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DESIGNING ERGONOMICS WORKSTATIONS ON THE BASIS OF 3D SCANNING

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PROJEKTOWANIE ERGONOMICZNYCH STANOWISK PRACY W OPARCIU O SKANOWANIE 3D

ABSTRACT
The article presents a project of production system visualization and analysis of work ergonomics. A production hall was scanned using a 3D scanner and on the basis of a point cloud, a model of the premises was built. Further steps involved preparing models of assembly workstations and suggesting a few variants of their layout in the hall. The 3D models of assembly workstations were also used to carry out an analysis of work ergonomics on designed assembly lines.

KEY WORDS: *ergonomics, 3D scanning, modelling*

RESEARCH TYPE: *research paper*

JEL classification:
I12: Health Production
L15: Information and Product Quality; Standardization and Compatibility
Q01 - Sustainable Development
O31: Innovation and Invention: Processes and Incentives
Q56 - Environment and Development; Environment and Trade; Sustainability; Environmental Accounts and Accounting; Environmental Equity; Population Growth

STRESZCZENIE
W artykule przedstawiono projekt wizualizacji systemu produkcyjnegooraz analizy ergonomii pracy. Przeprowadzono skanowanie hali produkcyjnej skanerem 3D i na podstawie chmury punktów zbudowano model tego obiektu. W dalszej kolejności przygotowano modele stanowisk montażowych i zaproponowano kilka wariantów ich rozłożenia na hali produkcyjnej. Modele 3D stanowisk montażowych wykorzystano również do przeprowadzenia analizy ergonomii pracy na projektowanych liniach montażowych.

SŁOWA KLUCZOWE: *ergonomia, skanowanie 3D, modelowanie*

1. Introduction

When designing and analyzing production systems, it is necessary to undertake many design decisions. A large number of possible variants of solutions and their complexity usually make it impossible to choose the optimal solution by means of classical tools of systems analysis. An effective tool aiding decision making on different stages of company management is nowadays the modelling and simulation method.

On the basis of a real, existing or designed system a computer model of the research object is created, on which simulation experiments are conducted. Thanks to preparing computer models of different variants of the process and simulating their operations, it is possible to compare them and choose the most optimal way of manufacturing from the point of view of the previously assumed criteria [1].

Statistics shows that processes of product design and production planning have a significant influence on the costs borne during production. Thanks to production systems visualization, it is possible to make a range of savings related to the following areas: [2]:

- 30% of cost saving due to better use of resources,
- Savings on the level of 35% resulting from materials flow optimization,
- Overall cost reduction of about 13%.

2. 3D scanning

3D scanners make is possible to gather three-dimensional data in a very efficient way. They allow to eliminate the traditional ways of data acquisition by means of telemeters, measuring tapes or photo cameras. In relatively short time, dependent on the required resolution, which determine the accuracy of the performed measurements, they create a precise, three-dimensional model of the scanned object.

Scanning products a point cloud, which is a collection of millions of points creating a three-dimensional model of the scanned area (Fig. 1).The point cloud is an exact representation of the scanned object in real size, which can provide different kind of data, like dimensions, cross-sections, plans or information about collision with newly designed object.

Cloud points of the scanned object serve to create accurate and realistic 3D models which are usually used for object documentation and its visualization. Within one second, a laser scanner may gather information about several hundred thousand measurement points.

One of the simplest visualization methods used in production engineering consists in reading actual object dimensions from a point cloud, and, on the basis of the dimensions, drawing an object using computer aided design software. On the basis of the read dimensions, parametrical models are created of significant objects which constitute the modelled workstation [2, 6].

