ISSN 1392 – 1215 ELEKTRONIKA IR ELEKTROTECHNIKA. 2005. Nr. 2(58)

T 190 ELEKTROS INŽINERIJA

Computer-Aided Ergonomics Methods in Design

R. Kurila
Kaunas University of Technology, Studentų str. 50, LT-51368 Kaunas, Lithuania; e-mail: romualdas.kurila@ktu.lt
V. Milukienė
Kaunas University of Technology, A. Mickevičiaus str. 37, LT-44244 Kaunas, Lithuania, e-mail: violeta.milukiene@ktu.lt

Introduction

The development of automation trough extensive implementation of technology is one of the major trends in modern society. Computers are being used more frequently to improve the quality of different areas of ergonomics and safety. Computer-Aided production and design technology requires implementation of Computer-Aided Ergonomics methods.

Computer-Aided Ergonomics Methods can be defined as the implementation of information technology in ergonomics and safety methods and the integration of those methods into design, production and decision making [8]. In Lithuania Ergonomics and Ergonomics methods are not developed.

The major aim of this article is description of the now-days trends in Ergonomics and definition of the branches of Ergonomics, which now have to be implemented in Lithuanian industry.

Ergonomics in Design

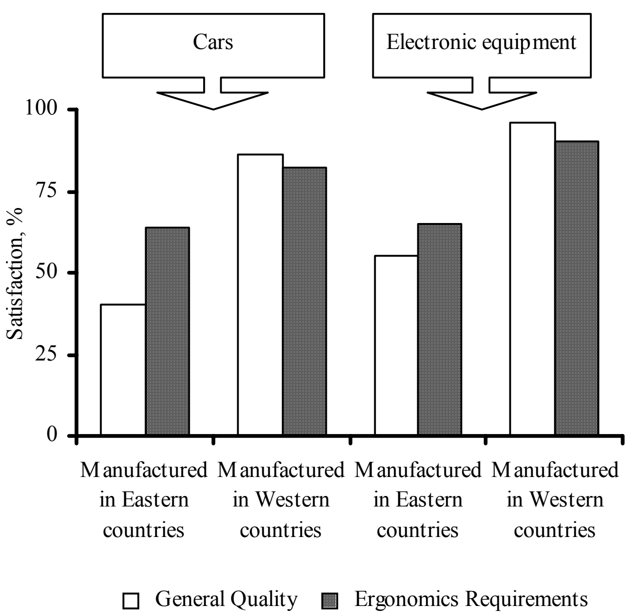

Fig. 1. Subjective evaluation of products quality

Ergonomics helps to make the best use of human and technical resources trough optimizing the application of existing and new technology to the benefit of users and environment. Its applications enhance job satisfaction, productivity and maximize the product or system quality by improving usability.

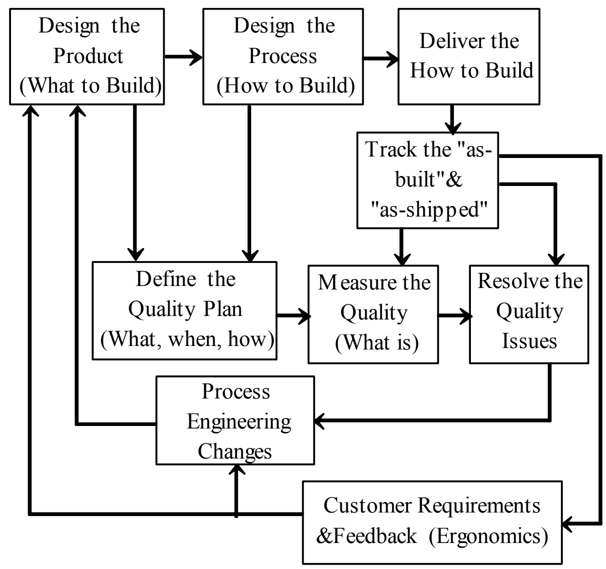

Fig. 2. Scheme of product design and production process

Ergonomics requirements have to be respected in all branches of production, such as mechanical and electronic equipment, machine-tools, work place design. Especially ergonomics methods in design and production process are wanted for Middle- and East-European countries industry, where Human factors/Ergonomics requirements traditionally were not respected. Not consideration in to Human factors/Ergonomics requirements caused low production quality. **Fig. 1** shows peoples evaluation (subjective) of quality and Ergonomics design quality of products manufactured in East-European countries, and in Western countries, where Human factors/Ergonomics requirements are respected (more 300 respondents were tested).

Ergonomics integrates knowledge derived from the human sciences to match jobs, systems, productions and environments to the physical and mental abilities and limitations of people.

