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Standardization of human activities as the component of a workflow efficiency model – a research experiment from a meat producing plant

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Abstract
The aim of the following research it to provide assumptions for creating workflow efficiency model that can be implemented in repeatable production workstations. One of the main components of this model are human activities and their interactions with other elements of working environment: human and artefacts. Recognition of patterns of human behaviours within working processes gives the opportunity to find critical points that influence workflow efficiency.
The subject of research is a working process existing in meat producing plant. The main method used for recognizing human activity patterns was observation and qualitative and quantitative assessments of operational activities based on video registration. Particularly, human activities were analyzed under ergonomics criteria in order to proof dependencies between process efficiency and specific ergonomic factors forming working conditions at meat plant.

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1. Introduction

Standardization is one of classic concepts in management theory and practice, whose precursor was F. Taylor (1912). This concept seeks to create unified rules for performing activities that will enable high repeatability of the way tasks are conducted, and, thus, greater pace of action and the ability to measure their effectiveness could be achieved. Currently, scientific management, based on process standardization is still used in manufacturing and service companies (Mijal, 2016; Rozinat et al., 2009). For example, it is an essential tool in Lean Manufacturing methodology.

Undoubtedly, standards are the basis for all improvement actions affecting the efficiency of processes in the organization. Bartnicka (2020) in her research on process standardization and workflow in health care industry, identified three areas for improving work processes.

These areas are as follows:

- Technical work area covering the implementation of activities requiring technical skills, e.g. assembly and disassembly of work tools; simultaneous performance of technical activities of work team members.
- Cognitive work area covering the performance of many activities at one time, the need for quick communication in a work team, stressful activities.
- Ergonomic work area covering the performance of forced positions causing fatigue, pain and even the risk of WMSDs (Work-related Musculoskeletal Disorders) (Dias et al., 2020; Candan et al., 2019, Clary et al., 2020).
- The course consists of repetitive patterns of behavior of participants in these processes, in particular developing interaction patterns in an ergonomic system (human-machine).The key factor in implementing work processes, according to proposed concept of creating activities schemes, is recognizing the repeatability of interactions in employee teams, and, more generally, in the plant. The way of representing such activities schemes is a method based on graphic modeling of work processes i.e., workflow. Workflow modeling involves transforming the actual course of a work process to its schematic formula. The transformation process itself must be based on reliable and orderly data, on the basis of which the stages of the procedure are recorded with a given assumed level of details.

Taking this into account, the paper aims to provide research evidence for creating workflow efficiency model that can be implemented in repeatable production workstations. Specifically, this research evidence was verified in production industry based on experimental use of a method for improving working processes that was primarily developed and validated in healthcare industry in surgical processes.

2. Experimentally use of a method for improvement of working processes based on workflow Methodology

The main scientific assumptions of the workflow-based method for working processes improvements are

- embedding the method in a classic knowledge management model,
- embedding the method in empirical sciences,
- building theory based on observational studies.

The following diagram (Fig. 1) was based upon building theory, which takes into account observed phenomena.

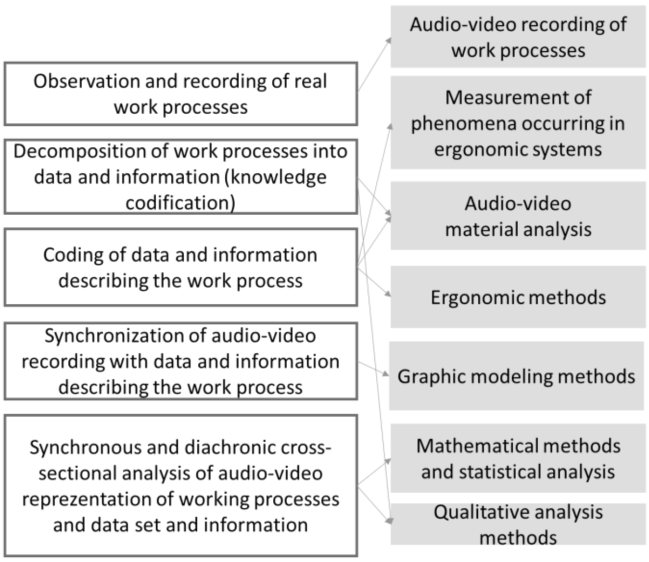

Fig. 1. A research diagram

Particularly, the research diagram represents a methodical basis for modeling workflow which is also treated as a tool for knowledge representation concerning work processes. The diagram consists of two columns. The first column indicates five basic phases characterizing the sequences for inductive reasoning. The purpose of such approach was to define a set of facts describing standardization during process description as well as the determinants of work process improvements. The second column gives recommended tools supporting each phase by collecting and processing data and information.

Dedicated two set of facts were taken for workflow analysis:

- A finite set describing the stages of the process.
- A finite set describing interactions in an ergonomic system.

