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ERGONOMIC EVALUATION OF PHYSICAL LOAD BY SIMULATION SOFTWARE IN ENGINEERING

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Keywords: ergonomics, simulation, Tecnomatix Jack, engineering
Abstract: In ergonomics, the evaluation of physical load is possible to do by various methods, calculation, assessing tables, etc. Recently, the evaluation by different ergonomic simulation tools is very widespread. Presented article is focused on introducing the application of simulation in the field of ergonomics. This article presents the practical example of physical load evaluation by simulation software Jack in engineering – the workplace of component packaging. In the simulation software, there is created the simulation model of the working environment and working activity. After that it is evaluated by means of three ergonomic methods – RULA, OWAS and SSP.

1 Introduction

Every kind of work performed by the employee is physiologically outcome of nerve, sensory and muscle activity of human. In the company focused on engineering production, there is a working load in the sphere of muscular activity. The employees are exposed to physical load. Physical load is defined as factors relating to biomechanical forces generated in the body. In the literature this has also been defined as "mechanical exposure", to indicate that the full working environment (i.e. lighting, noise, the thermal environment, work organization, psychosocial factors, etc.) is not considered [15]. The physical load is mainly influenced by the range of muscle activation because every working activity needs the muscles and energy [14].

The determination of the body part that is exposed during work activity, the physical load can be divided as follows:

General physical load – the load of muscles of the upper and lower extremities,
Local physical load - the load of muscles of the little muscles - the hand or forearm muscles

The measurement of physical activity is nowadays possible to solve differently [8]. The basic measurement types of the load are presented in the following table.

Table 1 The most common method of physical load measurement [11]

Methods of physical load measurement	Description of methods of physical load measurement
Tabular estimation	use of tables with the energy consumption (minutes or hours) for work of different muscles
Calculation	use of technical mechanics principles
Calorimetry	lab-methods, the measurement of heat expenditure during the work
Biomechanics	analysis of changes of specific substances in the human organism
Electromyography	the measurement of electric potential in the muscles
Changes of pulse frequency	by palpation or by pulsometers
Changes of blood pressure, quantity of discharged sweat, etc	these methods are used in the combination

The physical load is possible to measure and evaluate by various type of checklists. These checklists are divided by kind of load. The particular types of checklists are presented in the following figure.

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Figure 1 Checklists of physical load [5]

In the engineering production there is noticed the lower-back load during the sedentary working activities. The measurement and evaluation of this type of load is very difficult and it is possible to determine it by subjective evaluation, special methods or simulation tools. Certainly, this evaluation is not still reliable and exact. Physical loading on the back is often assessed using different design criteria such as spinal compression (biomechanics), oxygen consumption (physiology), and the percentage of the population that finds a task acceptable with respect to fatigue and stress (psychophysics). Although these criteria are assumed to prevent low-backdisorders, epidemiological evidence is sparse. However,these criteria have substantial application to job designer,which is rarely differentiated from risk assessment. The following table presents the advantages and disadvantages of use of various methods for the determination and evaluation of lower-back load.

Table 2Advantages and disadvantages of load determination of lower-back [3]

Assessment Method	Major Advantages	Major Disadvantages
Biomechanical Model	1. Appropriate for jobs requiring high forces, handling of heavy loads 2. Quantitative 3. Covers lifting, lowering, pushing and pulling	1. Practicality limits application to static analyses in the workplace 2. Fairly expensive 3. Fairly high expertise required 4. Carrying is excluded
Psychophysical Tables	1. Easy to use 2. Inexpensive 3. Extensive data available 4. Covers lifting, lowering, pushing and pulling	1. May ingnore high biomechanical and physiologiocal demands 2. Based on subjective responses
Energy Expenditure Models	1. Appropriate for high frequency tasks 2. Usually the only practical method of assessing energy expenditure	1. Validity of available models is questionable 2. Relationship between energy expediture and health effects has not been demonstrated
1991 NIOSH Equation	1. Captures major risk factors associated with lifting and lowering 2. Is a useful toll for training non-ergonomists on how different parameters affect lifting capacity	1. Has not been validated 2. Applies to few MMH jobs 3. Only applies to lifting and lowering

Physical load requirements and the methodology of evaluation are defined by Decree No. 542/2007. The basic requirements are the following [14]:

- General physical load of worker has not exceed the limit values of general physical load of worker which are given considering the energy expenditure and heart rate
- Local physical load of worker has not exceed the limit values of local physical load in relation to muscular forces and frequency of working moves which are given in the individual attachment

To prevent the increased physical load during the work are carried out the technical, organization and other arrangements [14].

The basic technical arrangements are the following:

- ergonomic modification of workplace
- limitation of application of products, tools, devices, machines and technical procedure causing the increased physical load during the working activity
- adequate microclimatic conditions

The basic organization arrangements are the following:

- working mode and recreation mode
- organization of work

The other arrangements are the following:

- continuous evaluation of health risks to workers working in risk of excessive physical load
- evaluation of worker health capability to the working performance including the realization of medical routine checkups in relation to work

One of the ways to identify and eliminate the physical load in the workplace is the use of ergonomic simulation tools especially in the sedentary activities [4]. The simulation is possible to define as a numerical method of complex dynamic systems by experimenting with computer model.

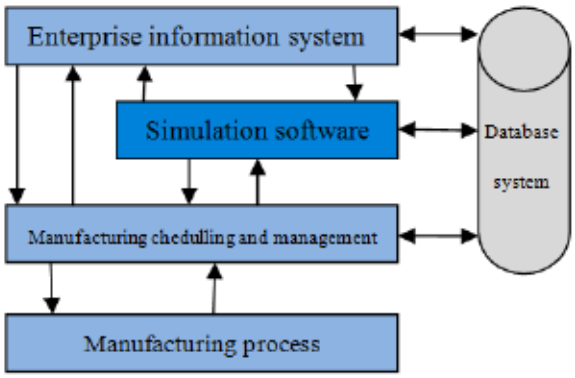

Figure 2 Integration of simulation in the systems [2]

At the basic categorization of simulation, it is possible to classify the experimental method and the essence of simulation consists in the fact that studied dynamic system simulator and replace it with him then conduct the experiment in order to obtain information about the original investigation system. Simulation can be read from the following aspects [7]:

Economic aspect - simulation serves for identification and skipping the objects which are in the system moreover

Controlling aspect – simulation serves for prediction of impact of accepted decisions

Simulation has found the application in the field such as space flights, military operation, urbanistic systems, computer systems, logistic and manufacturing systems, financial models, ecolology and environmental protection, ergonomics, etc. [6].