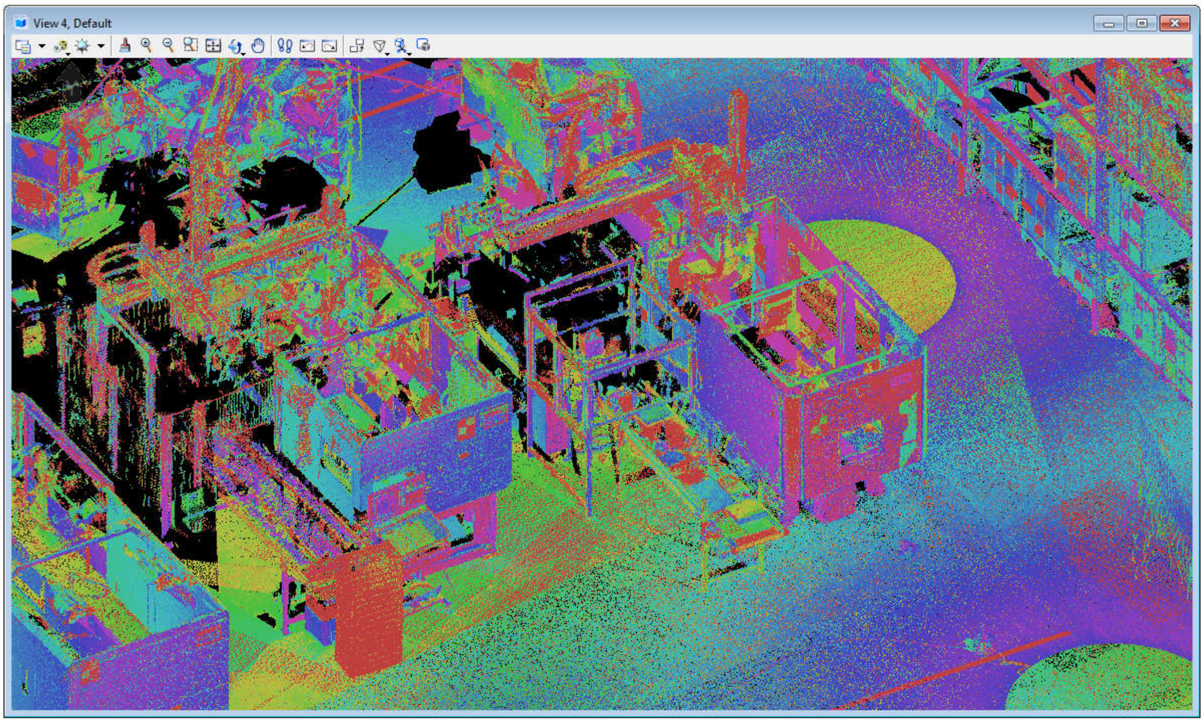

Fig. 1. 3D Scanning - point cloud [3]

Nowadays, there is a whole range of devices for carrying out contactless measurements using laser beams, differentiated with respect to the size of the scanned object and accuracy of the preformed measurement.

There are many possible methods of classifying 3D scanners, however,basically it is possible to distinguish 2 groups (fig. 2):

- Contact scanners,
- Non-contact scanners.

In case of measurements performed by means of the contact method, direct contact of the measuring head with the measured object allows to obtain contact point coordinates. The second group are non contact scanners, which take measurements without touching the measured object with a measuring device. Scanners included in this group are laser scanners and scanners using structural light.

The group also includes medical devices: magnetic resonance imaging and computer tomography. The main advantage of is type of devices is their non-invasiveness, thanks to which it is possible to measure objects without contacting their surface.

