Software Support of Modelling using Ergonomic Tools in Engineering

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Abstract **– One of the preconditions for correct development of industrial production is continuous interconnecting of virtual reality and real world by computer software. Computer software are used for product modelling, creation of technical documentation, scheduling, management and optimization of manufacturing processes, and efficiency increase of human work in manufacturing plants. This article describes the frequent used ergonomic software which helping to increase of human work by error rate reducing, risks factors of working environment, injury in workplaces and elimination of arising occupational diseases. They are categorized in the field of micro ergonomics and they are applicable at the manufacturing level with flexible approach in solving of established problems.**

Keywords **– Manufacturing Plant, Ergonomic software, Tecnomatix Jack, 3D SSPP.**

1. Introduction

In general, it is possible to note that the ergonomics is a scientific discipline which is focused on understanding between human and other parts of the system. It improves the health, performance and well-being via application of suitable methods, theory and data. It contributes to evaluation of work, products, environment, systems and design. It covers all aspects of human activity and it includes physical, social, organization and many other factors [1].

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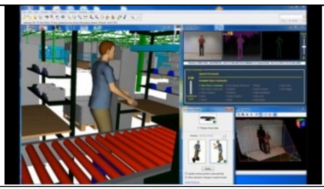
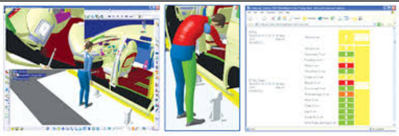
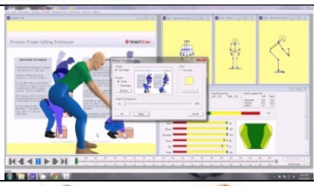
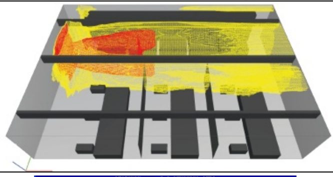
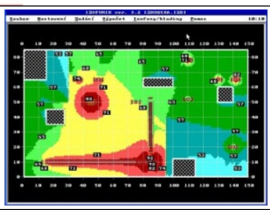
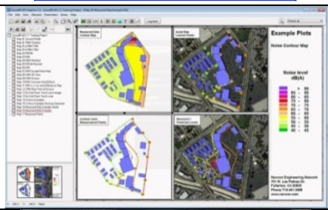
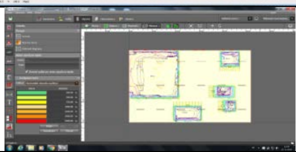
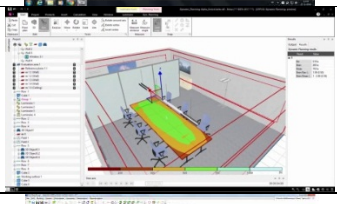
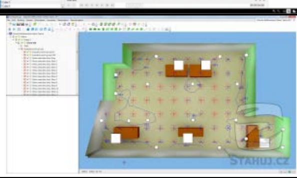
The ergonomics comes from ancient Greece and it passes through several phases during its development. These phases are dated from the mid-19th century when it launched the so-called trade development phase in which the main object was to improve the health at work. In the early 20th century (until 1945) they are connected with ergonomic phase of development which is focused on the increase in efficiency of work – performance, fatigue, time analysis) in connection to blocking of negative influence of working environment. After World War II until the early 80´s, it was coming about the penultimate phase of ergonomics development – production phase. The main subject and target of this phase was increasing the human performance and elimination of motor and sensory limitation. To date, it is recorded the last part of ergonomics development in the humanizing phase. The aim of this phase is human studying during the work in accordance with system analysis and synthesis. [2]

The last phase of development (the main part of process is the human) is presented by implementation of computer software into the manufacturing plants. Ergonomic software have broad scale focus and they analyse, evaluate and provide the solutions for optimization of working process with the main emphasis on the safety and the human protection during the work. [3] In the manufacturing plants, they are using the simulation software for cutting, milling, drilling, planning, assembly, manufacturing, management, etc. [4-6] It is possible to use the simulation software during the production of composite materials in simulation of material flows. [7]

The following table presents the overview of the best known ergonomic software for the manufacturing plants. Particular software are focused on 2D and 3D simulation of the human activities in the manufacturing plants, analysis and evaluation of noise, illumination and other physical factors of the working environment.