Design and production process requires the Feedback realized by Ergonomics (**Fig. 2**) [2]. The feedback contains the Ergonomics data from design and engineering change reviews, suggested product and process improvements, and comments about actual situations encountered during production which affect the “What to Build”.

Computer-Aided Ergonomics and Safety Design

Computer-Aided Design (CAD) clearly offers new possibilities to integrate new possibilities to integrate ergonomic knowledge into the design process. A wide variety of ergonomic topics are of relevance to the application of computer-aided design systems concerned with layout design, displays and controls, fields of vision, areas of movement, physical strength and working environment. Computer systems have been developed, for example, to analyze and to improve workplace structures, man-machine systems, production information systems, working methods and operator instructions.

Different approaches to realizing this may be categorized as follows:

- Computer-based checklists for design quality analysis such as the FMS Safety Checklist [3];
- Computer-supported risk analysis like STARS – a program package for computer-aided safety and reliability analysis[7];
- Knowledge-based expert systems in ergonomics and safety, like M-LIFTAN, ALIE, and GSA [3];
- Ergonomic oriented information systems for workplace designers [6];
- Computer models of man;
- Systems for the measuring of 3-dimensional postures[12];
- Computer-based tool for evaluation and design of manual materials handling tasks.

Ergonomic principles require user-centred design [13]. A user-centred information systems development approach is one in which, trough appropriate structures, process and scope, all types of user needs (functional, physical and aspirational) are addressed so that usability (effectiveness, efficiency and satisfaction) is maximized in the end product.

Ergonomics expert systems

One simple example of this kind of designer support programs is the FMS (Flexible Manufacturing System) ergonomic and safety checklist [11]. In the FMS ergonomic and safety checklist computer program all the ergonomic and safety requirements for FMS given in the relevant standards are presented and are able to be checked by the designer when the system is under design. Trough the use of this program, ergonomics and safety information is integrated in to the design process. The designer is able to document the standards used for the object in question, and is thereafter able to accept liability as required by modern legislation.

A new ergonomic oriented information system, ErgoCop, has been developed for workplace designers. Designers during the design process for assembly workplaces intend ErgoCop for use. The program consists of:

Information about ergonomic requirements and design principles for different workplaces;

Cards containing the documents created during the design process for each workplace designed; feedback from workers and safety and health professionals about workplaces in operation;

Photographs and drawings of workplaces and successful ergonomic solutions;

A library of components (equipment, tools and fittings) used when building workplaces.

The ErgoCop program is accessible to the ergonomic and safety personnel so they can add their knowledge to the program and give both their own and workers feedback about the design implemented. Designers can consult the system when they need ergonomic information during designing and take advantage of the solutions used in earlier projects and the feedback given in order to avoid poor solutions and reinforce good ones.

Man models

Several computer-aided man-models have been developed using different computer programs. The most obvious application of a man model is in the visualization of man-machine interactions and in placing humans in the workplace design.

There are categorized different applications of computer-aided man-models [9] as follows: assessment of fit, maximal reach, clearance, and field of vision;

Assessment of strength demands to predict strength require and lower back load, posture recording and muscle activation.

Man models have been developed to enable the calculation of biomechanical forces and the risks for musculoskeletal injuries or to analyze working postures required, when the planned tasks will be carried out by the forthcoming operator. One example of 3-Dimensional Anthropometric Man-Models is CAD tool RAMSIS widely used to improve the design of cars [1].

The integration of ergonomic questions in the construction process of workplaces requires the use of adequate construction aids. In the past decades, the templates of percentile types were used. The conventional templates resulted from the measurement of lengths of human body parts of a large number of persons. The data was statistically analyzed by calculation of percentiles.

The basically new idea, which distinguishes the RAMSIS-measuring concept from other systems, is to use the man model itself as a measuring tool. The man is recorded by up to four digital cameras. A frame grabber digitizes the picture signals delivered by the cameras and visualizes them on the screen of the computer. After the 3-dimensional man models has been adapted to the anthropometric measures of the test person, “mathematical photos” of the manare calculated. For the calculation of images the same camera parameters (focal length, camera distance, camera position) are available as those in case of a real recording with a digital camera. The essential measuring process is effected by an interactive posture adjustment of the man model to the recordings of the test person. RAMSIS program is widely used by car manufactures FIAT, AUDI, BMW, FORD, OPEL, and MERCEDES-BENZ.