Process and system simulation should include the following stages [2]:

System analysis and defining the issue, formulation of simulation targets

Collection and processing of information, estimation of parameters and types of random variables.

Creation of abstract logical model

Construction computer model

Verification and testing of model

Planning and preparation of simulation experiments

Realization of simulation experiment, changes of elements in the model, correction of model

Evaluation and processing of simulation results, final report

Simulation according to the nature of changes in the model over time is possible to divide [9]:

Discrete event simulation

Continuous simulation

Combined simulation

A discrete-event simulation models the operation of a system as a discrete sequence of events in time. Each event occurs at a particular instant in time and marks a change of state in the system. Continuous Simulation refers to a computer model of a physical system that continuously tracks system response according to a set of equations typically involving differential equations. [10]

According to the type of model is possible to divide the simulation into [9]:

Determinist simulation

Stochastic simulation

All of simulation tools like any other real tools have several advantages and disadvantages. The overview of the basic advantages and disadvantages are presented in the following table.

Table 3Advantages and disadvantages of simulation [1]

Advantages	Disadvantages
choose correctly	model building requires special training
compress and expand time	results may be difficult to interpret
explore possibilities	modeling and analysis can be time consuming and expensive
diagnose problem	simulation may be used inappropriately
visualize the plan	

2 Tecnomatix Jack – ergonomic simulation tool

Jack is a human modeling and simulation tool that enables to improve the ergonomics of your product designs and to refine industrial tasks. Jack, and its optional toolkits, provides human-centered design tools for performing ergonomic analysis of virtual products and virtual work environments. Jack enables you to size the human models to match worker populations, as well as test your designs for multiple factors, including injury risk, user comfort, reachability, line of sight, energy expenditure, fatigue limits and other important human parameters. Using Jack facilitates significant cost and time savings by enabling you to improve product quality and process feasibility early in the product lifecycle [13].

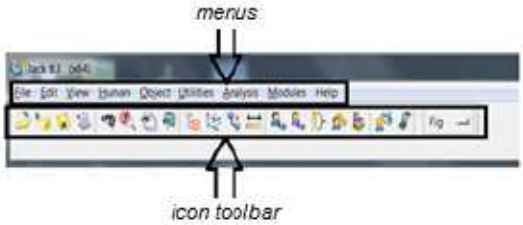

Figure 3 Control bar – Tecnomatix Jack

Jack provides a complete environment for all ergonomics and human factors needs, offering a comprehensive suite of analysis capabilities [12]. It enables to uncover human performance and feasibility issues early in the design process, allowing for big savings from a small investment. Simulation software Jack has 4 basic application:

- Create a digital human
- Posture the manikin or create a simulation
- Analyze human performance
- Experience virtual reality

3 Evaluation of physical load – Tecnomatix Jack

Ergonomic tool Jack is possible to use during the evaluation of load in the various fields. One of them is the application in the mechanical engineering, particularly for packaging works. These working activities produce the big static load to the lower back. In the following part of this article it is presented the possibility of application the ergonomic simulation tool for determination and evaluation of this type of physical load. This ergonomic simulation is implemented into the practice. The

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evaluated working posture is presented in the following figure.

Figure 4Working posture

In the ergonomic simulation software Tecnomatix Jack, it was created the model according to the previous figure. In the first step, there were defined the anthropometrical data of worker and then it was created the working environment. Defined worker was implemented into the working environment in the specified working posture. The created model of working posture is presented in the following figure.

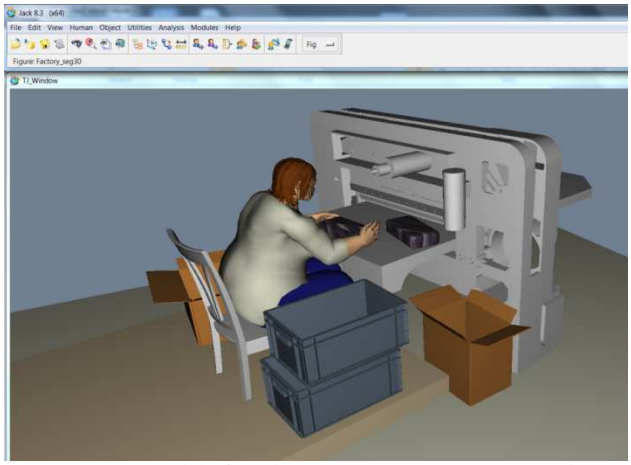

Figure 5Model of working posture – Tecnomatix Jack

After the creation of virtual model of working posture it was applied the evaluation methods – RULA, OWAS and SSP. First of all, it was applied the evaluation of physical load by RULA method. The final score of this method is 3- further investigation needed and it may be required the changes.

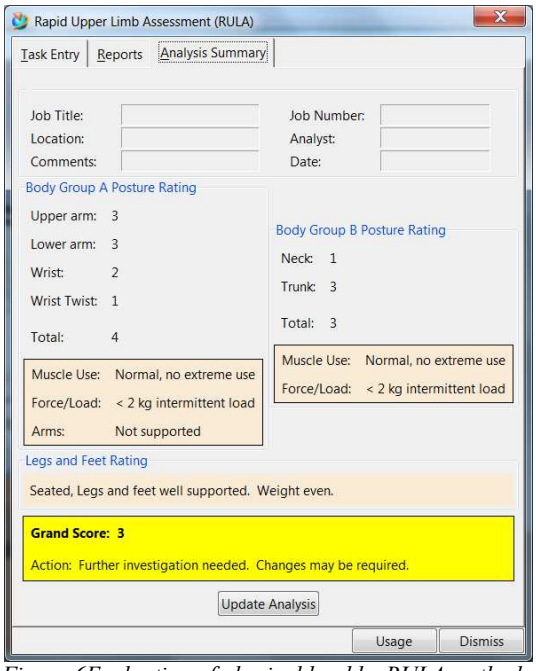

Figure 6Evaluation of physical load by RULA method - Tecnomatix Jack

To the evaluation of working posture it is suitable to use the OWAS method, too. The final score of this method is the value 3 – work posture will case harmful levels of stress on the musculoskeletal system. The system also warns that it is necessary to perform the optimization at the earliest possible time.