Table 1. Overview of ergonomic software for manufacturing plants

Software	View	Description
Tecnomatix Jack		- Evaluation of working environment - Workplace reorganization - Simulation of exact working motions - Fatigue reducing
Delmia V5 Human		- Anthropometrical databases - Analysis and evaluation of lifting, laying down and carrying of burdens - Simulation of working activities
3D SSPP		- 3D software for prediction of static strength - Analysis of lifting, pulling and pushing - Flexion analysis - NIOSH
ANTHROPOS Ergo Max		- Analysis of load state - Design of workplaces and manufacturing halls - Ergonomic and biomechanical analysis
CadnaR		- Noise calculation - Determination of noise impact to working area - Determination of quality of space acoustics
Izofonik		- Single and dual channel measurement of noise - Calculation of noise levels $L_{A99} - L_{A01}$ - Results by - Results through histograms and distribution functions
SoundPLAN		- Simulation of noise and pollution of air - Basic modules: Geo-Database (creation of models), Road Noise Propagation (emission), Industry Noise Propagation (industrial noise), Indoor Factory Noise (factory noise)
DIALux		- Light – technical calculations - Calculation of interior and exterior illumination - Calculation of illumination levels
ReluxPro		- Illumination calculation - Raytracing - Results by 3D graphs of illumination distribution - Space graphs, isograms, distribution of brightness
Wills		- Calculation of day and artificial illumination - Application of such a point method - Glare factor calculation

2. Application of 3D SSPP ergonomic software in the manufacturing plant – example

Simulation in 3D SSPP provides the basic ergonomic analysis and evaluation which are stated in Table 1. The simulation was realized by worker whose task was to pick up and pass on the burden (Toolbox of 1 kg).

Figure 1. presents the view on the creation of model during the burden lifting. The left part of the figure presents the creation of model and the right part of figure presents model of burden lifting. The creation of model consists in the assignment of anthropometric data, metrical units, gravitational acceleration, type of grip, and creation of particular models.

Figure 1. Example of model creation in 3D SSPP software

On the basis of created model they are already available during the simulation reports - Fatigue (fatigue evaluation), Low back Analysis - 3D, Sagittal Plane (evaluation of strengths affecting on worker), Strength Capabilities (strength abilities of hands worker), Anthropometry (overview of anthropometric data), Balance (evaluation of stability, centre of balance, legs load), Forces (forces evaluation considering the human weight and exterior loads affecting on worker), Location (overview of human body position), Moments (display of total forces moments which are produced by load), Posture (evaluation of body posture), Strength Direction Vectors (value of the resulting torque of vector forces). The next figure presents the examples of table results in 3D SSPP software.

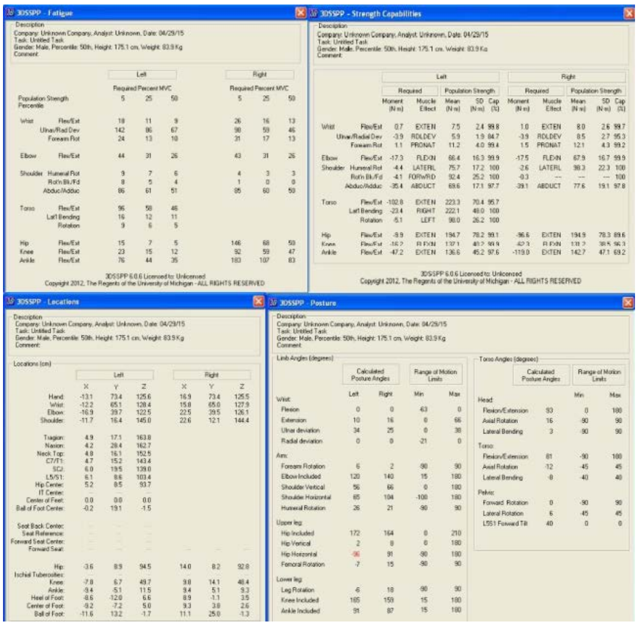


Figure 2. Reports from 3D SSPP ergonomic software

3. Application of Tecnomatix Jack ergonomic software in the manufacturing plant - example

Tecnomatix Jack is simulation software from Siemens which is used all over the world by manufacturing plants due to its broad spectrum analyses and compatibility. [8] Similarly to the first case, realised was simulation of lifting and transmission of burden (weight 1 kg) by worker.

