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THE USE OF SIMULATION FOR THE SOLUTION OF EFFICIENCY INCREASE PROBLEMS IN TECHNOLOGICAL PROCESSES IN THE AUTOMOTIVE INDUSTRY

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Abstract

Article is devoted to practical model designing for selecting technological process optimum parameters in mechanical engineering. The growing requirements to the quality and competitiveness of production, the growing globalization of the economy, forcing the producers to find reserves of the productivity and safety of work.

In the past two decades many companies are identifying the reasons for the ineffectiveness of technological processes, using modern tools like, for example, simulation.

One of such directions is the account of ergonomic parameters. Today special software solutions are used on the basis of accurate three-dimensional model of the person . Such approach allows to refuse from the more costly physical modeling, significantly reduce time for ergonomic analysis, since such an analysis can be conducted in parallel with technological preparation of production, and not after their launch, raise efficiency of the production, to lower loading on the personnel and to reduce the risk of injury.

Key words: *automobile industry, simulation modeling, technological process*

1. INTRODUCTION

The automotive industry does not accidentally take a special place in the economy of developed countries, because by creating high-tech products, it, at the same time, largely determine the development of other industries. According to one of the definitions of a transport - it is an industry that generates useful space, being one of the economy sectors that is critical from the point of view of satisfaction of public needs and ensure sustainable functioning and development of the economic complex as a whole. And in addition to that the automotive technology solves the problem of mobility of the population, carries out delivery of cargoes «from door to door», besides, a wide range of equipment on chassis is represented practically in all the sectors. But, at the same time, motorization, the level of which has reached the critical size both globally and in Russia, creates a number of problems which force the manufacturer to find all the new solutions, constant improving both the design and production technologies, as to withstand significant market competition becomes possible only by continuous development and application of innovative solutions.

In the conditions of globalization of the market and high competition, which is typical especially for high-tech and science-intensive sectors, companies related to the above mentioned industries are engaged in search of reserves for reduction of time-to-market for new products. This largely relates to the improvement of technological processes. However, the introduction of technologies for intensification of production, such as Lean production, often leads to negative results, due to the deterioration of working conditions. In conditions, when human capital is becoming one of the most important factors of sustainable companies in the world markets, it is necessary to pay attention to the quality of the working environment and safety of production and technological processes.

World auto manufacturers pay special attention to researches in the field of industrial ergonomics, since taking into account anthropometric parameters not only of consumer of goods, but of manufacturer, and also of personnel providing service support, increases the competitiveness of goods and customer attraction.

Muscular-skeletal disorders, including cumulative disorders due to injuries in the process of implementation of assembly works, constitute more than 60% of all injuries with disability in this production. The assembly process is the most dangerous among all processes of the automotive industry because of the monotony of work and overstrain. However, currently there are already tools for simulation and analysis of technological processes, taking into account ergonomic factors, allowing digital manikins to evaluate the risks when executing

transactions, and to optimize the process through a structural reduction of power, frequency and position of stress when performing work with a high degree of risk.

In consideration of the above, and that manufacturing processes are usually associated with significant both physical and psychological stress and in addition are associated with different types of risks, constant improvement of technologies are necessary with the account of the need to create comfortable and safe working environment.

2. TENDENCIES OF TRANSITION TO SUSTAINABLE DEVELOPMENT AND «GREEN ECONOMY»

The world economy in the new millennium is characterized by two main trends: on the one hand, it is the rapid development of techniques and technologies that require significant resources and cause the appearance of an increasing number of sources of negative impact on the environment, on the other hand - the growing number of adherents of transition to a «green» economy, initiating the development of strategies and policy documents on sustainable development (SD) in all spheres of human activity. For the automotive as one of the high-tech and resource-intensive industries such trends are typical mainly because quality of the products at a significant degree is determined by the quality of human capital: high qualification of the personnel should be ensured at all stages of the product life cycle. Therefore introduction of new technologies for the development of both the product and technologies of its production, application of new materials and the improvement of production processes is urgent for the whole industry.

In the new millennium in developed countries both at the level of the governments and business community the idea of ecological modernization has been actively promoted, the basic premise of which is that the environmental adaptation of economic growth and industrial development economically viable as it helps to save resources and creates competitive advantages for companies implementing «green» technology and product innovation.