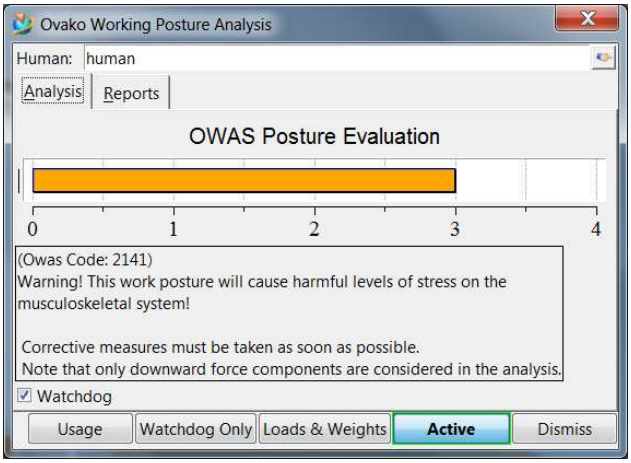

Figure 7Evaluation of physical load by OWAS method – Tecnomatix Jack

The final evaluation of the possibility to carry out an analysis through a SSP. Results can be found in the following figure in graphical and tabular form.

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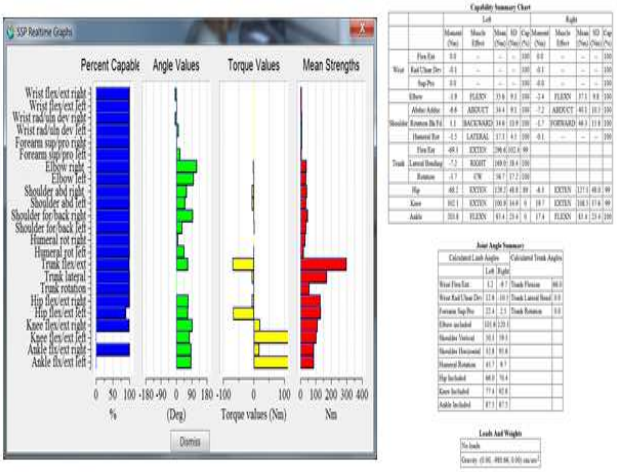

Figure 8Evaluation of physical load by SSP method – Tecnomatix Jack

The evaluation by individual methods showed that the static load of worker is inadequate and consequently it is necessary to perform the optimization of working posture or working environment for compliance with the required limits.

Conclusions

Nowadays, simulation ergonomic software Jack is possible to apply in the different industrial branches for evaluation of dynamical and static load of worker during the realization of various working activities. On the previous practical examples it is presented the ergonomic evaluation of the static load that impacts the worker involved in packaging components. In addition to the above mentioned analyses it is possible to realise the in time evaluation during the realisation of working activities. This evaluation requires the compilation of an accurate model and then compiling the working moves via Task simulation builder. The simulation is an essential part of small and medium-sized enterprises that use it in solving various tasks.

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DRAFT LAYOUT OF A DISTRIBUTION WAREHOUSE ON THE RESULTS OF CLUSTER ANALYSIS

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Keywords: layout, cluster analysis distribution warehouse
Abstract: In the article, we focused on the proposal of a layout solution for the distribution warehouse of the manufacturing company using the cluster analysis. In the dendrogram we selected the optimal number of clusters, which are groups of stocks according to share in the expedition. Cluster analysis belongs to multivariate statistical methods. Cluster analysis is defined as general logical technique, procedure, which allows to cluster variate objects into groups – clusters on the basis of *similarity* or *dissimilarity*. Cluster analysis involves computational procedures, which purpose is to reduced a set of data on several relatively homogenic groups – clusters, while the condition of reduction is - maximal and simultaneously minimal similarity of clusters.

1 Charakteristic of cluster analysis

Cluster analysis belongs to multivariate statistical methods. Cluster analysis is defined as general logical technique, procedure, which allows to cluster variate objects into groups – clusters on the basis of *similarity* or *dissimilarity*. Cluster analysis involves computational procedures, which purpose is to reduced a set of data on several relatively homogenic groups – clusters, while the condition of reduction is - maximal and simultaneously minimal similarity of clusters.

Similarity of objects is studied by the degree of similarity(correlation coefficient and association coeficient) or the degree of dissimalarity – degree of distance (distance coefficient). Methods of cluster analysis are on the basis of clustering clasified as hierarchical or non-hierarchical methods.

2 Description of the supply in the enterprise

For the analysis, we have customer demand data for one calendar year, which corresponds to the production plan and plan the expedition. This information represents inputs for an cluster analysis of stock of the products of the selected manufacturing enterprise. The production line of the enterprise is divided into 5 basic groups: Nara, J77, J104, J108, J110. The evolution of the expedition of products during the individual months of the selected calendar year is shown in Figure1.

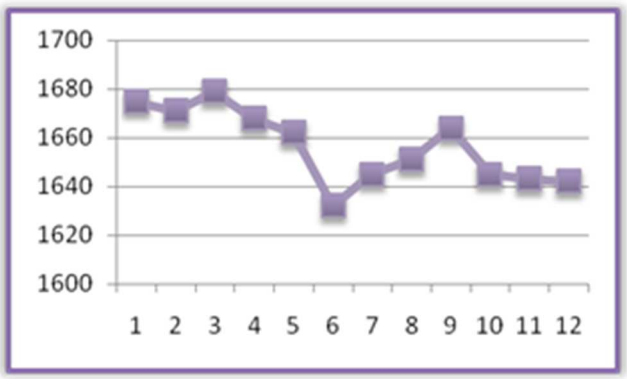

Figure 1 Development of product expedition

Product development expedition has fluctuating course, the average company produces and dispatches the goods 1656 pieces of products per month, the largest export was registered in March of that year and the lowest in June of that year. Since it is a custom form of production, in some months of the year a one-time customer demand for the selected product has arisen.

Percentage of basic types of products in the total expedition is shown in Figure 2.