Evaluation and design of manual materials handling tasks

One of the most important occupational health problems is the high number and severity of chronic or acute back disorders caused by manual materials handling. In 1990 the European Community has issued the directive 90/269/EC on manual materials handling. This Directive requires from the employer the evaluation of the design of manual materials handling tasks with respect to workers health risk. A simple way to introduce the idea of prevention injuries in the industry would be evaluation of the workers health risk by determining a load limit characteristic of the worker. Several methods have been developed to determine a weight limit for the manual handling of objects. The NIOSH-method (USA) [10] is internationally accepted. In 1991 the NIOSH lifting equations were modified. The ErgonLIFT-computer based tool for evaluation and design of manual material handling tasks uses NIOSH modified equations.

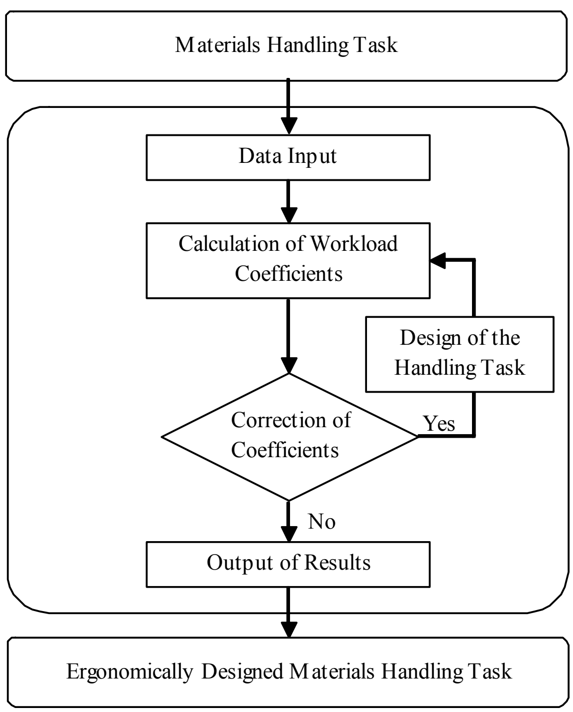

Fig. 3 Flow chart of a risk analysis with ErgonLIFT

A risk analysis of a manual material handling task using ErgonLIFT [14] starts with the input of the task data, and of the individual characteristic of the worker. Ergon LIFT then calculates the described workload coefficients.

Fig. 3 shows the process of the risk analysis and the re-design of the manual materials handling task with ErgonLIFT. With ErgonLIFT the practical user in industry gets an easy-to-use tool enabling him to quantitatively describe the health risk of a worker performing a manual material handling task. If the health risk cannot be characterized as tolerable, ErgonLIFT proposes preventive measures to reduce the risk, and the user is led to an ergonomic re-design of the task.

Conclusions

1. Computer-aided Ergonomics methods make it possible to improve the quality of design.
2. Computer-aided Ergonomics methods in Lithuanian industry are not implemented and are needed for more extensive use in practice.

References

1. **Bubb H., Geuss H.** Possibilities of Ergonomic Modelling of Products and Workplaces. Advances in Occupational Ergonomics and Safety 1. – Switzerland, 1995. – Vol. 2. – P. 566 – 571.
2. **Dickey R.** The need for Speed. Computer integrated manufacturing & engineering. – Vol. 1, No. 2. – P. 16 – 20.
3. **Jarvinen J., Karwowski W.** Applications of knowledge-based expert systems in industrial ergonomics: a review and appraisal. // Mattila M., Karwowski W. Computer Applications in Ergonomics, Occupational Safety and Health. –Amsterdam: Elsevier Science Publishers, 1992. – P. 45 – 54.
4. **Kurila R.** Kompiuteriniai metodai ergonomikoje ir darbų saugoje. // Integruotos projektavimo ir gamybos sistemos. – Kaunas: Technologija, 1998. – P. 45 – 50.
5. **Kurila R.** Modeling of harmfulness of work environment //Proceedings of the 13th Triennial Congress of the International Ergonomics Association. – Finland, 1997. – Vol. 7. – P. 249 – 251.
6. **Lehtela J., Kiskinen M.** Information system for workplace designers. // Proceedings of Nordiska Ergonomisallskapets arskonferens Ergonomii och Foretagsekonomi. – Ergonomics Society of Finland, Turku, 1993. – P. 157 – 162.
7. **Mattila M., Karwowski W.** Computer Applications in Ergonomics, Occupational Safety and Health. – Amsterdam: Elsevier Science Publishers, 1992. – P. 513.
8. **Mattila M.** Computer-Aided Ergonomics and Safety –a Challenge for Integrated Ergonomics // Proceedings of the 12th Triennial Congress of the International Ergonomics Association. – Canada, 1994. – Vol. 1. – P. 69 – 71.
9. **Moore A., Wells R.** Towards a definition of repetitiveness in manual tasks // Mattila M., Karwowski W. Computer Applications in Ergonomics, Occupational Safety and Health. – Amsterdam: Elsevier Science Publishers, 1992. – P. 401 – 408.
10. **NIOSH** 1981. Work Practices Guide for Manual Lifting. – NIOSH Technical Report. – No. 81. – P. 122.
11. **Poucet A.** Knowledge-based systems for risk assessment and monitoring // Mattila M., Karwowski W. Computer Applications in Ergonomics, Occupational Safety and Health. – Amsterdam: Elsevier Science Publishers, 1992. – P. 29– 36.
12. **Seidi A. RAMSIS –** a newly developed CAD-tool for ergonomic analysis of vehicles and its 3-dimensional system of analysis of postures and movements // Proceedings of the 12th Triennial Congress of the International Ergonomics Association. – Canada, 1994. – Vol. 2. – P. 26 – 28.
13. **Smith A., Dunckley L.** A practical model of user-centred information system development. // Proceedings of the 13th Triennial Congress of the International Ergonomics Association. – Finland, 1997. – Vol. 5. – P. 113-115.