In the formulation of the Brundtland Commission (World Commiss., 1987; Runnalls D., 2011) the sustainable development is understood as a development in which « the needs of the present are met without compromising the ability of future generations to meet their own needs». The World Bank has offered a more «economic» definition of sustainable development that is the process of managing the basis of portfolio assets, aimed at the preservation and expansion of opportunities available to the people. In accordance with that sustainable development includes economic, environmental and social sustainability, which is achieved through the efficient management of the physical, natural and human capital (i.e. the sum of assets) (Beyond Economic…).

UNEP formulated the concept of «green» economy, recognizing that this kind of economy increases the welfare of people and ensures social justice, and this substantially reduces the risks to the environment and its poor» (UNEP, 2011). In other words, the «green» economy must be low-carbon, resource-efficient and socially inclusive.

«Global “green” new deal» identified the global economic recovery maintaining the existing and creating new jobs and observing the interests of the least protected groups of the population as the main short-term objectives. While short-term goals should not contradict a medium-term (sustainable economic growth and achievement development Goals of the millennium) and long term (reducing dependence on hydrocarbons and the preservation and restoration of biodiversity and ecosystem services). In these conditions the creation of a safe working environment is of high priority and should be decided during the development of new technologies and modernization of production processes.

3. EXISTING METHODS AND SOLUTIONS FOR DESIGN OF A SAFE WORKING ENVIRONMENT

The industrial complex of Russia is currently in need of modernization due to stiff competition in the world markets, which has been compounded by Russia's joining the WTO. This fully applies to the automotive industry as one of the high-tech, resource-intensive industries. The production of cars, which, in particular, concerns the assembly processes, is complex and labor intensive, and in order to reduce the physical strain on the collector, the level of occupational injuries and risks of occupational diseases, it is necessary to investigate technological processes and improve them.

In the last two decades an extremely intensive introduction of information technologies took place in all spheres of modern society. The modern engineering and technologies state allows to create the means and methods not only to control the technical and organizational-technical systems and devices for the analysis of functional systems of humans and their impacts. This gives the opportunity to adjust and optimize human activity indirectly, using the recommended load and parameters, and in real time, allowing you to create a comfortable working environment and to enhance the safety and efficiency of labor.

Flow car assembly system management is carried by enterprise employee through effectors of the body, so the quality of its professional activity is determined by the efficiency - the property of the employee, which are defined by the state of physiological and mental functions, characterizing the ability of an employee to perform a certain activity with the required quality and within a priori given interval of time (Lomov, M., 1986).

The main characteristics of activity of the employee during the car assembly are speed, accuracy, reliability. The most important condition for improving the quality and effectiveness of activities - provision of high reliability. To do this, all operations on assemblage of cars should be executed timely and accurately, for a certain period of time with minimum resources: energy, money, energy (Glukhov D.V., 2007).

As flow car assembly can be regarded as a functioning organizational-technical system, it is possible to apply mathematical and simulation models for modeling employee activity, using experimental data of monitoring of real processes as baseline information. Such methods of improvement of the processes in organizational-technical systems are due to the fact that the full-scale experiments for the study of large systems are unnecessarily, due to the significant economic and time costs. Furthermore, such testing may be associated with danger to the health or life of people, as well as the inability of the experimental reproduction of some situations.

Simulation is a tool that allows to perform not only a qualitative analysis of the processes, but also to explore the consequences of any changes in them, and to choose the option that meets all specified limits, while receiving the parameters of the system, which will be optimal under specified conditions. Software developed for these purposes allows to build models which represent the processes as they passed in reality, and then conduct a series of virtual experiments, setting-up model time. You can examine the process with a unit test or setting-up a number of them which allows to select optimal parameters of the process: the results will be determined by a random character.

Numerous researches of domestic and foreign scientists were devoted to the problem of the interaction of human and technical objects on the production, creation of comfortable working environment taking into account the requirements of ergonomics. In numerous scientific publications and technical literature there are examples showing that there is a communication between ergonomic component and the cases of temporary disability on assembly. In 1988 in their work (Voynenko V.M., Munipov V.M., 1988) the authors pointed out: «...it is impossible not to take into account that as the technical systems become more automated and complex, they are increasingly vulnerable to human error. To minimize the probability of erroneous actions of man is possible if during the development of the system and its subsequent operation take into account requirements of ergonomics.»