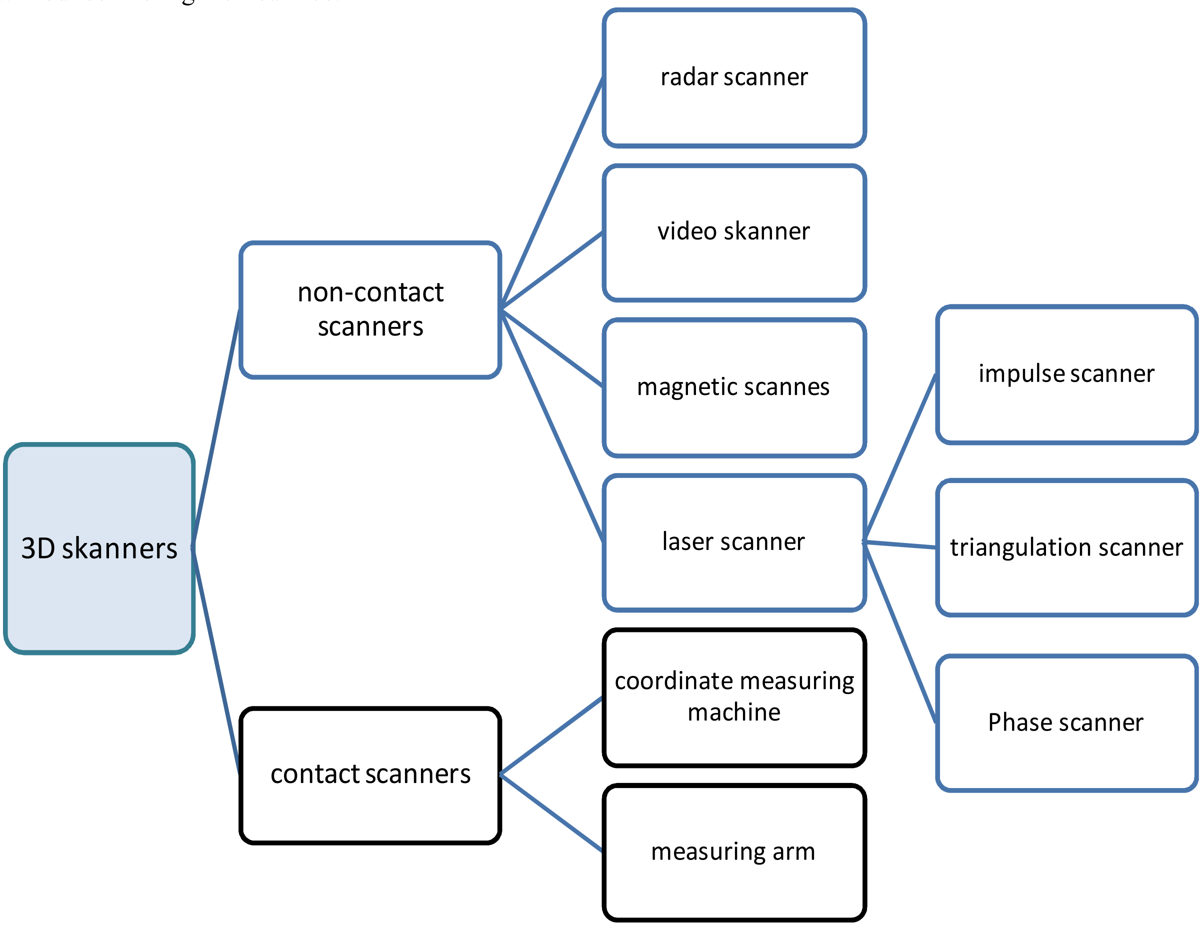

Fig. 2. Types of scanners

3. Presentation of research results

The research aim was to improve an assembly line for automotive industry needs basing on the already existing and functioning production hall with machines and devices. The concept of research realization was presented in Fig. 3.

The first stage of the project consists in preparing the assembly hall to the scanning process. The activities include creating the plan of scanning and placing target plates and reference spheres in the hall. An important aspect is also to make sure that all scanned machines are idle, as each move causes decreased accuracy and lower scan legibility. Before scanning begins, it is necessary to set the measurement parameters. The key factor directly influencing the time of scanning is resolution. It determines the number of points obtained as a result of scanning, so also the accuracy and the detail of the acquired data.The chosen resolution is a compromise between scanning time and the accuracy of the obtained point clouds. High resolution allows to get accurate data, but makes the Canning processes much longer. In case of using FARO LS 880 scanner, scanning time with lowest resolution amounts to 2 minutes, whereas in highest resolution it is almost 2 hours. Therefore, it is advisable to set possibly lowest resolution, which will allow to obtain data accurate enough to create a proper model.