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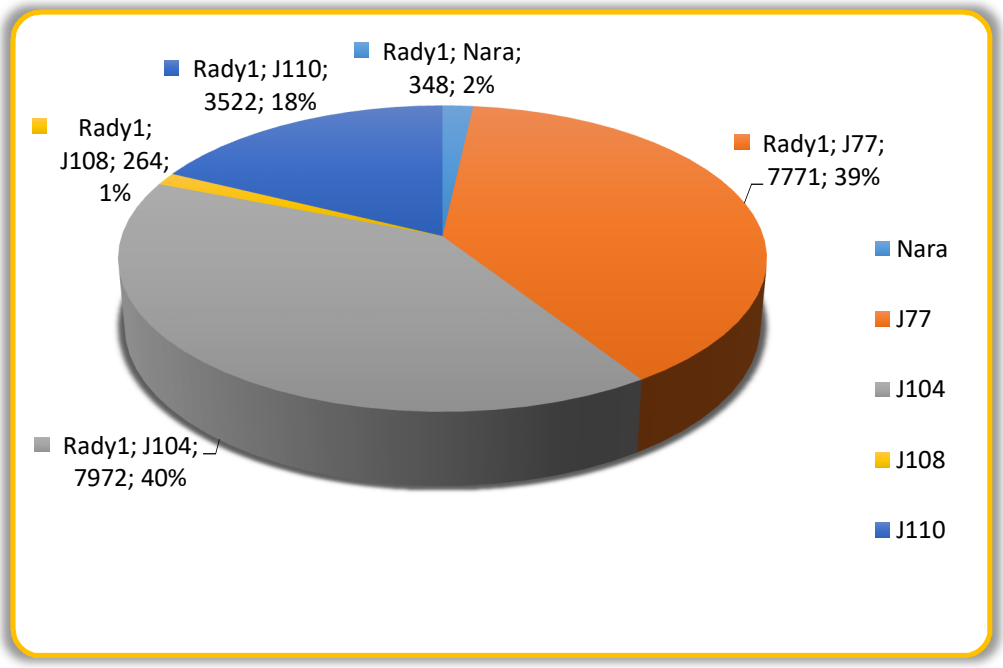

Figure 2 The share of types of products on an expedition

The largest share of the expedition has J10 chairs with 40% share and J77 chairs with 39% share.

3 Cluster analysis in distribution warehouse

Data on monthly expedition individual products have been entering for performing cluster analysis. The Ward method, which belongs to the hierarchical methods, was used, and the square Euclidean distance was used to express the distance. The result of cluster analysis is a dendrogram showing the various clusters depending on the distance connections. The dendrogram is a section for selecting the optimal number of clusters.

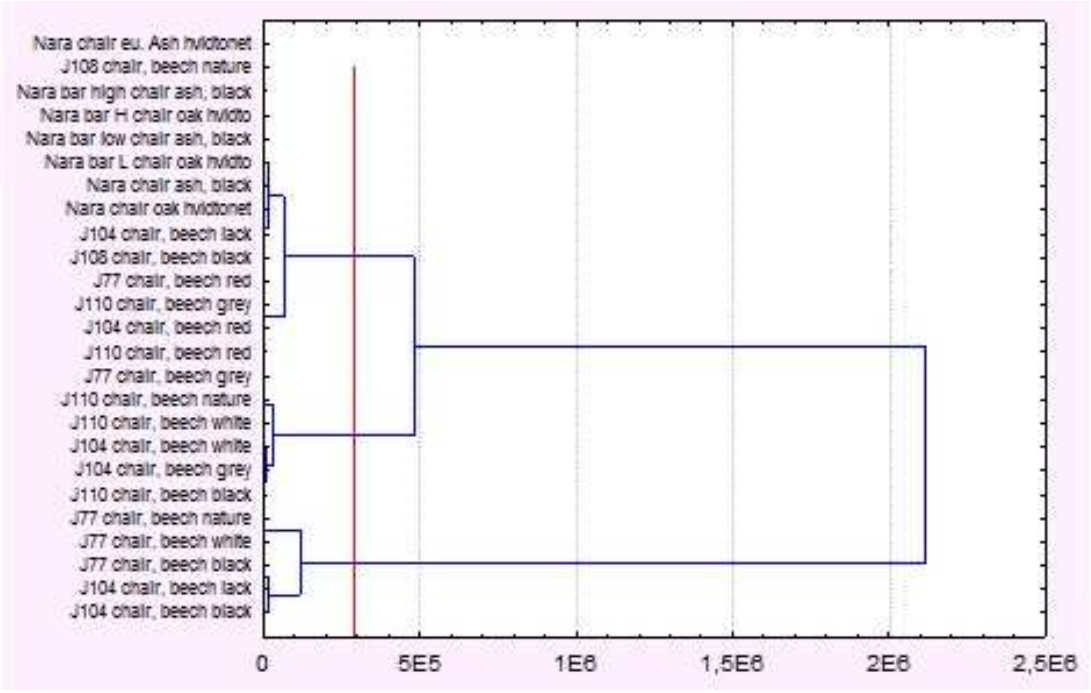

Figure 3 Dendrogram

From the dendrogram results follow optimal clusters describsed in the Table 1.

Table 1 Clusters

Clusters	Products	Σ
1.cluster	Nara chair eu. Ash hvidtonet	**2657**
	J108 chair, beech nature	
	Nara bar high chair ash, black	
	Nara bar H chair oak hvidto	
	Nara bar low chair ash, black	
	Nara bar L chair oak hvidto	
	Nara chair ash, black	
	Nara chair oak hvidtonet	
	J104 chair, beech lack	
	J108 chair, beech black	
	J77 chair, beech red	
	J110 chair, beech grey	
	J104 chair, beech red	
	J110 chair, beech red	
2. cluster	J77 chair, beech grey	**6111**
	J110 chair, beech nature	
	J110 chair, beech white	
	J104 chair, beech white	
	J104 chair, beech grey	
	J110 chair, beech black	
3. cluster	J77 chair, beech nature	**11109**
	J77 chair, beech white	
	J77 chair, beech black	
	J104 chair, beech lack	
	J104 chair, beech black	

The result of cluster analysis of the finished goods manufacturing companies is to identify three clusters of products. These clusters can be taken into account when solving individual warehouse items in the enterprise.