Munipov V.M. (Voynenko V.M., Munipov V.M., 1988; Munipov V.M., Zinchenko V.P., 2001) in his works defined the framework of comprehensive study of the person in work. He summarized the experience of the organization of interdisciplinary researches in the field of hygiene, biomechanics, physiology, psychophysiology, psychology of labor and engineering psychology. V.M. Munipov proposed a new concept of quality of work, hanging his thoughtfulness and appeal, based on multidisciplinary approach and, in particular, on the psychological theory of activity.

Methodological, historical and experimental work of V.M. Munipov in the field of ergonomics allowed to determine simultaneously area of scientific knowledge and practical (design) activities, the complex solutions of the problems of design engineering, software, working conditions, vocational training and selection. The concept of ErgoDesign is based on experimental studies of visual thinking, made by V.M. Munipov.

The work «Concrete examples of the effects of changes technologies» by American researcher Michael Wright (Wright Michael J.) is devoted to the research of ergonomics of workplaces. In (Timothy F. Morse, 1998) the economic and social consequences of the muscular-skeletal disorders are analysed. The relationship between ergonomics and quality of the process was investigated in the work by S.D.Drury (Colin G. Drury, 2000), as well as the works of other authors.

The report of Italian researchers (D.Battini et al., 2007), released in 2009 at the 19th International conference on research production in Italy, the results of studies of optimal configurations of shower cabins, the increase of

labour productivity at the production of a new line, and the motivation of employees by improving the ergonomic characteristics of the production system were shown.

Currently, there are numerous software developments for simulation of human activity, which are widely used in solving questions of labour protection at enterprises of different industries, including the automotive and manufacturing industries. Modern modeling tools are: Tecnomatix Jack, RAMSIS Autimotive, DELMIA Ergonomics Task Definition, SAMMIE, Santos Human (Tom I.E., 2002; SantosHuman Inc. 2014).

4. THE IMPACT OF ERGONOMIC FACTORS ON THE EFFICIENCY OF PRODUCTION PROCESSES

One of the methods of improvement of processes in high-tech industries, which is widespread, is the concept of «lean production», developed for the automotive industry and first applied to automotive enterprises. However, as it is shown by studies about the consequences of implementing the technology by international automakers (Peter Hasle, 2009; 2014; Falck Ann-Christine, Rosenqvist Mikael, 2012; Koukoulaki Theoni, 2014), the effects of its implementation are ambiguous and, in most cases, rather negative. According to foreign researchers, changes in technological processes with the purpose of improvement and optimization should be carried out with account of ergonomic factors, adherence to principles of quality and safety of the working environment.

Works of many foreign scientists in the field of ergonomics, occupational safety, modeling production environment are dedicated to identifying factors affecting the quality of the working environment, the causes of congestion, the risk of occupational injuries (Vissera Steven et al., 2013; Donoghue Maurice F., O'Reilly David S., Walsh Michael T., 2013; Yildirim Yucel, Gunay Sevtap, Karadibak Didem, 2014; Xu Xu, Jin Qin, Tao Zhang, Jia-Hua Lin, 2014; Falck Ann-Christine, Rosenqvist Mikael, 2014; Altemeier Simon et al., 2010; Guerin Clément, Hoc Jean-Michel, Mebarki Nasser, 2012). Multifactor modeling, including also ergonomic factors, allows not only to increase efficiency in resource-limited settings (Kara Yakup, 2014), but also to study working conditions (Anghel, D.-C., Ene, A., Belu, N., 2014; Dukic T., Rönnäng M. and Christmansson M., 2007), and subsequently to predict the fatigue (Perez J. et al., 2013) and to prevent accidents on manufacture (Garcia-Herrero Susana et al., 2013). In addition, the use of virtual manufacturing environment when designing processes allows to solve tasks for timely equipment maintenance (Regazzoni Daniele & Rizzi Caterina, 2013).

Analyzing the role of ergonomic studies in ensuring the sustainability of the production systems and the quality of working environment, the researchers note positive changes in companies that have implemented recommendations for changes in processes with account of ergonomic parameters (So R.H.Y., Lam S.T., 2014), however, it is also noted that this issue needs more attention, because this affects the quality of processes and sustainability of production systems, and on the psycho-emotional state of the running and harmonious development of human potential (Bolis Ivan et al., 2013).

The solution of such tasks is based on adequate information unique to each manufacturing facility, depending on a number of factors, which are often of stochastic character. Thus, the anthropometric characteristics of the staff of any company are unique, and it allows to build an adequate model of a person in a production environment (Nadadur Gopal and Parkinson Matthew B., 2013). To make information, on the basis of which the models are built, adequate, monitoring of production processes can be applied (Han SangUk et al., 2013; Zunjic Aleksandar et al., 2012). In addition, the monitoring data can serve as a basis for assessing the adequacy of the developed models for virtual experiment.

