DESIGN OF MANUAL ASSEMBLY WORSTATIONS IN CATIA

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Abstract

The paper describes procedure for design manual assembly workstation in CAD environment to achieve such design of workstation, which will create good conditions for productivity and high quality of human work. This is reason why is necessary to take in account ergonomics aspects of workspace. In described procedure are used CATIA ergonomics modules for analysis of designed solutions and optimize layout of manual workstations.

Key words

manual assembly, workstation, ergonomics, CATIA

Introduction

All manual assembly workstations should be designed with taking in account the worker who will work there. Take no notice of the human and his demands can lead to less productivity and quality as well as to the health problems. This is the reason why is necessary to apply ergonomic demands to manual workstation design. In nowadays when usually CAD systems are used to design whole production system is possible use them to design and optimize manual workstation also from ergonomics aspects. Producers of CAD systems integrate to theirs systems modules for ergonomics analysis e.g. PTC – in Pro/Engineer, Siemens – in NX (Jack and Jill), Dassault systemes – CATIA. Except above mentioned producers exists others, which produce specialized ergonomics software only and some these software is possible to integrate to some existing CAD systems, but some works as a standalone software products. In practice are usually used different CAD systems so it is very suitable to have possibility to interchange CAD models and data among them to import all models to one environment where is possible to realize ergonomics analysis.

Manual assembly workstation design

Design of the manual assembly workstation very simplified said begins with assembled product analysis and creation of the assembly operation sequence. After assembly devices and tool selection and/or proposal is possible to create an assembly workstation. In the manual assembly must be taken into the consideration also ergonomics aspects. All this steps are usually realized with 3D CAD system support and using. We can say, that we "skip" from the 3D model of the assembled product to the 3D model of the assembly workstation. For this purposes can be used several CAD system. One of them is CATIA – product of Dassault Systemes Group, which provides also some other tools for assembly workstation planning and analysis. Good solution is using of the same CAD system for product as well as for workstation design (see figure 1.).