The following figure presents the sight of the created model of worker during the lifting of burden. The model creation consists in the selection of worker from the database and then it consists of defining the basic anthropometric parameters. The simulation is realised by function Task Simulation Builder (TSB) where the activities are minutely defined by left toolbar. The check of the whole simulation is possible to realise by additional bar which shows the course of simulation in time intervals.

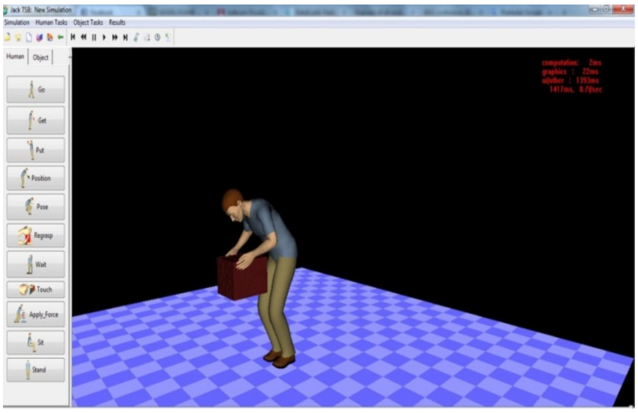


Figure 3. Burden lifting model - Tecnomatix Jack

This simulation software provides the ergonomics analyses and evaluations by Task Analysis Toolkit module in form of tables and graphs after the simulation and also in course of simulation in defined time intervals. The first tool of ergonomic analysis is the Lower Back tool which is focused on the evaluation of possibilities of lower back spine damaging of a worker. Further ergonomic tool is Static Strength Prediction (SSP) which provides the possibility of design or modification of manual tasks via results considering force limitations of workers. In the manufacturing plants, the ergonomic evaluation tool NIOSH is used for design and modification of lifting technique of heavy burdens. Metabolic Energy Expenditure tool identifies the more exacting tasks which are done by workers and they contribute to their elimination. In the manufacturing plants, the Fatigue analysis is used whereby it is possible to determine the recovery time of the worker after the strenuous activity and it is possible to generate recommended weights of transferred burdens. In addition to the above mentioned parts of TAT modules, they are offered the ergonomic tools such as RULA, OWAS, Manual Handling Limits, Force Solver a Predetermined Time. Figure 4. resents all of graphical interpretation of results of the above mentioned tools.

Figure 4. Graphical representation of results - Tecnomatix Jack

4. Comparison of simulation software on the basis of selected criterions

On the basis of realised simulation in ergonomic software, the table was compiled which presents comparison according to pre-established criterions. These criterions were selected on the basis of requirements of the manufacturing plants.

Table 2. Comparison of ergonomic software

Criterion	3D SSPP	Tecnomatix Jack
Price ($)	1495	2400
2D analysis	+	+
3D analysis	+	+
Import of video files	-	-
OWAS analysis	-	+
RULA analysis	-	+
NIOSH analysis	+	+
REBA analysis	-	-
Energy analysis	+	+
Predefined human models	+	+
Predefined object models	-	+
Anthropometric data	+	+
Fatigue analysis	-	+
Evaluation of several human models simultaneously	+	+
Individual settings of body position	+	+

Legend to Table 2:
\+ Criterion is met.
\- Criterion is not met.

From the previous table of software evaluation, it can be stated that the suitable tool for ergonomic evaluation is Tecnomatix Jack for the requirements of manufacturing plants. The huge advantage of this software is a good arrangement and simple control.

Taking into account various criteria, this software has a broader scope than the individual analyses as OWAS, RULA and so on and therefore it is possible to wide-scale use of this software in the several manufacturing sectors. The second simulation software is 3D SSPP. This software does not contain numerous amounts of ergonomic analyses but it is also available in smaller production companies.

5. Conclusion

It is necessary to study human musculoskeletal system and also needs to be presented in the scientific manner in order to describe and analyse human body motion. [9] On the basis of the current trend of increasing production they are often used ergonomic software which serve as increasing of productivity, security, elimination of occupational diseases and consequently to increase business efficiency. This article was focused on introducing the often used ergonomics software in manufacturing companies and for creating basic models and simulated various examples highlighted by various features, analyses and methods. This case study shows not only comparison of selected software but also to provide the information for manufacturing companies.

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