5. SOFTWARE ENVIRONMENT FOR SIMULATION OF HUMAN ACTIVITIES AND THE ERGONOMIC ANALYSIS OF TECHNOLOGICAL OPERATIONS

5.1. System analysis of the state of Ovako (OWAS)

The load on workers in various positions of the body can be analyzed using Ovako (OWAS), described in the research of Karhu, Kansi and Kuorinka (Karhu Osmo, Kansi Pekka, Kuorinka Iikka, 1977) and Karhu, Harkonen, Sorvali and Vepsalainen (Karhu Osmo et al., 1981). The system represents an observational study method of musculo-skeletal loads in different working conditions. Method OWAS (OWAS method, 2009) was applied for the preparation of samples by the values of loads in the back, regions of superior limbs and lower limbs articulation of the steel company employees. The calculation of the frequency of each position and time spent in each position, and then identifying the most dangerous working postures that cause stress, helped to reduce the load, resulting in better posture of production workers.

Currently, during experimental studies video recording apparatus is used, on the obtained in-situ results simulation models are built, in the development of which interactive simulation tools are used. So, in 1992, the researchers Loukhevaara and Suurnakki conducted experiments with the use of video recording Panasonic equipment. For each position of the body, to improve the quality of observations in the investigated part of the body they chose the special angle of the shot. 5 hours of video were analyzed, 2371 measurements were made: at least 100 observations for each position of the body of the object.

5.2. Rapid assessment of the upper limbs articulation (RULA)

RULA - method of observations used in the evaluation provisions of the upper limbs articulation. This method assesses the position of the neck, spine and other top articulations with regard to the functions of the muscles and external loads. The method was developed by researchers McAtamney and Corlett in 1993 (McAtamney Lynn, Corlett E. Nigel, 1993). A special encoding system is used to play a sequence of actions, with the help of which it is possible to define how the physical load on the operator should be reduced to decrease the risk of injury.

5.3. The method of the National Institute of Occupational Safety and Health (NIOSH).

This method of ergonomic analysis is described in detail in the works of Waters, Putz-Anderson, Garg and Fine in 1993 (Waters Thomas R. et al., 1993). Method NIOSH (Encyclopedia of Public Health, 2002) is used to determine the level of risk associated with the task of lifting of a particular cargo. Calculation model takes into account such factors as vertical and horizontal loads, the frequency of the lifting, asymmetric load, and compression ratio. The method allows to determine the load, recommended for safe work, by a comparison of the indicators with biomechanical, physiological and psychophysical characteristics. To identify dangerous operations while the cargo raising, index of rise (LI) can be used and the index of relative physical activity, specified in the document.

5.4. Modeling of human activity. Virtual mannequin

The modern models of a human (Fig.1) being have a complex kinematic editing system that closely resembles human skeletal structure, joints, obeying the physiological range of movement restrictions, and geometry, closely resembling a real human form (Production Manufacturing Modeling, 2012).

Models of a human being are created on the basis of the actual in time comprehensive anthropometric surveys. These software products grants the user the possibility of designing real workspaces, using their own CAD modeling tools and libraries of objects in a wide range: from primitive objects to office furniture and equipment, tools and tooling. In addition, workspaces can be imported into multiple formats. The range of analytical tools of human factors is very wide, including graphic reach zones and zones of visibility.

For processes visualization and building 3D models the sensors of motion capture Kinect (El-Laithy, R.A., Huang, J., Yeh, M., 2012) are used which can also be used in robotic industries to prevent injury to operators who service robots (Anton, F.D., Anton, S., Borangiu, T., 2014).

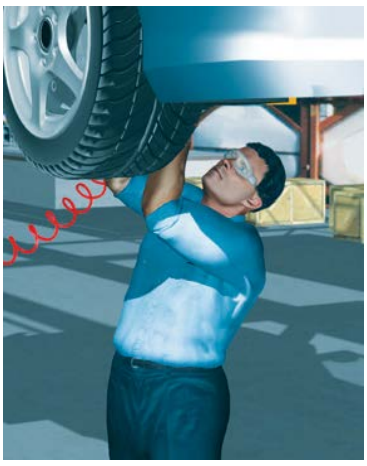


Figure 1. Modeling of production processes in the software complex Santos

5.5. Data analysis and decision making

For analysis and strategic decision-making aggregated information is used, for the storage of it a data warehouse (DW) is created, the aim of building of which is in integration, updating and harmonization of operational data from disparate sources to provide a single consistent view of the object of management in general. DW contains information gathered from several online databases OLTP systems (OLTP (On-Line TransactionProcessing) - on-line transaction processing in real time).