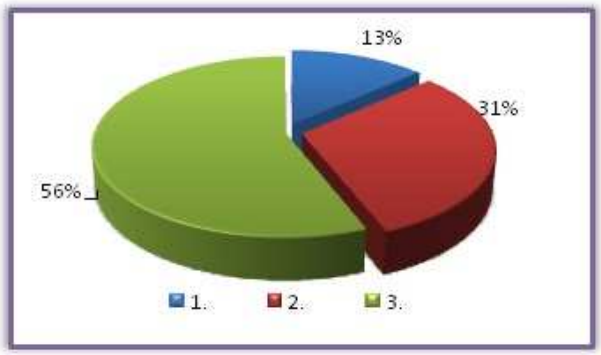

Figure 4 Share of clusters of products on expedition

From the graphical representation in Figure 4 shows that the largest share of the expedition has products 3.cluster, then 2.cluster and the smallest share has 1.cluster. It is therefore appropriate to place products 3. cluster within the warehouse closer towards to loading finished products. 3.cluster contains the products of the main groups J77 and J104.

Conclusions

From the results of the cluster analysis follow three clusters of final products which are shown in Figure 2D (Figure 5) and the 3D sketch (Figure 6) of the layout of warehouse of final products.

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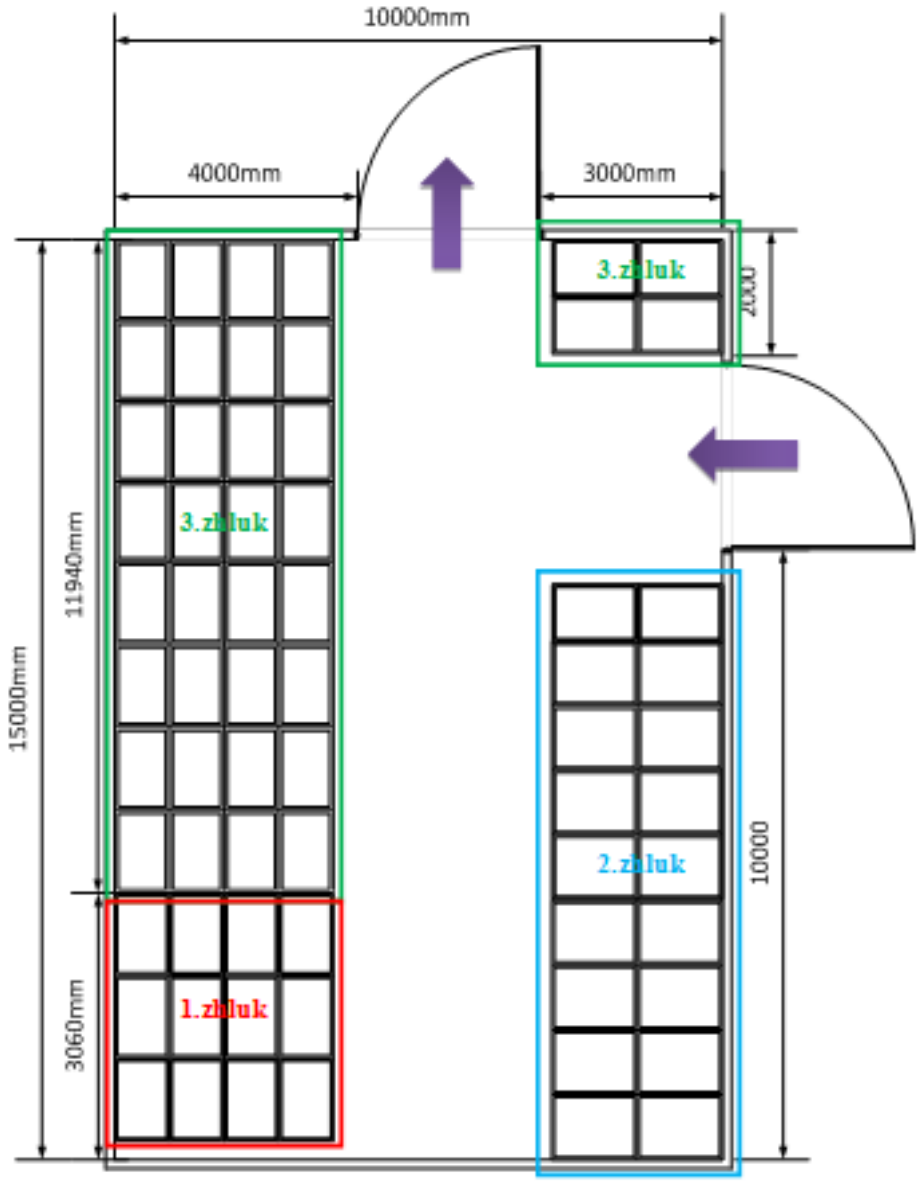