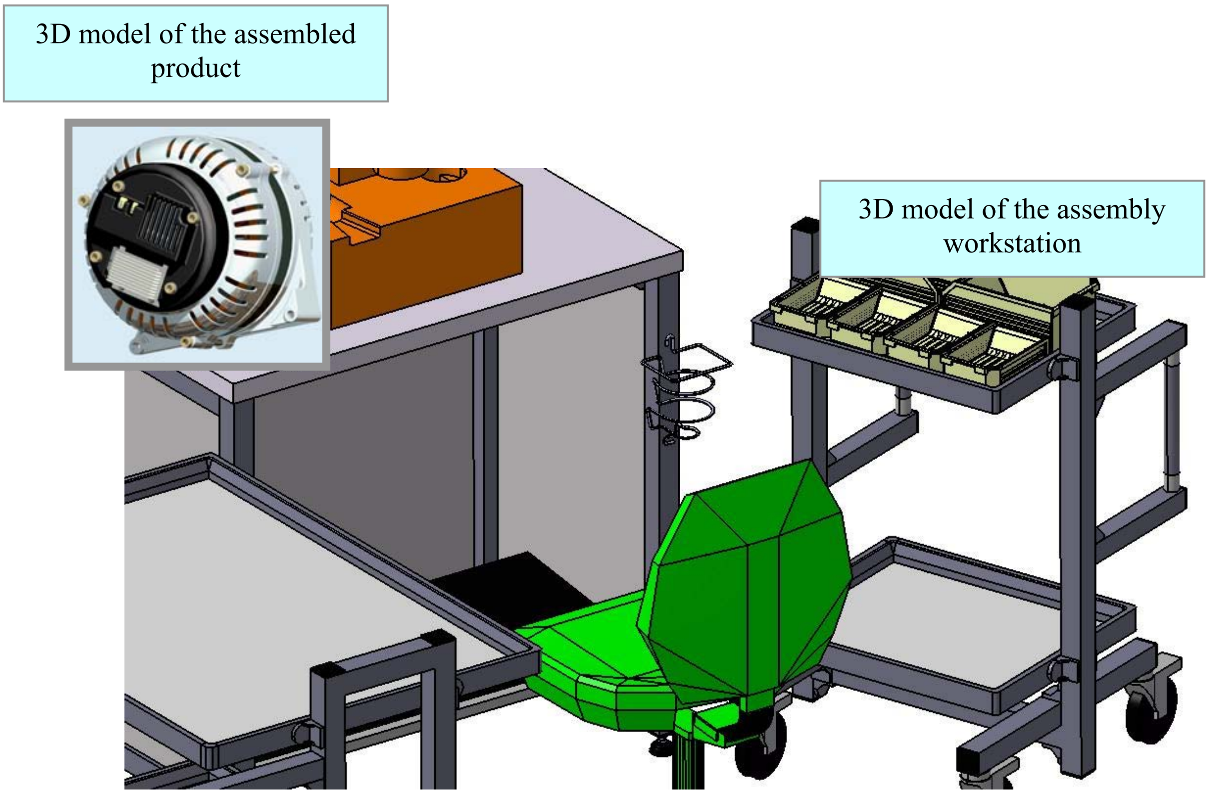


Fig. 1. *3D model of the assembled product and manual workstation created in the CATIA*

3D models of the assembly devices

For assembly workstation design is important to have 3D models of equipments and devices, because many of them are purchased from the other producers. While the main field of database using is product propose and design (normalized parts, etc.), also by design of production and assembly stations are this databases useful. Today exist a lot of databases, which contain so normalized parts as other products. Some of 3Dmodels are free accessible or free accessible after registration. These models are obtained in several usual formats or in universal data formats as DXF, Step, SAT, IGES. So obtained 3D model can be direct used by workstation design. In the table 1 are listed selected databases of production devices, equipments and parts. The main sources of 3D models for manual assembly workstation design illustrate the figure 2.

SELECTED DATABASES OF PRODUCTION DEVICES, EQUIPMENTS AND PARTS CAD MODELS

Table 1

Database	WWW side
Traceparts	http://www.traceparts.com
CADRegister	http://cad.thomasnet.com/
Partserver	http://www.partserver.com
CADsymbols	http://www.cadsymbols.com
3D ContentCentral	http://www.3dcontentcentral.com/3DContentCentral
Machine Design CAD models	http://machinedesign.partcommunity.com/PARTcommunity/Portal/machine_design