The best tool that allows to react quickly to changes of both external and internal parameters of the production system, is the decision support systems (DSS), which is based on technology that uses an online database, data warehousing, online analytical system of information processing and intellectual analysis of data. DSS have the resorce to provide the user with aggregate data for different samples from the original set in an easy to understand and analyze form. Aggregate functions form the multidimensional data set (hypercube or metacube), so users can formulate queries, generate reports, receive data subset. This technology of a complex multidimensional data analysis, OLAP (On-Line Analytical Processing) – is an analytical processing in real time, which is a key component of data warehousing. Implementation technique involves various patented ideas: varieties architecture «client-server», time series analysis, object orientation, and optimizing data storage, parallel processes, etc. Applications also differ. So, in article (Lee C.K.H. et al., 2013) the experience of application of the OLAP cube for the analysis of causes of product defects in the quality system of garment production is described, in article (Cheng Ying-Mei, Leu Sou-Sen, 2011)multivariate analysis is used for clustering of defects in the construction of bridges, in article (Chow Harry K.H et al., 2005) the possibility of creating an expert system, which is knowledge-based and uses multidimensional data analysis to develop strategies when organizing the logistics processes is described. Article (Labib Ashraf W.) is devoted to the development of a computerized system maintenance control, designed for the analysis of solutions to the causes of failures in the system, taking into account various criteria such as time and frequency of outages, the availability of spare parts and others. The described technologies are implemented in the form of a DSS for quality management (Deslandres, V., Pierreval, H., 1997; Lau H.C.W. et al., 2009), and also for management of production systems and processes at all stages of the product life cycle (Kusiak Andrew, Smith Matthew, 2007).

6. DEVELOPMENT OF SOFTWARE MODULES FOR DATA COLLECTION, INFORMATION ANALYSIS AND FORECASTING

Since the assembly process is the final stage of manufacturing the final product - the car or its unit, and to a large extent determines its operational quality, special importance and responsibility of this stage is obvious. The method of imitation modeling in this case is optimal from the point of view that it allows to take into account many parameters, but also to get the desired result without resorting to in-situ experiment.

The initial stage of design of virtual production is the preparation of data for the development of simulation models (identification, specification and information collection), as well as the determination of the conditions for the virtual experiment on the model. Software that is used for modeling of the technological process and the structural scheme of information flows (input and output), including the types of documents and software modules, is presented in Fig.1.

To identify the problem areas statistical data on occupational diseases, injuries and accidents of workers on an assembly line is used, fixed by the labour safety service for 2010-2011 years. The analysis of statistic data showed that the automobile factory, where the assembly lines are situated, is on the first place in a number of cases of temporary disability on production.

From the maps of distribution of injuries (fig. 2) it is seen that the most frequent injure places are the fingers of the hands, legs, feet, wrists and hand, head, eyes and shoulders, and in absolutely most they are repetitive, which proves poor ergonomics of workplaces of operators. The analysis of the frequency of occurrence of injuries by age and gender characteristics shows that in most-at-risk are workers aged from 45 to 55 and from 18 till 30, the number of affected males account to 62% of all the injured, that can be explained by their employment in work with large loads. Research has shown that the most exposed to the risk of injuries are the assembly workers in the first 2 months of work, which indicates the necessity of a more attentive attitude to the newly adopted and control of compliance with safety regulations by them.

High risk of injury suggests that adjustment of the technological process in a continuous flow system assembling of vehicles with regard to ergonomic indicators of human activity is necessary. On the first stage of development

of a simulation model the ranking of the problematic places has been created, with the greatest risk of occupational diseases, injuries and accidents.

The analysis of the positions on the first line of the main assembly line on compliance with the ergonomic principles comfortable provisions (Fig.3.) showed that the majority of operations and assembly operations at its second position are carried out in less usable area - less than 900 mm, and in consequence, it is a potential bottleneck. The assembly tables, some types of packaging and the frame of the truck are situated in this zone.

