Przem. Drzewn. 10: 12-14. [in Polish].
14. Smith J., Gesner R., 1995, AutoLISP that is to say programming AutoCAD. Helion. [in Polish].
15. PN-F-06000-2. Office Furniture. Requirements and investigations. [in Polish].
16. Manual adaptive – Help for AutoCAD 2000. Autodesk 1999. [in Polish].
17. Roszkowski M., Swaczyna I., 1997, Actual tendencies in office furniture design. Przem. Drzewn. 8: 11-16. [in Polish].
18. Order Minister of Work and Social Policies from 1 of December 1998 (Dz. U. 10.12.1998, Nr 148, poz. 973). [in Polish].

Submited:

Jerzy Smardzewski, Sebastian Beszterda
Department of Furniture Design
August Cieszkowski Agricultural University of Poznań
Wojska Polskiego 38/42, 60-637 Poznań, Poland
e-mail: JSmardzewski@woodcock.au.poznan.pl

Responses to this article, comments are invited and should be submitted within three months of the publication of the article. If accepted for publication, they will be published in the chapter headed 'Discussions' in each series and hyperlinked to the article.