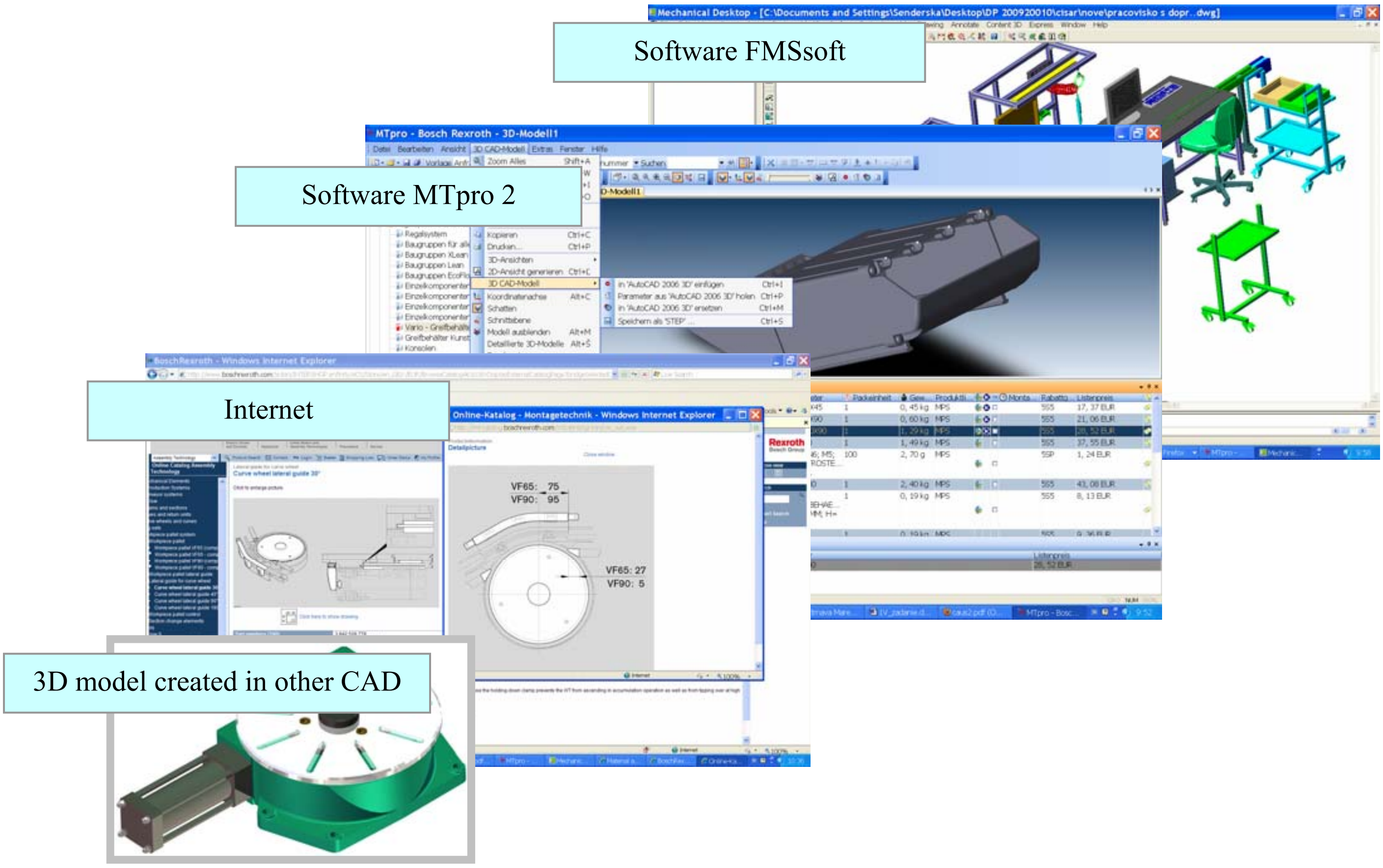
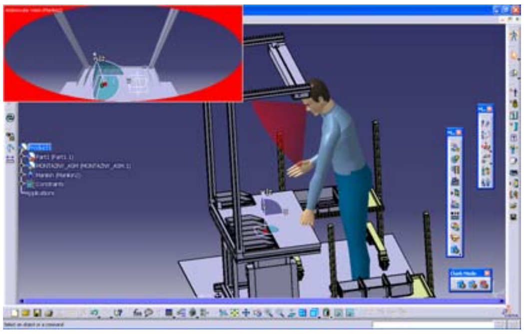


***Fig. 2.** Possible special external sources of the equipment and device 3D models for assembly workstation 3D model design in CATIA*

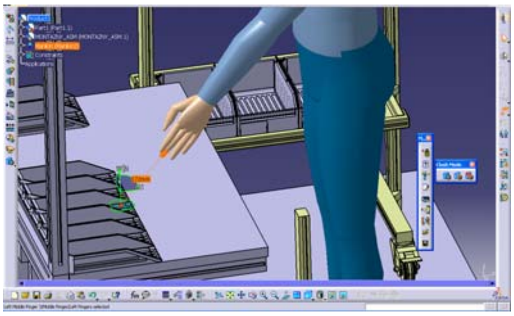
Ergonomics at the manual assembly station

The CATIA offers for solving of the ergonomics two main software tools. The first one is ***Human Measurements Editor*** dedicated to creation of detailed digital human model to extended analysis. Enables to create the human manikin by complex series of advanced anthropomorphic tools. 103 anthropomorphic variables can be adjusted and so to adapt whichever body size to precise requirements. It is also possible to create the manikin by adaptation of smaller number of "critical" variables and than to request the program for completion of the rest variables. Also is possible to define the middle and standard tolerance of all anthropometric variables.