Figure 5 2D layout warehouse of finished products

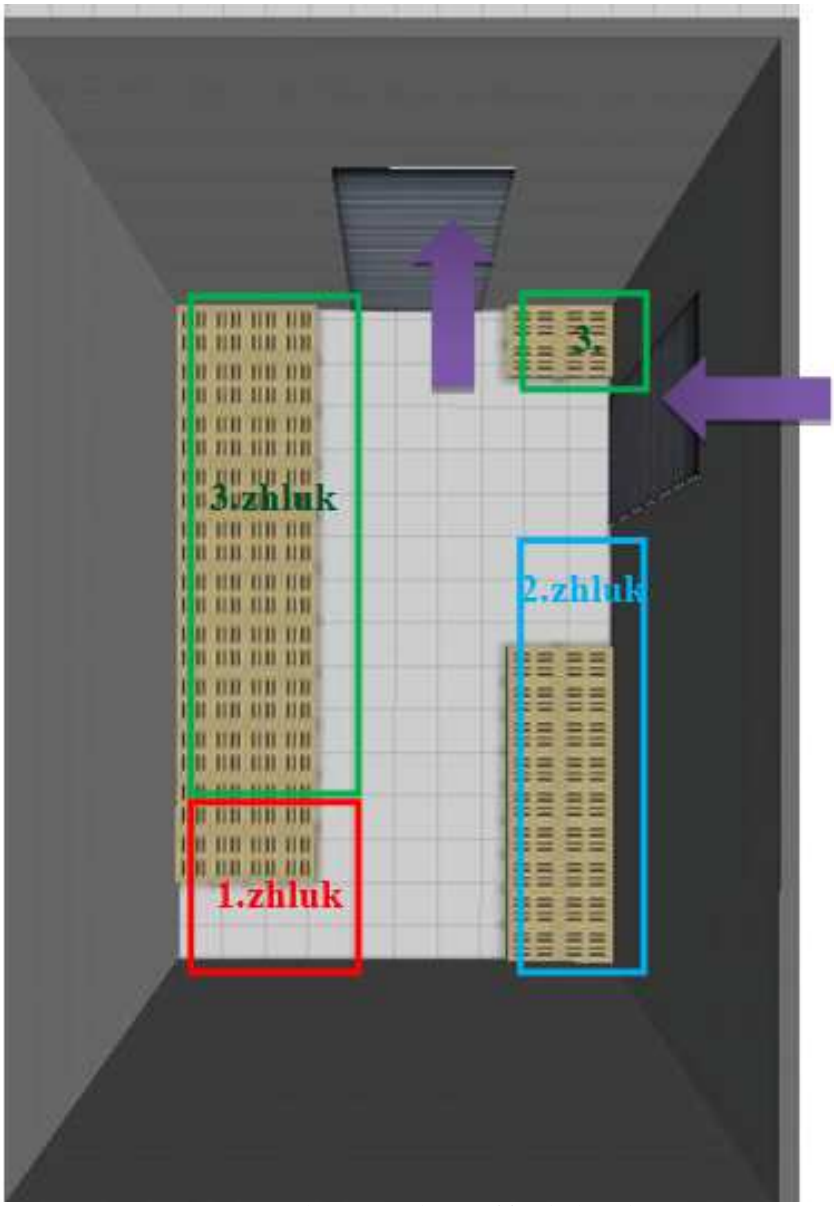

Figure 6 3D layout warehouse of finished products

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SIMULATION OF INTELLIGENT AND ACTIVE PACKAGING PERCEPTIONS IN SLOVAKIA

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Keywords: innovation, active packaging, intelligent packaging, functions of packaging
Abstract: The importance of packaging functions is still growing and consequently, the interest of the company is to access to the packaging more innovative. The primary functions of packaging were always practical – to protect a product, to keep the product together, to contain it and to identify it. Today packaging is also a container for promoting the product and making it easier and safer to use. The paper deals with the innovative forms of packaging - active and intelligent packaging. Using KANO model, we monitored the perception of the active packaging functions in comparison to intelligent packaging function among different age categories of respondents in Slovakia.

1 Introduction

Nowdays as well as over the last decades the importance of the packaging system and its various functions is increasing. Whereas the packaging is traditionally intended as a mean of protection, preservation, handling, transport and storage of products, also the other functions such as promotion, getting the attention of customers and brand communication are becoming more recognizable. As a result of global change and progress in recent decades, access to packaging materials and packaging techniques also changes. Packaging functions are improved to increase product durability, track product and increase consumer awareness. Therefore the current interest of the company is to offer a customer such a packaging that will meet the marketing requirements and the needs of handling and transport at the same time. In the case of innovation it is important to target it to the specific customer segment and therewith it is in the company's interest to properly identify the target groups of the packaging innovation [1]. According to this the aim of the paper is to identify the perception of the active packaging functions in comparison to intelligent packaging function among different age categories of respondents in Slovakia and to illustrate that perception by a 3D simulation method.

The packaging size, shape, design, selected color and font significantly influence the consumer decision-making process and thereby affect the marketability of the product itself [2].

When creating product innovations it is necessary to think about the product at different levels [3] whereas each level increases its value to the customer. Regarding the packaging innovation companies should monitor changes in consumers' preferences and also focus on an attention to the new technology of packaging when selecting and introducing the packaging to the market.

In the past, there was a change in design about every 15 years, but now due to the changes in the market environment and the impact of environmental pressure the companies should apply more innovative and creative approach to packaging.

Traditional perception of packaging classifies the main functions of packaging into four basic categories[4]:

- Protection – the package protects the product against the deteriorative effects of the external environment,
- Communication – the package is a marketing tool that communicates with the consumer,
- Convenience – the package provides the consumer with greater ease of use and time-saving convenience,
- Containment – the package can contain products of various sizes and shapes.

The basic functions of the packaging are classified differently, for example, Zeman [5] and Kačenák [6] referred to 6 key function classification: protection, guarantee, rationalization, economic, communication and ecological. Dzurová [7] refers to the classification according to Schulte, who lists five functions, namely: protection, storage, transport, handling and information. According to Kollar [8] essential functions are the protection, handling, information and publicity, environmental and economic.

Innovative packaging is the result of creative, unconventional thinking [4], resulting to the creation of packaging with interactive features – intelligent and active packaging. They focus to improve packaging functions to

meet current consumer demands, increased regulatory requirements, as well as increased interest in security.

Active packaging represent shift in the protection function from passive to active. The packaging is not only a passive barrier between the product and its environment, but the aim of protective function is to actively protect the product [4] and actively changes the condition of the package to extend shelf life or improve food safety, while maintaining the quality of the food [6]. According to the way in which they affect the characteristics of the product the active packaging can be classified as follows [9]:

- absorbers – active packaging systems based on absorption,
- emitters – active packaging systems based on the release of substances.

Intelligent packaging is associated with the performance of smart features and intelligent functions (such as detecting, sensing, recording, tracing, communicating, and applying scientific logic) to: facilitate decision making to extend shelf life, enhance safety, improve quality, provide information, and warn about possible problems [4]. According to Kačeňák [6] intelligent packaging is the term for systems that monitor conditions around the product and thus provide information about the quality of food during transport and storage. The time-temperature indicators, indicators of oxygen and carbon dioxide, the color temperature indicators, pathogen indicators and breakage indicators are distinguished [9].

