EXPERT SYSTEM FOR LAYOUT OF TECHNOLOGICAL WORKPLACES

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Abstract:
A technological project of workplace is a fairly busy activity which expects professional knowledge, large number of input information and knowledge of standards, rudders, directives. Our research team solves the problems related to automation of technological workplace design by means of an expert system. This expert system will increase project quality and cut down the time of project processing. The knowledge base and inference net of the system are based on the model of main activities related to design of workplace. The methods and procedures are included in processing knowledge base and rudders and standards are included in the database part of the knowledge base. A control program leads a designer from the setting of the task to its accomplishment.

Key words: expert system, computer support, workplace design, ecology, ergonomy

1. INTRODUCTION

The solution to automated technological workplace design using an expert system put forward here enables a technologist with an average knowledge of technological design, ecology, and ergonomics to produce a computer aided workplace design. The concept of the expert system allows for its integration into a higher-level automated technological design system. The system is created in Borland Delphi program environment.

2. ACTIVITY MODEL AND WORKPLACE DESIGN SYSTEM INFERENCE NETWORK

Detailed workplace design is part of the total technological design process that starts with receiving an order and input data and ends with project implementation (Hlavenka, 1995). The expert system will cover only the set of activities related to Detailed workplace design – see Figure 1.

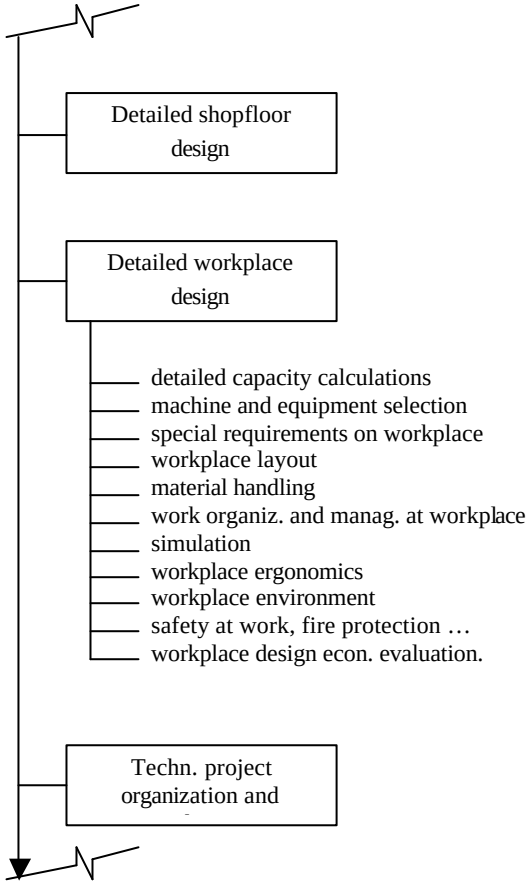

Fig. 1. Incorporation of detailed workplace design into the technological design process

3. KNOWLEDGE BASE OF THE SYSTEM

3.1 Capacity calculations

Capacity calculations are used to determine the required number of machines and equipment, operators and space requirements. Of the many capacity calculation methods available the following three, which sufficiently meet the needs of workplace design, have been selected for use in the system:

1. An exact method based on technological procedures and technical-economic performance standards. The method is not suitable for processes involving very quick operations (cutting, die forging…).
2. Approximate capacity calculations based on direct indicators. The method is applied to quick, rough calculations based on the performance of the machine, operator and floorspace and is also suitable for processes with short operation times.
3. Capacity calculation production for high volume production (mass production) based on cycle time calculation.

3.2 Workplace layout

In contrast to the inherently routine capacity calculations, designing the layout is, on the whole, a creative activity. In this case the inputs for the design will include the results of the automated processing of the optimum arrangement of workplaces in space, list of principles to be taken into consideration in proposing the layout, list of prescribed clearances between the workplaces and their environment and will consider other necessary information. Of the methods that are used to find an optimum workplace layout the following have been incorporated in the expert system: CRAFT, the

triangular method, and the centre of gravity method. It will also contain references to using AutoCAD for layout drawings.