The next step of the project involves scanning the hall using a phase scanner FARO LS 880in particular locations according to the assumed plan. Next, the data obtained as a result of scanning is processed. Activities on this stage include clearing individual scans of noise and connecting them into one piece. The next stage of the project consists in creating a three-dimensional model of the production hall on the basis of the obtained point cloudby means of Bentley Descartes software.

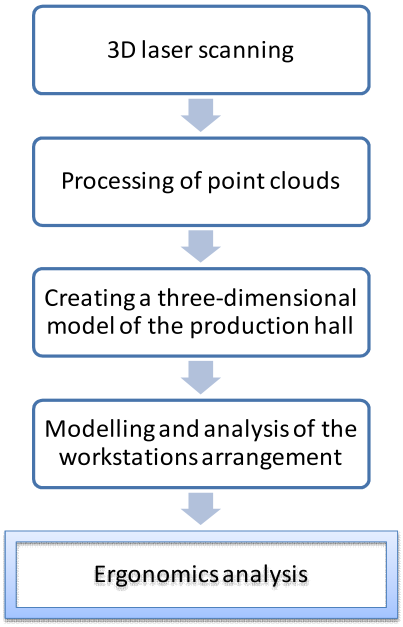

Fig. 3. A concept of project realization

First of all, construction of the production hall was made (Fig.4), which was later complemented with permanent fixtures. In case of walls, horizontal projection was usedfor contour of the walls, and vertical one – for drawing them to the proper height.

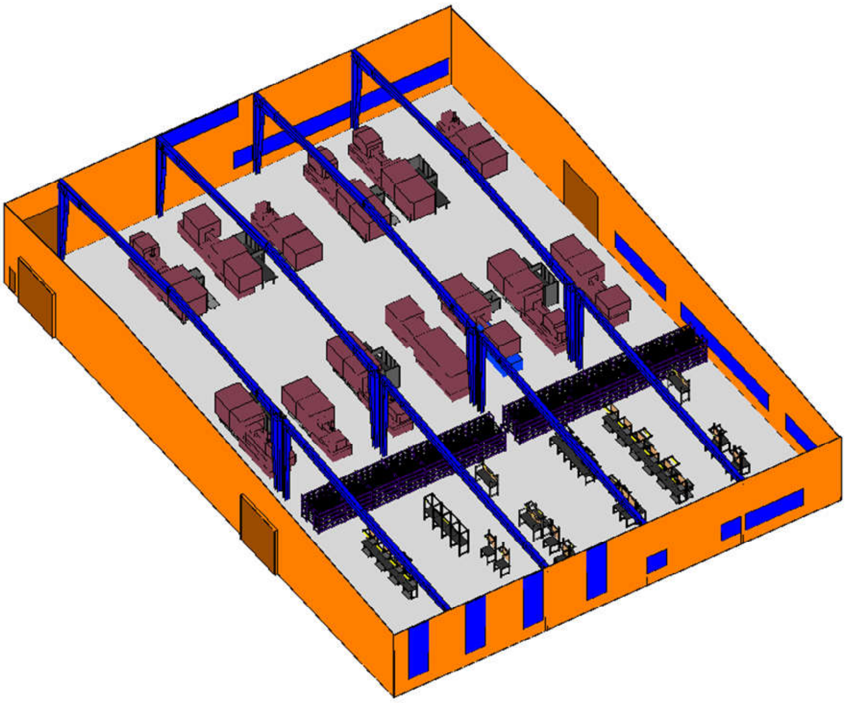

Fig. 4.Preparation of a 3Dproduction hall modelon the basis of a point cloud [3]

The second stage of modelling involved the equipment of the production hall, like assembly workstation and racks (Fig. 5). Some elements were made identically as the hall model, but much more often it was necessary to perform additional operations on the solids. Despite efforts, during scanning some dead areas appeared in the point cloud, that is places not reached by the laser beams emitted by the scanner. In such situations, objects repeatedly present in the model were copied and properly oriented. The workstation were placed in different systems forming assembly lines. The models also included space for containers and marked transport routes and directions of material flow.

