MANUAL ASSEMBLY WORKSTATION DESIGN SUPPORTED BY ERGONOMICS SOFTWARE TOOLS

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Abstract: Manual assembly workplaces need to be designed to take into account ergonomic requirements resulting from the physical and psychological characteristics of human. In an effort to propose workplaces that meet these requirements are very helpful software tools that allow you to insert into CAD model of workstation Manikin and perform directly at the design stage an ergonomic analysis. Article describes the design of manual workstation and using some software ergonomics analysis tools.

Keywords: ergonomics, manual assembly, assembly workstation, CATIA

1. INTRODUCTION

Workstations, where the workers play a decisive role, whether the role of the management, supervision or performance have in manufacturing practices their unique place. In all these cases it is necessary to have a workplace designed so, that during the design was take into account ergonomic requirements of human activities. Failure to take into account of these requirements can lead to rapid fatigue of personnel and, consequently, to a decrease in productivity, errors and even accidents. The current status in the development of computer technology allows during workstation design use different software tools that, when are used correctly, it possible to achieve such a workplace proposal, that reflects the ergonomic aspects.

2. IMPORTANCE OF THE ERGONOMICS IN THE WORKPLACE DESIGN

As mentioned, ergonomically designed workstation is essential for the production process. Ergonomics as a discipline is focused on the relationship between human and the working environment and working means integrates knowledge from various disciplines such as: anthropology, statistics, occupational hygiene, work organization, psychology, etc. This makes it a complex scientific discipline and it is difficult in terms of its application. When designing the new workstation there are increased demands on designers. Because not every designer is an expert in ergonomics, there was looked for ways, how to provide to designers an ergonomics research results. These results should be provided by such way, that they can be in a relatively simple form applied to solve workstation design. Some of these instruments were somatography templates and various tables with the recommended dimensions of the work tables, chairs and mutual distances of objects in the workplace and so on. With the gradual development of computer technology these tools were converted to a software form, either as a separate tools for specific ergonomic tasks, or as a comprehensive solutions. Since designers during development are using CAD systems, some manufacturers of CAD systems integrated ergonomic software tools into environment of developed CAD respectively PLM systems. These systems are different in number and type of tools for ergonomic analysis and possibility of correction of the proposed workstations. The basic element of these tools is the digital model of human.

3. DIGITAL MODEL OF HUMAN

Since 1960, when it was first human digital model developed were gradually developed a numbers of models of human. At present, we have routinely met with a 3D model of human also called as Manikin. Some models are only for illustrative purposes and it is not possible to do analysis with them, but some models are very sophisticated in detail, and offer a detailed handling with Manikin and ergonomic analysis. In Fig.1 shown are examples of 3D human models for various applications used in workstations 3D design. There are:

- Digital human model supplied by Autodesk in the design package called Autodesk Factory Design Suite. This model does not allow for positioning and ergonomic analysis, because these features are not supported in that software.
- V5 Human and V6 Human are human models used in the products of Dassault Systemes, such as CATIA and DELMIA. These models allow you to choose the
gender and change the physical dimensions, place the model in any position as well as create motion animation model and perform a variety of ergonomic analysis.

- PTC Creo Elements / Pro Manikin Extension - 3D human model used in applications Creo (formerly known as Pro/Engineer). Allows gender selection, adjust body size, detailed model positioning and creating of animations. Along with supplement PTC Creo Elements/Pro Manikin Analysis Extension enables the implementation of ergonomic analyzes.
- Tecnomatix Jack human model from Siemens is used in application Tecnomatix intended for design of digital production. It enables to choose the gender, change the physical dimensions and also the detailed positioning, model animation and detailed ergonomic analysis.
- Digital human model RAMSIS is model of the firm Human Solutions Group. This model is primarily focused on the ergonomic design of interior transport equipment (cars, trucks, buses, planes and helicopters as well as industrial vehicles - excavators, cranes, loaders, etc.). It allows you to change the dimensions of the model, positioning of the model in detail and to perform detailed ergonomic analysis.

In addition to these software, there is also a range of others that are focused on ergonomic tasks. Some of them are standalone software applications and others are a supplement of CAD systems. Whereas for solving the tasks described in the article were used ergonomic modules of CATIA in the next section just paid attention to CATIA ergonomics modules.

4. CATIA ERGONOMIC MODULES

In the CATIA are integrated four modules for ergonomic analyzes. There are: Human Activity Analysis, Human Builder, Human Measurements Editor and Human Posture Analysis. This modules allow you to create a 3D model of any human figure and make a various types of ergonomic analyzes, such as: RULA (Rapid Upper Limb Assessment), NIOSH (National Institute for Occupational Safety and Health), push-pull, Carry and Biomechanics analysis Single Action. Human Builder module allows you to quickly create a model based on the of gender and population percentile. There are data for American, Canadian, French, Japanese, Korean, German and Chinese (Taiwan) population. Human Measurements Editor module allows editing model dimensions according to the individual requirements, making it possible to create a model of any human. Human Posture Analysis modules quantitatively and qualitatively analyze all aspects of manikin posture. Human Activity Analysis module evaluates all elements of human performance from static posture analysis to complex task activities.