The ***Human Builder*** – consists from complex set of tools that are dedicated to creation of human digital model (manikin), manipulation with the manikin and analysis their interaction with the product. The manikins can be used to advisement of the product from the point of view form, comfort and function. The creation of the manikins and the manipulation with them is intuitive. The tolls containable in this module incorporate the manikin generation, sex specification and percentiles, techniques to manipulation with the manikin (normal and inverse kinematics), creation of the animation, simulation of the monocular, binocular and ambinocular sight as well as the cone of viewing filed (see fig. 3).



sight simulation



function "reach""

Fig. 3. *Man simulation in CATIA V5*

Assembly workstation analysis

CATIA together with the above-mentioned tools provides also the analysis of assembly workstation. For this purpose are included two other software modules:

- ***Human Activity Analysis*** – is dedicated to interaction the human with the objects in the working area as well as to effects of the lifting, sinking, pressing, pulling and bringing to the efficiency. Evaluates all aspects of human effectiveness from the analysis of the static position up to the complex activities by tasks execution. Enables the user to maximize the comfort, safety and efficiency by using of wide spectrum of tolls to ergonomic analysis, that complex evaluate the interaction of the manikin with the objects in their virtual environment. The module supports following analysis: RULA (Rapid Upper Limb Assessment), loading analysis by load lifting (according to NIOSH 1981, NIOSH 1991 and Snook & Ciriello), Push/Pull analysis, Carry and biomechanical analysis. This tolls enable to create the workstations in accordance with health and safety standards and to maximize the comfort and safety.

- ***Human Posture Analysis*** – analyze how the human posture influences the productivity by task execution. They are analyzed the local and total postures, preferred angels and convenience. This module allows the user qualitative and quantitative analysis of all aspects of the manikin postures. Whole body and localized postures can be tested, evaluated, iterated and optimized.

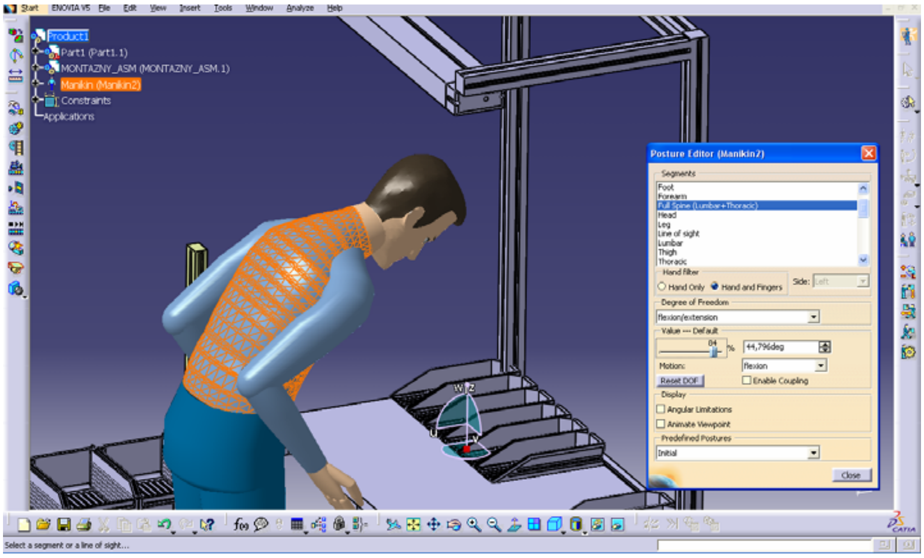


Fig. 4. *Editing of virtual man position in the CATIA V5*

Manual assembly workstation analysis procedure

The first step is a proposal of manual assembly workstation – a 3D model created according to the known procedure. In this procedure can be used existing accessible 3D models of devices and equipments from various producers. Input for this procedure is also the assembly operation sequence e.g. technological procedure of the product assembly. In this is very useful when exists also a CATIA 3D model of the assembled product. Sometimes is also necessary to create own special design of some equipments and devices.

The second step is creating and description of the virtual man. The basic parameters are: father product, manikin name, gender and percentile. The expended parameters are: population, model and referential (see Figure 5).