The research was carried out in one of a meat producing plant located in Silesian region in Poland, which employs the total of 122 employees. The main area of activity is cutting of pork half-carcasses, sale of meat and sausage products. Currently, the plant produces about 150 types of finely divided, medium, coarsely ground, block and smoked products. The company was founded in 1945. In 2005, a new production hall with an area of 4000 m^2 was built, in which the research was carried out.

The research has been conducted since the beginning of 2018. The subject of observation for this particular research case was the production process of medium coarse sausage, in particular, organization of the production process, organization of work stations (including rhythm and pace of work, position at work, work space). In addition, the studies were conducted with the company's employees, and the company documentation was analyzed.

The obtained research material has been collected and thematically ordered in a dedicated database. Particularly, the summary results of this research in the enterprise was an experimental confirmation of the possibility of transferring the method of improving work processes from the area of health care to the area of traditional manufacturing industry.

3. Results and discussion

According to observation, the sequence of works during manual palletization has been recognized and, consequently, divided into characteristic activities. Particular activities analyzed for the purpose of describing specific interactions in an ergonomic system, mainly represented position assessment of the employee during the performance of activities. This representation was coded with help of OWAS method (Karhu et al., 1977).

Works on manual palletizing were following:

- Taking carton from roller conveyor.
- The transition from the carton to the pallet.
- Putting carton on a pallet.
  - First layer (extreme size).
  - Middle layer.
  - Last layer (extreme size).
- Return to conveyor.

The Fig. 2 reflects spatial layout of tested workplace.

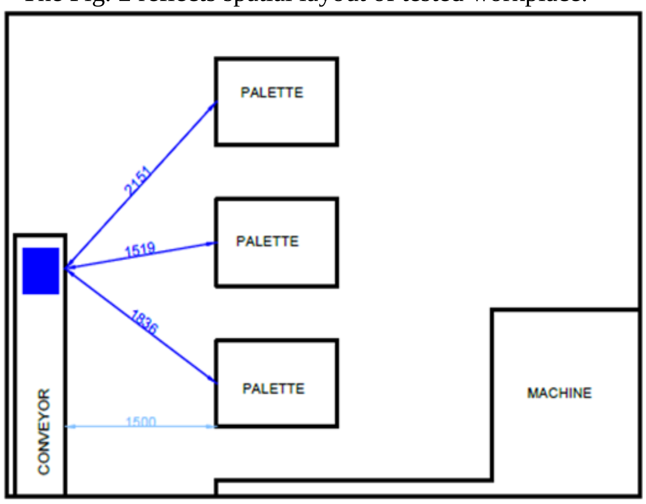

Fig. 2. Spatial layout of tested workplace

The weight of cartons is different and estimated from 11 kg to 18 kg. Certain palette corresponds to the specific weight of cartons however the location of palette with cartons with the same weight is random.

The essence of the research is the integration of all the data and information, including video recording in the timeline, creating graphical and quantitative model of workflow (Fig. 3).

The workflow model is consequently used to perform cross-sectional synchronous and diachronic analysis simultaneously in both areas effectiveness and ergonomics. According to statistical and qualitative analysis gained from the data embedded into workflow model, essential information is proceeding. Table 1 presents average times of performing tasks at the workplace during the work shift and the result of the OWAS analysis.