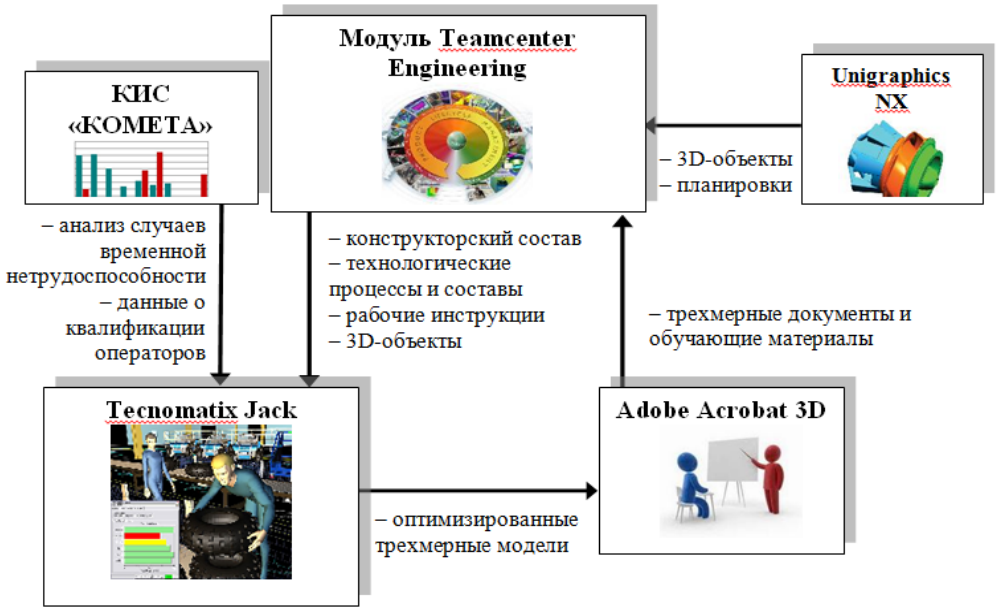


Fig. 1. The integrated circuit between software modules and their composition



Голова	8
Глаза	6
Уши	1
Спина	2
Грудная клетка	3
Плечо	6
Локоть	3
Запястье, кисть	9
Пальцы на руке	23
Колено	1
Стопа	9
Голень	17
Копчик	1
Всего	89

Fig. 2. Distribution map of injuries

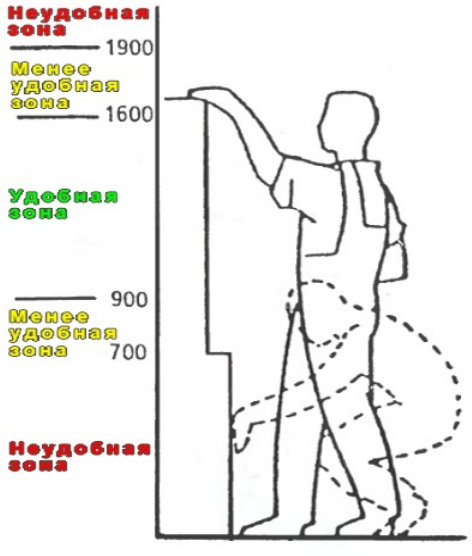


Fig.3. The distribution of injuries by body position (height indicated in mm)

Modeling the activities of the operators of the assembly production is carried out using information about workflows real production and playback starts with a 2D layout of work areas in an interactive 3D environment

Tecnomatix Jack. Then interactive planning using 3D objects and technical staff of trucks from the system of engineering data «Teamcenter Engineering» is being played and created in CAD «Unigraphics NX 3D models of instruments, accessories, and equipment. In ready interactive three-dimensional model virtual operators-assemblers are added, number of which corresponds to the number of actual employees of the given site. In the 3D environment verification of the values of the weights of all active objects with which the operators of assembly works interact is carried out. When creating the model only those elements of the production system that have significant influence on the studied objects are taken into account.

In the study of efficiency of a car assembly system functioning with ergonomic indicators the following factors were considered: manufacturability operations (X1); tools and snap-ins ergonomics (X2); the experience of the operator (X3); anthropometric data of the operator (X4); sex of operator (X5). So, figure 4 shows an example of two variants of performance of technological operations. Similarly possible options for all factors have been selected and their best combination have been identified.