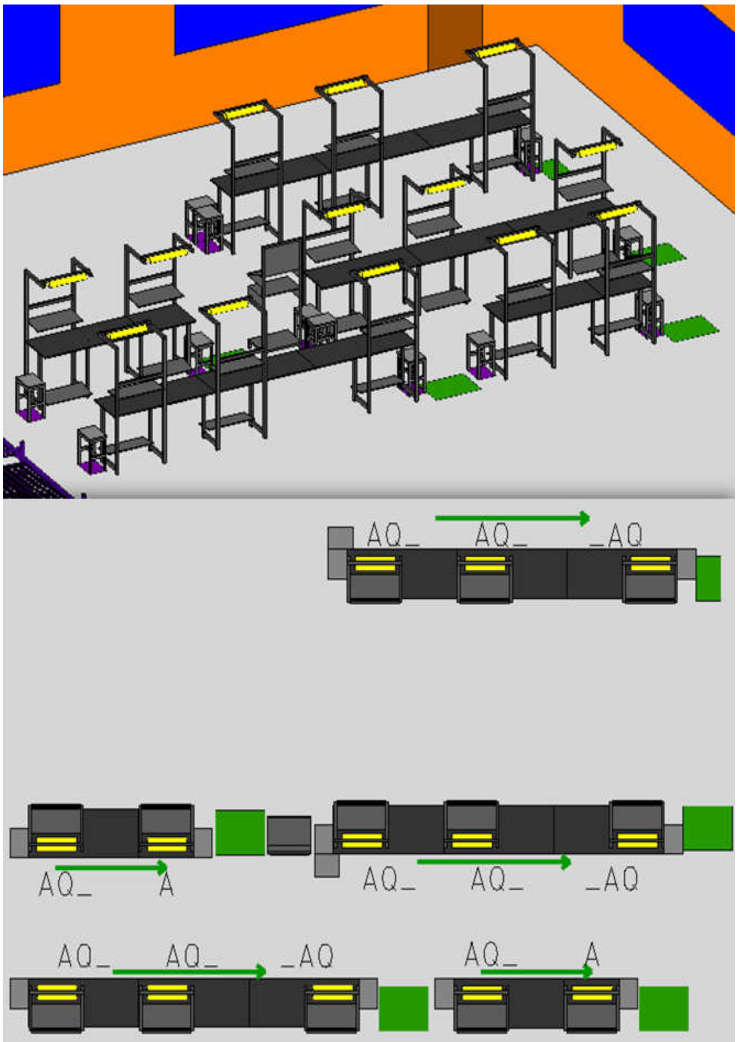

Fig. 5.Designing assembly modules [3]

The next step involved carrying out ergonomic analysis of the chosen assembly workstation. Three variants were proposed to increase the comfort of work of the assembly workstation. (Fig. 6).Work ergonomics analysis on the line was performed on the basis of the ergonomic positions table. Each position was evaluated with points referring to the 3-zone scale [4,5]:

- First zone - 1 point:the position of work is ergonomic,
- Second zone - 2 points:correction of the workstation is advisable, it should be monitored with respect to ergonomics,
- Third zone - 3 points: changes are necessary of the workstation.

The conducted analysis allowed to find the activities which belong to the red and yellow zones, which constituted the basis for introducing changes aimed at the elimination of non-ergonomic activities.