The importance of active and intelligent packaging means mainly significant expansion of two packaging functions: protective function – especially in active packaging shift from passive to active protection and information functions – especially as intelligent packaging providing information monitoring the packing conditions. According [10] the requirements of customers to the innovation of packaging functions are as follows: the majority of respondents expect the packaging to be ecological and to fulfill principally information and protection function. These results confirm the actuality of intelligent and active packaging in terms of required packaging functions and therefore innovative packaging thus respond to the current market requirements.

Potential customers are more and more demanding information of product composition, quality, date mark and durability, thereby the companies should respond by that kind of innovation to meet these requirements. Regarding that research [10] the target group for packaging innovation represents the age category from 41 to 50 years according to their highest innovation status. This age category recognizes its own requirements in purchasing and selecting products and it considers protection and information function as the main important and ecological function as attractive [1].

2 Methodology

The research deals with the perception of active and intelligent packaging function and the Kano model was applied. Kano model aims to capture customers' opinion according to the requirements of an observed object [11]. Kano model is based on a survey using a Kano questionnaire. This questionnaire is constructed through pairs of customer requirement questions. Each question consequently has two parts: how do you feel if that feature is present in the product (functional form of the question), and how do you feel if that feature is not present in the product (dysfunctional form of the question). These pairs of positively and negatively conceived statements regarding the performance of monitored parameters, in this case packaging functions – protection, communication, convenience and containment. According to the methodological approach respondents had an opportunity to respond every question (statement) on a scale from 1 to 5 representing strong agreement to strong disagreement with that question (statement).

The sample of respondents was set at 120 respondents in Slovakia, keeping the same proportion of respondents for each given age category. The survey was conducted through electronic forms and personal questioning.

The responses were evaluated according to the cross rule [11], making it possible to categorize functions of packaging in the following categories according to how respondents perceived new packaging functions [10,11, 12, 13]:

- M (must be requirements) – are obligatory requirements that customers consider as normal and are automatically expected and their fulfillment is reflected in customers' satisfaction.
- O (one-dimensional requirements) – are those product attributes that lead to fulfillment and satisfaction in the event of non-compliance to customers dissatisfaction, but compared to the obligatory requirements customers automatically do not expect them.
- A (attractive requirements) – that have a clear impact on customers satisfaction because it is a requirement that customers did not expect, but it is attractive.
- R (reverse requirements) – are contradictory, they bother customers, as they require some additional action from them.
- I (indifferent, irrelevant requirements) – are requirements which do not affect customers satisfaction or dissatisfaction.
- S – are skeptical, questionable requirements

The results of Kano model allows to divide the monitored packaging functions into categories of mandatory, attractive, indifferent and reverse functions. Subsequently, the comparison analysis, which aims to identify and measure comparable data, was used. It was used to identify the differences between customers' perceptions of intelligent packaging functions and customers' perceptions of active packaging functions.

According to packaging functions definition by Yam et al. [4] we considered expansion of protection and containment function as a nature of active packaging and the expansion of communication and convenience function as a nature of intelligent packaging.

The comparison analysis was based on the customer requirements identification by Kano model. In the next step the weight were assigned to these requirements. Every identified requirement represents value 1, which was multiplied by weight according to identified category as follows: must be = 3, attractive = 2, one-dimensional = 1, indifferent = 0, reverse = -1 [13, 14]. Based on the sum of values, we can compare customers' perceptions of active and intelligent packaging functions and we identify the target age group for active and intelligent packaging [1].

Thereafter, a 3D simulation was used to figure the perception of intelligent and active packaging functions by respondents in Slovakia.

3 Simulation of perceptions of intelligent and active packaging functions by respondents in Slovakia

KANO model identified requirements of the packaging functions among the monitored age categories.

The customer's value (Table 1) was calculated as the sum of the points that have been assigned to the individual categories of the questionnaire. The results indicate different attitudes to intelligent and active packaging according to the age.

Both functions, active and also intelligent packaging functions, report the most significant value for customers in the age of 41 to 50 years (as shown by the total customer value 3) followed by age categories 51 to 60 (as shown by the total customer value 2).

Active packaging functions are most valuable for the customers in the age of 41 and older, for whom the active packaging represents attractive and one-dimensional requirement. It represents those active packaging attributes that lead to fulfillment and satisfaction and in the event of non-compliance to customers' dissatisfaction. The higher the degree of compliance with these requirements is, the customers are more satisfied and in addition the attractive requirements have a clear impact on customers satisfaction increase.

Table 1 The comparison analysis of perceptions of intelligent and active packaging functions in Slovakia

		Packaging functions				
		Containment	Protection	Communication	Convenience	Total
18-30	Requirement	I	I	I	O	-
	AP function	0	0	-	-	0
	IP function	-	-	0	1	1
31-40	Requirement	R	O	I	O	-
	AP function	-1	1	-	-	0
	IP function	-	-	0	1	1
41-50	Requirement	A	O	O	A	-
	AP function	2	1	-	-	3
	IP function	-	-	1	2	3
51-60	Requirement	O	O	O	O	-
	AP function	1	1	-	-	2
	IP function	-	-	1	1	2
61+	Requirement	A	I	I	I	-
	AP function	2	0	-	-	2
	IP function	-	-	0	0	0
Total		4	3	2	5	

Notes: AP – Active packaging, IP – Intelligent packaging
Source: authors' computation

On the other hand, the younger ones in the age less than 40 years are are more interested in intelligent packaging functions, they are not affected by active packaging and their functions. The functions are indifferent to them, it involves the attributes that are not critical for customers and their pass or fail does not affect their satisfaction or dissatisfaction, Figure 1.