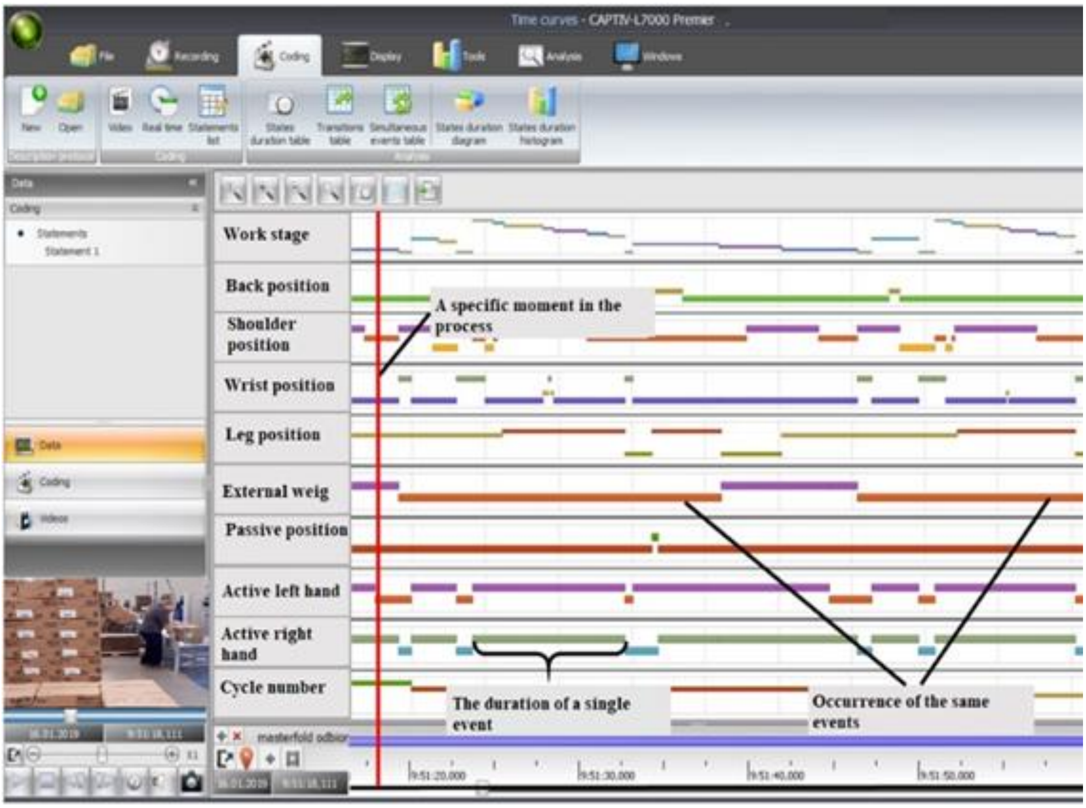

Fig. 3. Cross-sectional analysis based on observation methods

Table 1. Repetitive activities and ergonomic assessment during manual palletization

Actions	Time [s]	OWAS code	Category	Load
Palette 1				
Cycle 1 - First layer				
Taking carton from roller conveyor	03:54	4152	4	medium
The transition from the carton to the pallet	04:07	2172	3	medium
Putting carton on a pallet	03:17	4342	4	medium
Return to conveyor	03:14	2171	2	small
Cycle time	**14:32**			
Cycle 2 - Middle layer				
Taking carton from roller conveyor	03:54	4152	4	medium
The transition from the carton to the pallet	04:07	2172	3	medium
Putting carton on a pallet	02:40	4152	4	medium
Return to conveyor	03:14	2171	2	small
Cycle time	**13:55**			
Cycle 3 - Last layer				
Taking carton from roller conveyor	03:54	4152	4	medium
The transition from the carton to the pallet	04:07	2172	3	medium
Putting carton on a pallet	03:00	3332	3	medium
Return to conveyor	03:14	2171	2	small
Cycle time	**14:15**			
Palette 2				
Cycle 4 - First layer				
Taking carton from roller conveyor	03:54	4152	4	medium
The transition from the carton to the pallet	02:42	2172	3	medium
Putting carton on a pallet	03:17	4342	4	medium
Return to conveyor	01:40	2171	2	small
Cycle time	**11:33**			
Palette 3				
Cycle 5 - First layer				
Taking carton from roller conveyor	03:54	4152	4	medium
The transition from the carton to the pallet	02:00	2172	3	medium
Putting carton on a pallet	03:17	4342	4	medium
Return to conveyor	01:30	2171	2	small
Cycle time	**10:41**			

The OWAS method classifies body postures during the work, assigning each of them a four-digit code (column 3). The method takes into account the overload derived from four factors: back position, forearm position, leg work, external load amount. After determining the code of the selected body position, the load category is recognized (column 4) and then the interpretation of the overload of the musculoskeletal system is indicated (column 5).

In case of the analyzed workplace, 5 types of repetitive body postures (OWAS codes) were identified, which mostly belong to the average overload on the musculoskeletal system (Fig. 4).

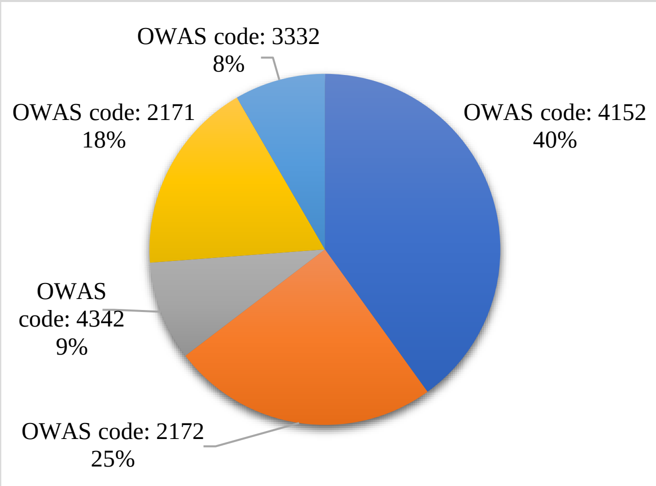

Fig. 4. Percentage data with OWAS codes

The duration of individual tasks is influenced by (1) the distance between the pallet and the roller conveyor, (2) the height of placing the carton on the pallet - layer (3) of the working method - the method of removing carton from the conveyor and the method of putting the carton on the pallet. The analysis was carried out for activities performed by one employee performing the work repeatedly, in the same way, hence, the working methods were omitted in further studies. It takes the longest to place the carton on the lowest layer (layer 1), and slightly less time it takes to place the pallet on the highest layer (layer 5). It is worth emphasizing that the employee's body position is unnatural while performing these tasks, which may be the cause of WMSD in the long-term maintenance of this way of performing the activities. This is reflected in division on two risk assessment categories (Fig. 5).