14. **Vedder J., Laurig W.** ErgonLift-a computer based tool for evaluation and design of manual material handling tasks. // Proceedings of the 12th Triennial Congress of the International Ergonomics Association. – Canada, 1994. – Vol. 2. – P. 293 – 295.

Pateikta spaudai 2004 09

R. Kurila, V. Milukienė. Kompiuterinių ergonomikos metodų taikymas konstruojant // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2005. – Nr. 2(58). – P. 74–77.

Straipsnyje apžvelgiami šiuolaikiniai kompiuteriniai ergonomikos metodai, taikomi konstruojant produktą, organizuojant darbo aplinką bei atliekant galutinio produkto ergonominę ekspertizę. Kompiuteriniai ergonomikos metodai sukurti darbo sąlygoms, žmogaus ir mašinos sistemoms, gamybos informacinėms sistemoms, darbo metodams ir saugos instrukcijoms analizuoti bei tobulinti. Pagrindinės kompiuterinės ergonomikos priemonės gali būti klasifikuojamos kaip kompiuteriniai kontroliniai kokybės analizės klausimynai (anketos), saugumo ir atitikmens kontrolės programos, ergonomikos ir saugos žinių bazės bei ekspertinės sistemos, ergonomikos informacinės sistemos gamybos ir darbo sąlygų projektuotojams, kompiuteriniai žmogaus modeliai ir kompiuterinės programos žmogaus fiziniam darbui vertinti. Il. 3, bibl. 14 (anglų kalba; santraukos lietuvių, anglų ir rusų k.).

R. Kurila, V. Milukienė. Computer – Aided Ergonomics Methods in Design // Electronics and Electrical Engineering. – Kaunas: Technologija, 2005. – No. 2(58). – P. 74–77.

The aim of this paper is to give an overview about the fields of ergonomics where computer-aided Ergonomics methods have been developed and to present experiences and possibilities how computer-aided ergonomics may benefit the implementation of ergonomics and safety expertise. Computer systems have been developed to analyze and to improve workplace structures, man-machine systems, production information systems, working methods and operator instructions.

The major Computer-Aided Ergonomics tools may be categorized as computer-based checklists for design quality analysis, program packages for computer-aided safety and reliability analysis; knowledge-based expert systems in ergonomics and safety; ergonomic oriented information systems for workplace designers; computer models of man, and computer-based tools for evaluation and design of manual materials handling tasks. Il. 3, bibl. 14 (in English; summaries in Lithuanian, English and Russian).

Р. Курила, В. Милукене. Компьютерные методы эргономики в конструировании // Электроника и электротехника. – Каунас: Технология, 2005. – № 2(58). – С. 74–77.

В статье рассматриваются современные компьютерные методы эргономики, используемые на стадии конструирования продукта, при организации рабочей среды, при проведении эргономической экспертизы конечного продукта.

Компьютерные методы эргономики созданы для анализа и совершенствования рабочих мест, систем человек-машина, информационных производственных систем, методов работы и инструкций безопасности. Основные компьютерные орудия эргономики могут быть классифицированы как компьютерные вопросники контроля качества конструирования, компьютерные программы анализа безопасности и эргономического соответствия, экспертные системы безопасности, компьютерные модели человека и компьютерные программы анализа физического труда. Ил. 3, библ. 14 (на английском языке; рефераты на литовском, английском и русском яз.)