After building models for assembly operations for all combinations of factors ergonomic analysis was performed using built-in Tecnomatix Jack tools and scientific methods of ergonomic analysis:

1) Tool «RULA» (Rapid Upper Limb Assessment) - a rapid assessment of traumatic situations;

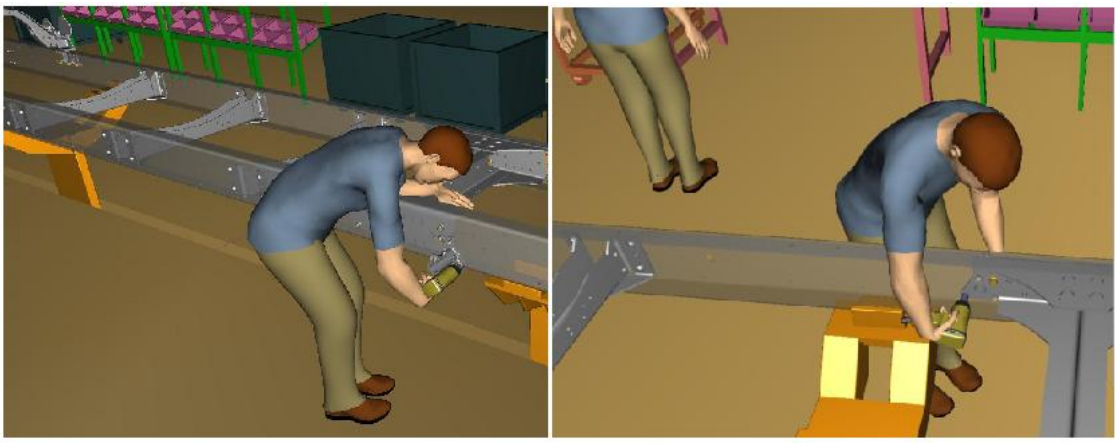
2) Tool «Lower Back Analysis» - analysis of the load on the back;

3) Tool «OWAS Posture Evaluation» - evaluation of body positions by degree of risk;

4) Tool «Fatigue and Recovery» - analysis on the degree of fatigue and recovery;

5) Tool «NIOSH Lifting Analysis» - analysis of problems lifting/lowering.

The results of ergonomic analysis are displayed in the summary tables 1 and 2.



a) b)

Fig.4. Checking the manufacturing assembly operations: a) the fixing of the detail with the external side of the frame, b) the fixing of the details on the inner side of the frame

Table 1. - Summary table 1 - a «beginner»

Parameters	Existing solutions						Optimal solution
	50 persons, male	5 persons, male	95 persons, male	50 persons, female	5 persons, female	95 persons, female	Women -50, technology change, ergonomic equipment
The load on back (L):	1380,75 (+37%)	1148,69 (+14%)	1631,56 (+62%)	1143,00 (+13%)	1059,25 (+5%)	1514,63 (+50%)	1009,44
Ergonomics assessment:	2,50 (+22%)	2,62 (+28%)	2,65 (+29%)	2,32 (+13%)	2,42 (+18%)	2,60 (+27%)	2,05
Recovery time (sec):	28,2 (+14%)	26,7 (+8%)	27,3 (+11%)	26,4 (+7%)	26,7 (+8%)	27 (+10%)	24,6

Table 2. Summary table 2 « experienced worker»

Parameters	Existing solutions						Optimal solution
	50 persons, male	5 persons, male	95 persons, male	50 persons, female	5 persons, female	95 persons, female	Women -50, technology change, ergonomic equipment
The load on back (L):	1380,75 (+37%)	1148,69 (+14%)	1631,56 (+62%)	1143,00 (+13%)	1059,25 (+5%)	1514,63 (+50%)	1009,44
Ergonomics assessment:	2,60 (+37%)	2,72 (+33%)	2,85 (+39%)	2,42 (+18%)	2,52 (+23%)	2,65 (+29%)	2,05
Recovery time (sec):	28,8 (+17%)	28,5 (+16%)	29,1 (+18%)	28,2 (+15%)	28,5 (+16%)	28,8 (+17%)	24,6

5. CONCLUSIONS

During a series of experiments on the simulation model the best combination of values of the input factors was found, which allowed to improve each of the factors, compared to existing solutions. In order to determine whether the combination of these factors is the best management decision, as established in the course of experiment on the simulation model, you must perform a feasibility study of this decision, because the variation of some of the factors needs financial costs, as well as to develop measures on safe application of the development.

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