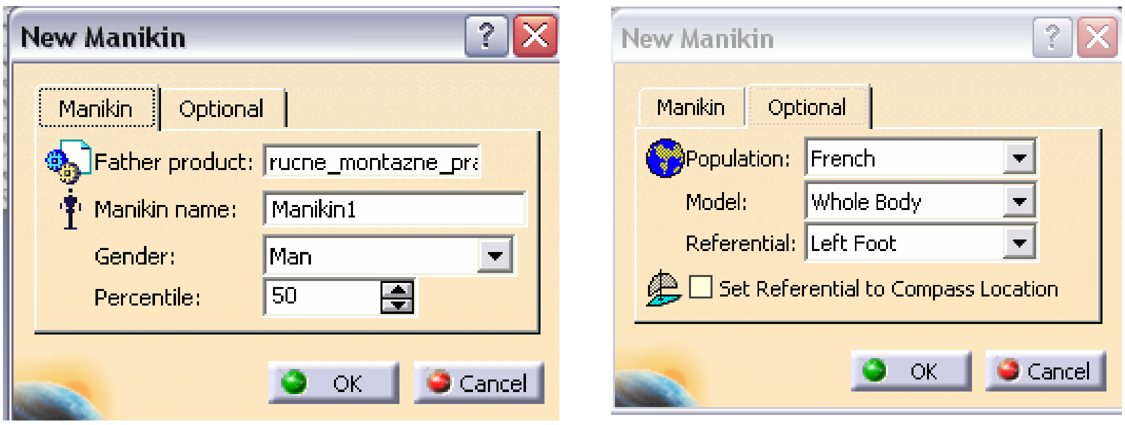


Fig. 5. *Windows for description of the virtual man*

Next must be descript the RULA analysis table (see Figure 6).

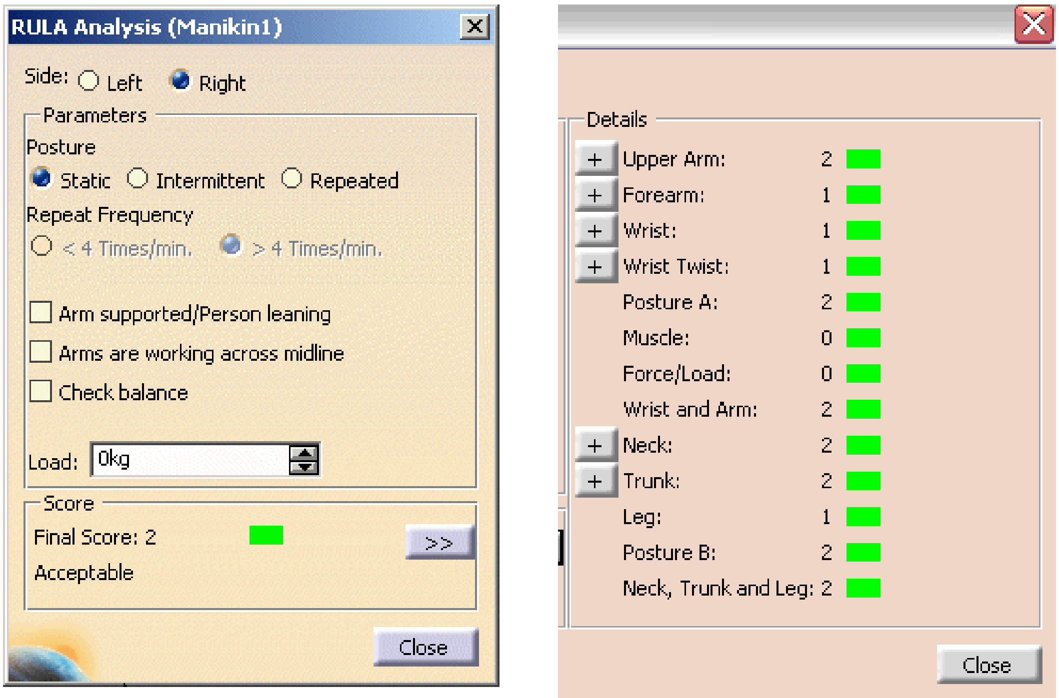


Fig. 6. *The RULA analysis table*

The procedure of the RULA analysis means an analysis of every posture of the manikin in proposed assembly workstation.