Mentioned modules where used to optimisation of assembly workstation.

5. MANUAL ASSEMBLY WORKSTATION

For the purpose of brake cylinder assembly was designed a manual assembly workstation. Brake cylinder is used in passenger as well as commercial vehicles equipped with drum brakes. It is a component which serves to hydraulically mashing brake shoes which provide braking of the wheel by friction on the brake drum, and consequently enables the car to stop. The effect is achieved by expansion of the hydraulic component - the brake cylinder which is fixed to the shield and located between the two braking jaws. Brake cylinder performs translational movement due to fluid pressure. Based on analysis of the brake cylinder 3D model which has been developed in CATIA (Fig. 2) was elaborated detailed technological process of assembly [5].

![Fig. 1. Human digital models (image source: V6 Human [1], Creo Manikin [2], Tecnomatix Jack [3], Ramsis [4])](image)

![Fig. 2. 3D model of brake cylinder [1]](image)
Subsequently, was in CATIA designed workstation for manual assembly. For workstation design were used standard modules of leading manufacturers of small modular assembly station (Fig. 3).

Fig. 3. 3D model of workstation [1]

For so designed workstation were sequentially carried out some ergonomic analysis.

6. MANUAL ASSEMBLY WORKSTATION ERGONOMICS ANALYSIS

The first task was by help of Human Builder modules and Human Measurement Editor to define a model of human. On this basis were performed pull-push, carry, lift/lower and RULA analysis.

6.1. Push/Pull analysis

The worker pushes or pulls rack on wheels in which are located 3 shelves. On the shelves there are placed either full containers of components, or empty containers returning from the assembly workstation. The worker so carry on the supply to assembly workstation. Worker brings the parts from the intermediate storage which is located approximately 10.5 meters from the assembly workstation. That operation is carried out once every two hours. As shown in Fig. 4 at the given parameters is the maximum allowable initial power of pushing 395.667 N and continuous power 259.007 N. The forces for pulling are slightly smaller. These forces are not identical to the load weight. This represents at the maximum load 59.46 kg.

Fig. 4. Push/Pull analysis

6.2. Lift/Lower analysis

In this analysis it is determined the limit weight that the worker is able without difficulty to lift (or run down) during working time. In our case the worker lifts up the pallet with full containers. The total weight of the load is 5.4 kg.

It is possible to choose between three methods of evaluation: NIOSH 1981, NIOSH 1991 and Snook and Ciriello. For the actual analysis was used NIOSH 1991. For the analysis, it is necessary to define the so-called initial and final position of load lifting and lowering (see Fig. 5). The result of performed analysis is that the operation is in order, because the maximum recommended weight limit is 14.4 kg (Fig. 6).

Fig. 5. Lift/Lower analysis

Another case when this analysis was applied was the pallet insertion into the rack. There was selected extreme case when it is necessary to insert the pallet to the highest place in the rack. In this case, the result - the recommended load in the top position is 0 kg. It follows that this operation is absolutely improper. This result was achieved also by the RULA analysis (see. Section 6.4).
6.3. Carry analysis

Building on operation mentioned in previous chapter, when the worker lifts up a pallet with assembled components was performed the carry analysis. The worker carries finished components to the rack (Fig. 8). The load weight remains 5.4 kg. The maximum distance that has to go is 3300 mm. The maximum acceptable force applied to the worker and his hand is 297.111 N. Because the actual workload of the worker is about 540 N is the operation right.

6.4. RULA analysis

As was mentioned by impose the pallet with assembled components into the rack, it was found unacceptable load. This operation was also analyzed by RULA analysis. The worker was arranged to the positions required for impose pallets in top placement of the rack (Fig. 9). Subsequently was started the RULA analysis as well as for right and left side of the body worker. The result for the left side is shown in Fig. 10. As can be seen, the resulting score is 7. This score means the worst-case. That load is totally unacceptable. For the right side of the worker body is the score the same. It follows that it is necessary to make changes of the workplace. One option is to modify the rack, it must be lower. The second option is to place stairs before the rack, which enable the worker to impose the pallet so way that he does not raise the hands so high, as it was in the original design of the workplace.

7. CONCLUSION

On model of workstation were carried out further analyzes, but because of the scope of article could not be mentioned. The application of these analyzes proved to be very beneficial in the design of workstation, because help eliminate problems even before the build up of the workplace. This procedure will allow improving the working conditions and thus increasing productivity, quality and costs reducing.

8. REFERENCES


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