SIMULATION OF INTELLIGENT AND ACTIVE PACKAGING PERCEPTIONS IN SLOVAKIA

Erika Loučanová; Martina Kalamárová; Ján Parobek; Ana Dopico

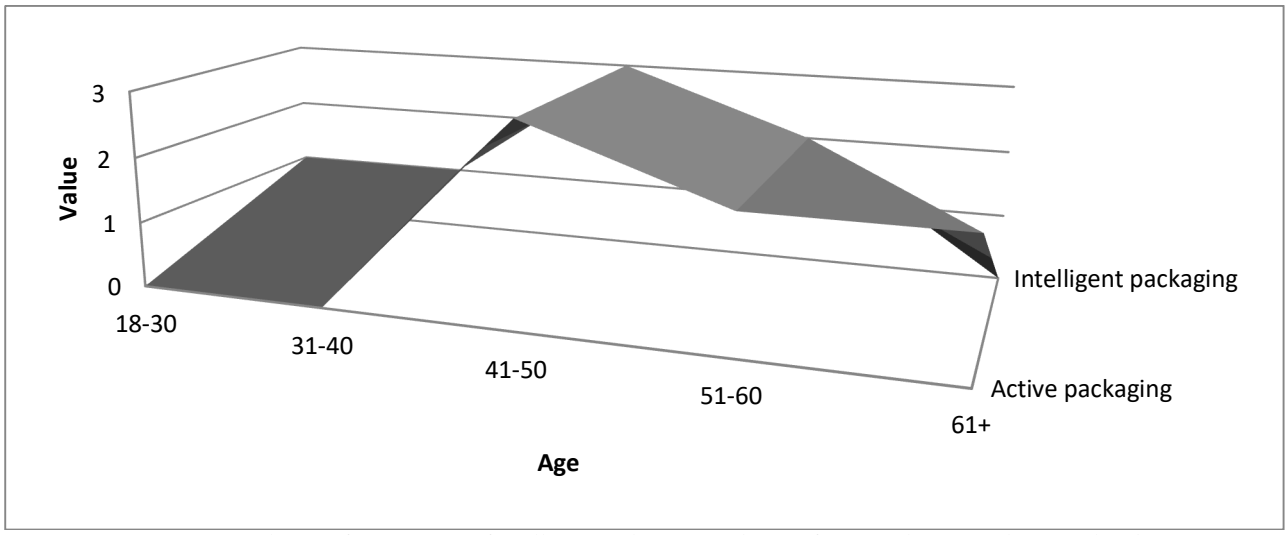

Figure 1 Simulation of perceptions of intelligent and active packaging functions by respondents in Slovakia

The comparison of the value of active and intelligent packaging functions for the customers indicates the differences in target groups of customer affected by these functions. To sum it up, the respondents in younger age are more oriented to the intelligent packaging. The generation of middle-aged is interested in intelligent and also in active packaging equally. And finally, the older age categories rather prefer only active packaging.

From the point of view of the individual functions influence, the most influential are two packaging functions – convenience and containment. The least influential for the respondents is the communication function, Figure 2.

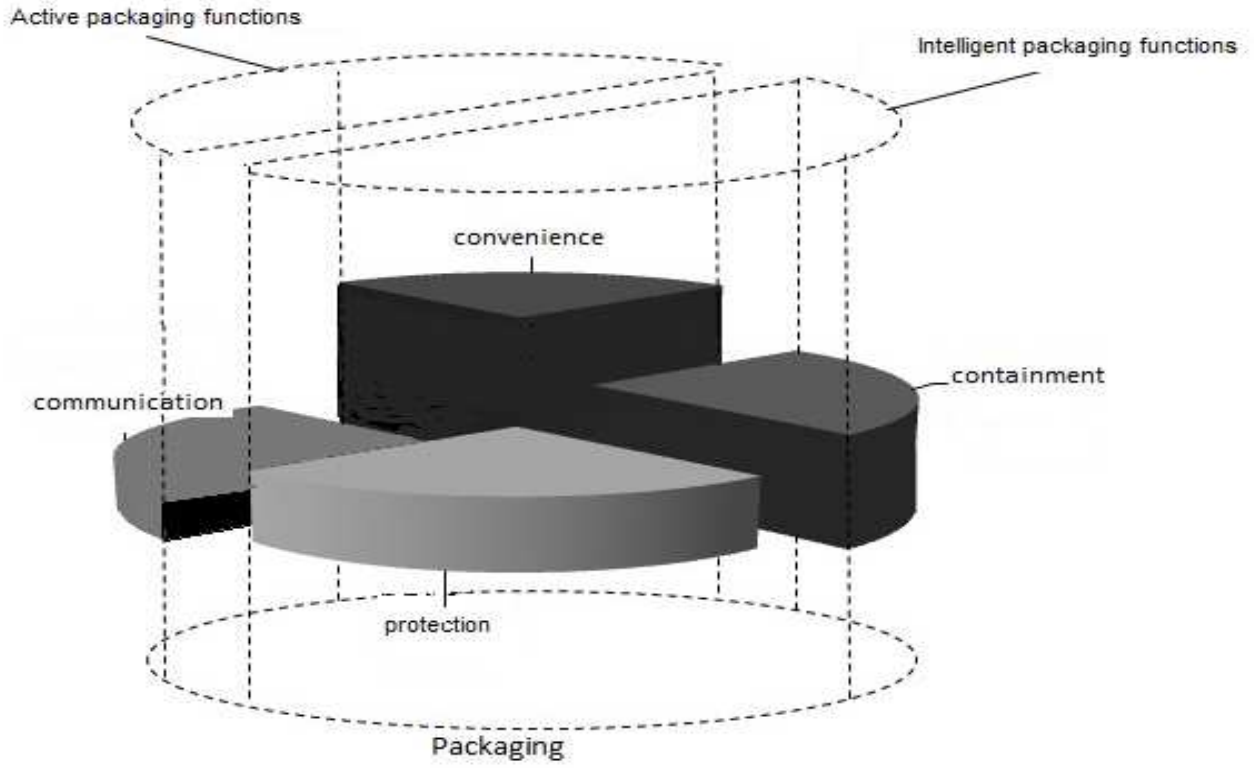

Figure 2 3D Simulation of perceptions of intelligent and active packaging functions by respondents in Slovakia

4 Conclusion

The sheer importance of packaging functions is still growing and consequently, the interest of the company is to access to the packaging more innovative and creative. Active and intelligent packaging influence customer decisions mainly as one-dimensional requirement, i.e. those active packaging attributes that lead to fulfillment and satisfaction and in the event of non-compliance to customers dissatisfaction – the higher the degree of compliance with these requirements, the customers are more satisfied. According to the innovative approaches to the packaging can be concluded that younger respondents are more focused on the intelligent functions of the packaging, as they appreciate the packaging in the role of intelligent communicator. With increasing age of the customers, they are more oriented on active packaging functions, that provides convenience in the carriage, stocking and consuming.

The results and information about the perceptions and preferences of the packaging functions by the customers different age can be subsequently used during communication and innovation of packaging.

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