The RULA analysis researches following risk factors: the number of movements, static work of the muscles, body posture by assembly executing and time of working without pause. All this factors are combined into the final score. The final score can have a value from 1 to 7 and is also expressed in color. The meaning of several values is following:

- 1 and 2 (green) – indicates, that the posture can be accepted under the assumption, that it is not the same for a long time or it is not often repeated for a long time,
- 3 a 4 (yellow) – indicates the need of further detailed research and than, maybe be necessary to change the postures,
- 5 a 6 (orange) – indicates, that the research and the changes are necessary in very short time,
- 7 (red) – indicates, that is necessary immediate to research and to change of the postures.

This final score is accounted as a middle value from the partial scores of the particular body parts. For every body part exists a separate evaluating scale, see table 2.

At the figure 7 you can see the analysis of worker reaching to the magazine containing the part needed in the next assembly step. The result of the RULA analysis (figure 8) will be displayed in the 3D model also as a colored part of the manikin model. The four basic colors have a defined meaning. The red color represents a not applicable posture, which must be changed; the orange color presents a position that also may be changed. Yellow color gives information about a need for further optimization and the green means that the loading of the worker is ok.

PARTIAL SCORE FOR SEVERAL PARTS OF THE BODY Table 2

Segment – part of body	Score	1	2	3	4	5	6
Upper arm	from 1 to 6						
Forearm	from 1to 3						
Wrist	from 1to 4						
Wrist twist	from 1to 2						
Neck	from 1to 6						
Trunk	from 1to 6						