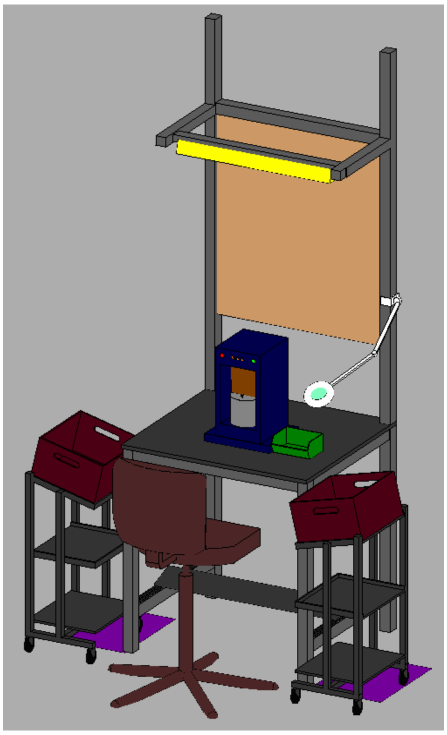

Fig. 6. Designing ergonomic workstations - variant 3 [3]

Among others, the industrial support was replaced with a chair with adjustable height, a adjustable footrest was introduced,the shape and size of containers were changed, as well as the height of the racks. Also, a magnifier facilitating the assembly operation was included.

The results of the point evaluation related to work ergonomics on the workstationwas presented in a table and charts(Fig. 7).It turned out that the best solution from the point of view of ergonomics was variant number 3.

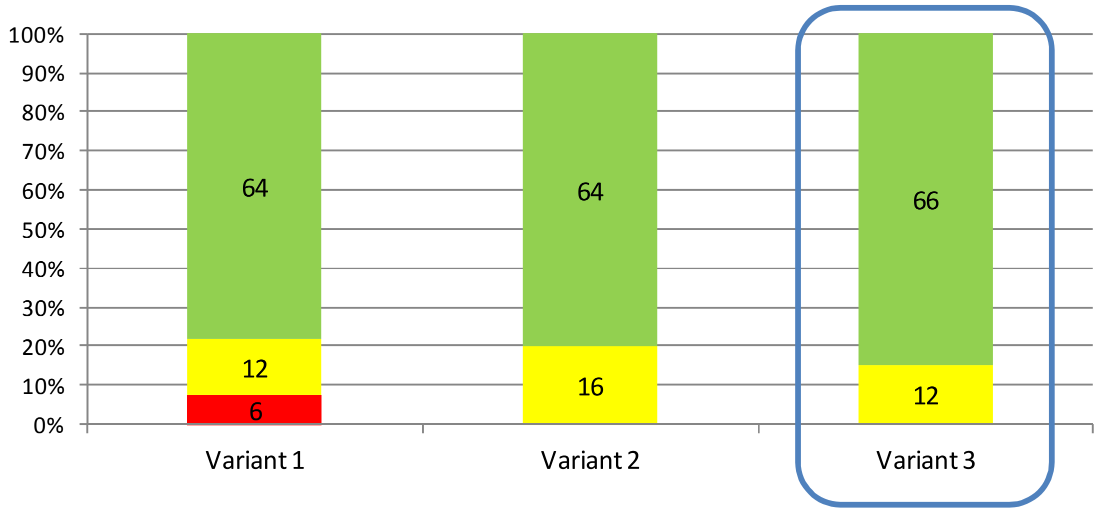

Fig. 7. Evaluationof ergonomics on an assembly workstation

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Summary

Production systems visualization often takes place by means of laser scanners, which ensure a fast, easy and precise method of capturing millionsof data points in 3D space.A 3D model created basing on a point cloud allows to verify the set project assumption before their practical application, to find potential inaccuracies during exploitation and to identify weak points of a designed or already functioning production system.

Application of 3D scanning made it possible to collect accurate data about geometrical dimensions of a production hall in relatively short time. They allowed to create a three-dimensional model of the research object, which was used in further stages of design works and analyses related to optimisation of assembly workstations layout.

Three-dimensional models of workstations also helped to design ergonomic and safe workplaces. Ergonomics evaluation allowed to find uncomfortable operations performed on a workstation and to introduce changes which limit the number of operations to be corrected.

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