The CRAFT (Computer Relative Allocation of Facilities Technique) method is an exact method based on finding a minimum of the mathematical model function:

$$TC = \sum_{i=1}^{n} \sum_{j=1}^{n} y_{ij} \cdot l_{ij} \qquad (1)$$

n = number of units of equipment
y_{ij} = costs of product movement between activities i and j over a distance unit
l_{ij} = distance between equipment i and j

3.3 Material handling

In workplace design the designer often faces the problem of material handling between and during operations. The current methods of designing the handling process are only rarely based on scientific principles using computer technology (Hlavenka, 1998). To avoid this, methods based on the theory of causal location have been implemented in the system. The basic procedure of evaluation and design, based on the above theory, starts by defining and classifying locations and operations (gravitational, transport, transfer operations…) and ends in finding creative procedures to determine the most suitable handling operations relative to the handled objects and handling conditions.

3.4 Simulation

Putting right an already implemented but flawed design is costly and undermines the faith of company management in the practicality of the investment. The application of simulation methods makes it possible to simulate the workplace operation on a computer, including breakdowns, before design implementation and verify the use of the different workplace sections, etc. (Rembold, 1994).

As the development of simulation programs is a complex process no attempts will be made to develop a new simulation program, rather an existing program will be recommended. Of the simulation programs available WITNESS and SIMFACTORY seem to meet our purpose best. The selection will depend on the affordability of the software. Both programs enable you to easily and quickly create a diagram of the analysed or proposed process, including the parameters of the workplaces and handling equipment used (operation times, transport vehicle speed…). The simulation is graphical. The system provides data for design correction and operational process control.

3.5 Ergonomics

The Ergonomics module covers areas that include the activity of man and his interaction with the machine and the working environment. From the designer‘s perspective the working environment design is the most important. A working environment with a positive impact increases efficiency and the ”feel-good” factor.

The expert system will contain design methods for daylight and artificial lighting. The knowledge database will store, in a clearly organized manner, important data from applicable standards.

Machines used in production emit noise and produce vibrations. The expert system will include methods of noise measurement, calculation of expected noise levels in the industrial facilities and permissible noise levels at the workplace.

The microclimate constitutes an independent subsystem of the working environment which critically affects the worker (air pollution). The expert system will contain a methodology for designing microclimatic conditions and a list of requirements imposed on a workplace by applicable regulations.

3.6 Environment

In workplace design, the designer must take into consideration waste (disposal of its harmful components) and toxic products of the production process. (Their disposal must be suited to the climate and the potential for wind-blown dispersal of pollution in the area). The system will integrate design principles based on the relevant hygiene regulations and permissible concentrations of pollutants.

3.7 Safety at work and fire protection

The expert system will contain principles of designing workplaces with regards to safety at work and fire protection regulations. (These regulations are set out for every machine tool and specified in standards).

3.8 Economic evaluation

Here, the expert system is employed to provide economic evaluation of investment projects (Hlavenka & Kubik, 1999). The system can assign different economic evaluation methods to different types of projects, calculate costs, savings, and use various criteria values to determine project effectiveness.

4. PROGRAM ENVIRONMENT AND INFORMATION TECHNOLOGY

The development tool chosen for the expert system is Borland Delphi 3.0. The program runs under Windows 95 and compatible operating systems (e.g. Windows 98). System requirements include a PC with a Pentium processor, 100 MB of hard disk space and at least 16 MB of memory.

As the system core (inference network) is written in the Delphi program, control has the touch and feel of other programs running under Windows 95. This, however, need not concern the control of external programs integrated into the system. After entering data a check is made of the values entered, followed by their processing and display of results. In some cases the program interprets the calculated values and recommends the course of action.

5. CONCLUSION

It is hoped that the system for layout planning of technological workplaces that we are developing will be a great contribution to the work of designers. Designer companies currently have only capacity for the production of their own projects. Designers are forced to invent their own design methods building on their, often painfully obtained, experience. Using tried and tested methods is much more effective. These methods resulting from many years of experience will now be integrated into our expert system.

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