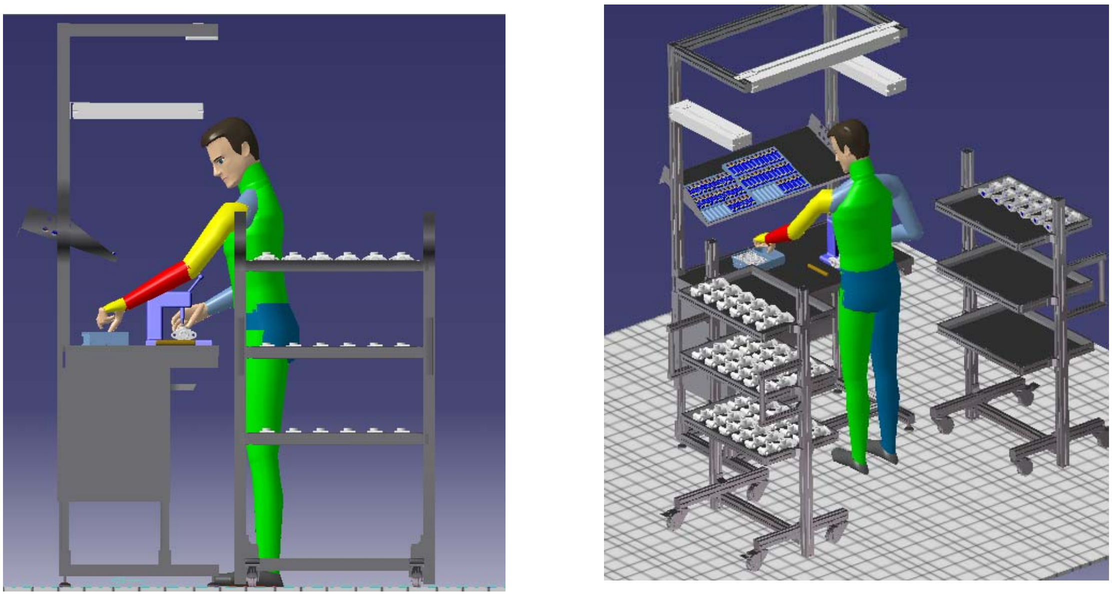


Fig. 7. Analysis of worker reaching into the magazine

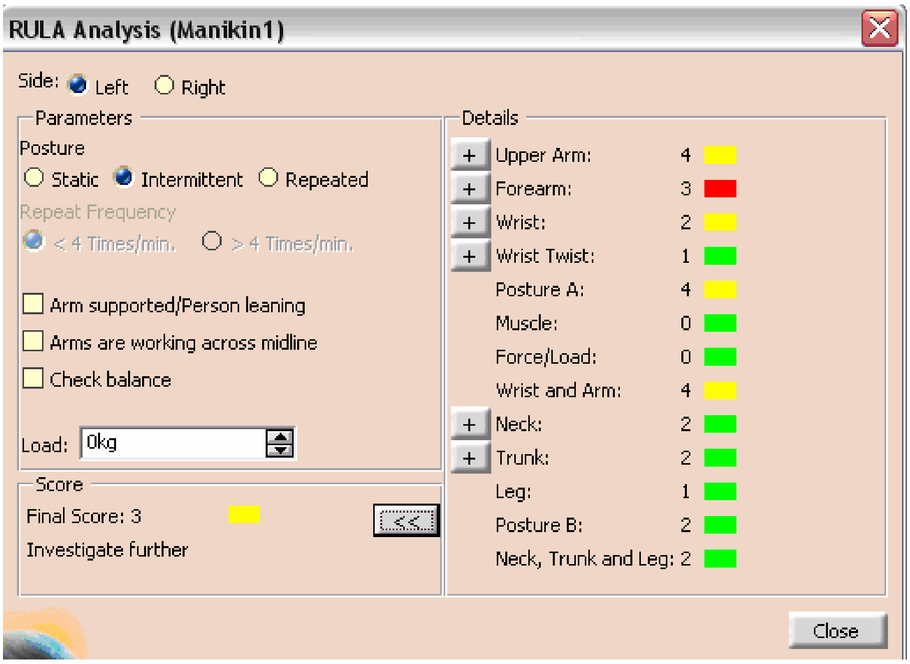


Fig. 8. RULA analysis table for above presented assembly operation

In such a way can be step by step analyzed all assembly operations - postures at the designed assembly workstation. All “not green” assembly operation can be changed and so can be realized the assembly workstation optimization. The obtained result is of course often a compromise solution. At the figure 9 is presented the result of worker viewing zone.

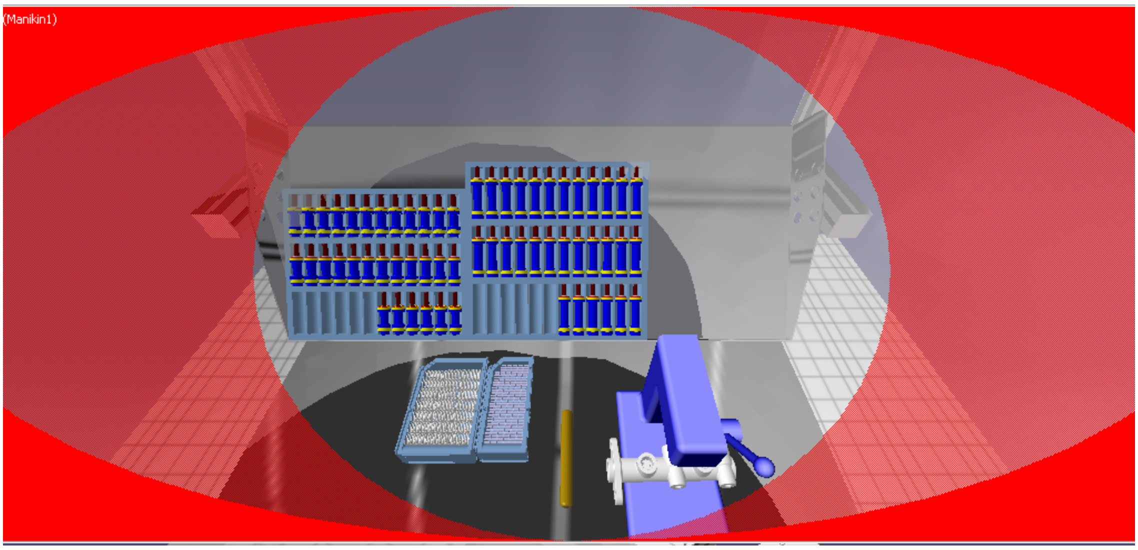


Fig. 9. *Worker viewing field with viewable limit of the reach zone*

Conclusion

The software tools considerably save the, otherwise time consuming labor. At the base of the above described procedure can be stated, that the application of CATIA ergonomic modules is conditioned by knowledge of the basic modeling techniques in 3D space or else is the using of CATIA ergonomic modules intuitive and can be mastered so from the point of view knowledge as time. The aforementioned optimization procedure can be applied so in the education as by creating of the complex solution in the praxis

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