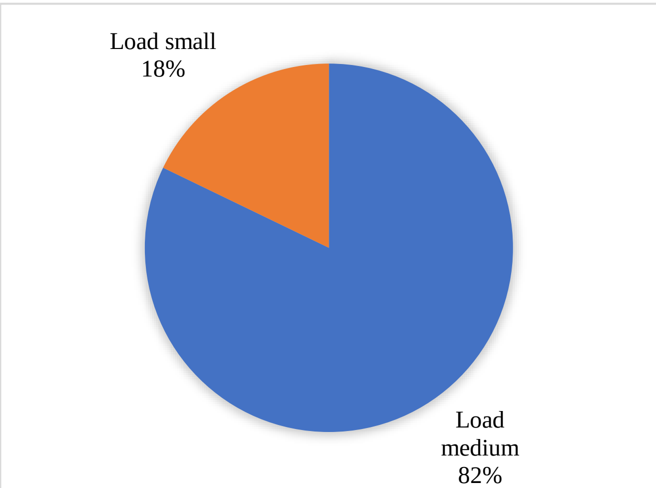

Fig. 5. Risk assessment of musculoskeletal overload

Finally, it was possible to identify a set of activities patterns described by workflow parameters and to look for standardization of the process in a way of improving the specific components of working processes. In this case the exemplary standardization elements are simple but effective:

- Standardization of spatial layout of working place. The location of palette with cartons is changed from random location to predefined location: the palettes with the heaviest cartons are located closest to the conveyor.
- The layout with palette is not in line but in the shape of an arch which shorts the way a worker moving with cartons (see Fig. 6).
- Standardizations of cartons' construction. The cartons are changed from construction with no grips to construction with special grips.
- Standardizations of working methods from non-ergonomic to ergonomic.

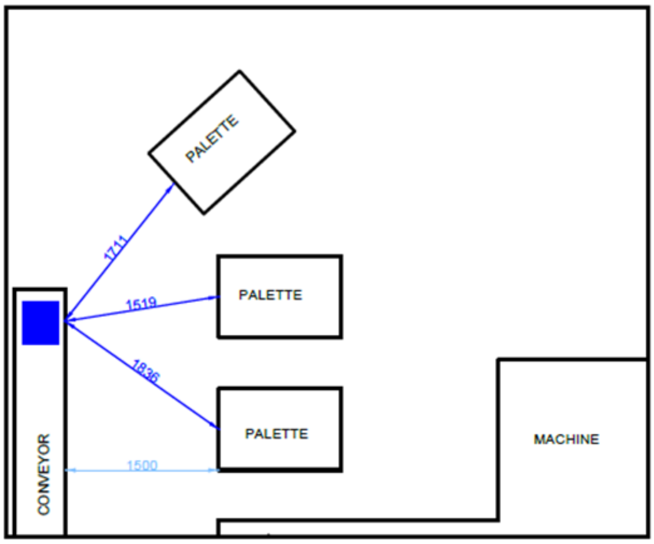

Fig. 6. New layout of workplace

4. Conclusion

Two different workflow parameters are improved that are integrated and dependent: effectiveness denoting a time of performing task and ergonomics denoting the musculoskeletal system comfort. The research showed that improving ergonomic factors leads not only to health and wellbeing factors of workers but to shorten time spent on lifting and carrying cartons. It is estimated, according to simulation of new working standards, that the working time after changing workplace layout and working methods is 10 percent less than before what means c.a. 42 minutes.

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标准化人类活动作为工作流效率模型的组成部分 – 来自肉类生产厂的一项研究实验

關鍵詞
工作流程
标准化
人机工程学
活动方式
效率

摘要
以下研究的目的是为创建可在可重复生产工作站中实现的工作流效率模型提供假设。该模型的主要组成部分之一是人类活动及其与工作环境其他元素（人类和人工制品）的相互作用。对工作流程中人类行为模式的认识为寻找影响工作流程效率的关键点提供了机会。研究的主题是肉类生产工厂中存在的工作过程。识别人类活动模式的主要方法是基于视频注册的观察以及对活动的定性和定量评估。特别是，人类活动是根据人体工程学标准进行分析的，以证明过程效率与形成肉类工厂工作条件的特定人体工程学因素之间的相关性。