

DIFFERENCES IN SIMULATION OF HUMAN OPERATIONS BETWEEN SIMULATION SOFTWARE PROCESS SIMULATE_HUMAN AND TX JACK

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Keywords: process simulate, human, Tx Jack, simulation, modelling

Abstract: Article deals with the use of simulation software to design and optimize the work activities in the industrial enterprise. It is a optimization of the manual operation in connection with the elimination of physical stress of workers through ergonomic analyses that are part of software products and are realized in the process of simulation, specifically, two software products Siemens - Process Simulate module Human with a Texnomatic Jack. The article compared the virtual environment in which the project manager works.

1 Introduction

Most companies looking for savings in purchased materials, overheads, energy. They are looking for ways to achieve these savings. One way is to use software products for the creation of virtual reality and optimization of the current state of business processes without the cost of direct implementation of suggestions for improvement.

The principle of modelling in Tx Jack and Process Simulate Human (Figure 1) is demanding in terms of modelling machines, equipment, vehicles, etc. To create a working environment, it is appropriate to use other softwares, which creates a working environment easier.

Software Tx Jack is compatible with the software, which can create a virtual environment of a particular workplace or halls such as CAD. Thus created environment can be imported into the working environment of Tx Jack and then place a concrete worker in it with concrete working activities

Main function of Tx Jack and Process Simulate Human (Figure 2) are therefore creating a human being with accurate anthropometric parameters, simulation of movements (individual body parts) and determine the burden caused by work's activities and work's

environment (Figure 3). It is not necessary to determine the physical stress on the particular operator, but it is necessary to dimension the workplace in general (Figure 4), (Figure 5). It is possible to use the database ANSUR (Survey of U.S.Army) which contains data collected realization of survey personnel of military of USS in 1988.

Siemens Tecnomatix software package has several modules for each area of usage. For modelling and simulation of the impact of the working environment on staff, creating 3D models of working environment, workers and their activities and detect physical stress through a specific predefined base of ergonomic analysis can be used two modules (Table 1):

- Tx Jack/Jill - it's a 3D simulation tool for evaluating of physical stress during the manual work activities, this is the instrument through which it is possible design workplace in the virtual environment and simulate various solutions that meet ergonomic standards without investing in equipment and technology. Digital human model in this program is a real biomechanical properties of natural motion and joint rang - taken from NASA studies.

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• Process Simulate Human - allows users to verify the design of work stations, verify the achievement of the required safety of the individual parts of a product. The module offers powerful features for analysing and optimizing the ergonomics of human activity, thereby

providing an ergonomic and safe production process according to industry standards. Using simulation tool of human activity, the user can perform realistic simulation of the human tasks and optimize process times of the production cycle according to the standards of ergonomic.

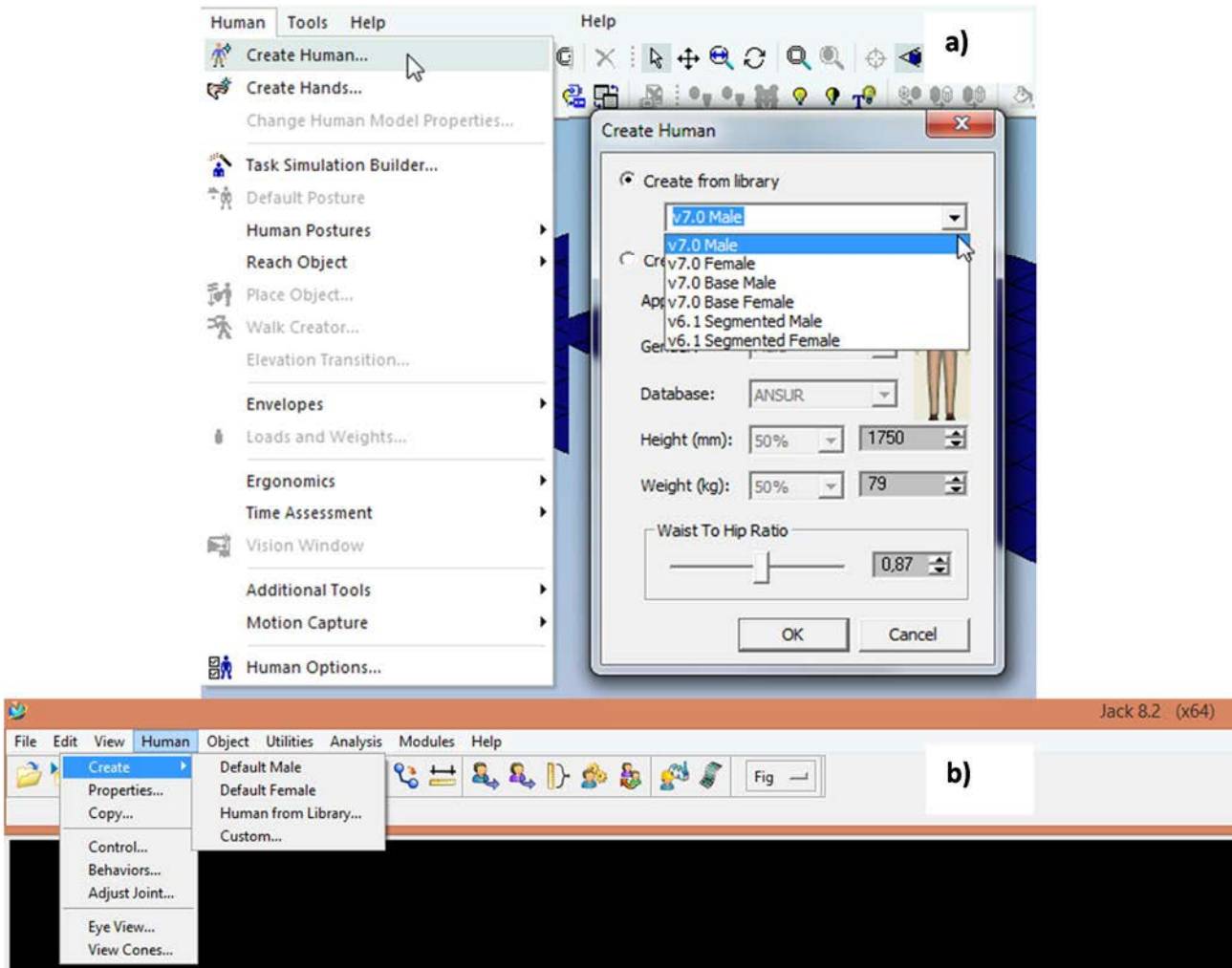


Figure 1 a) Process Simulate - Create Human; b) Tx Jack - Default Male/Female

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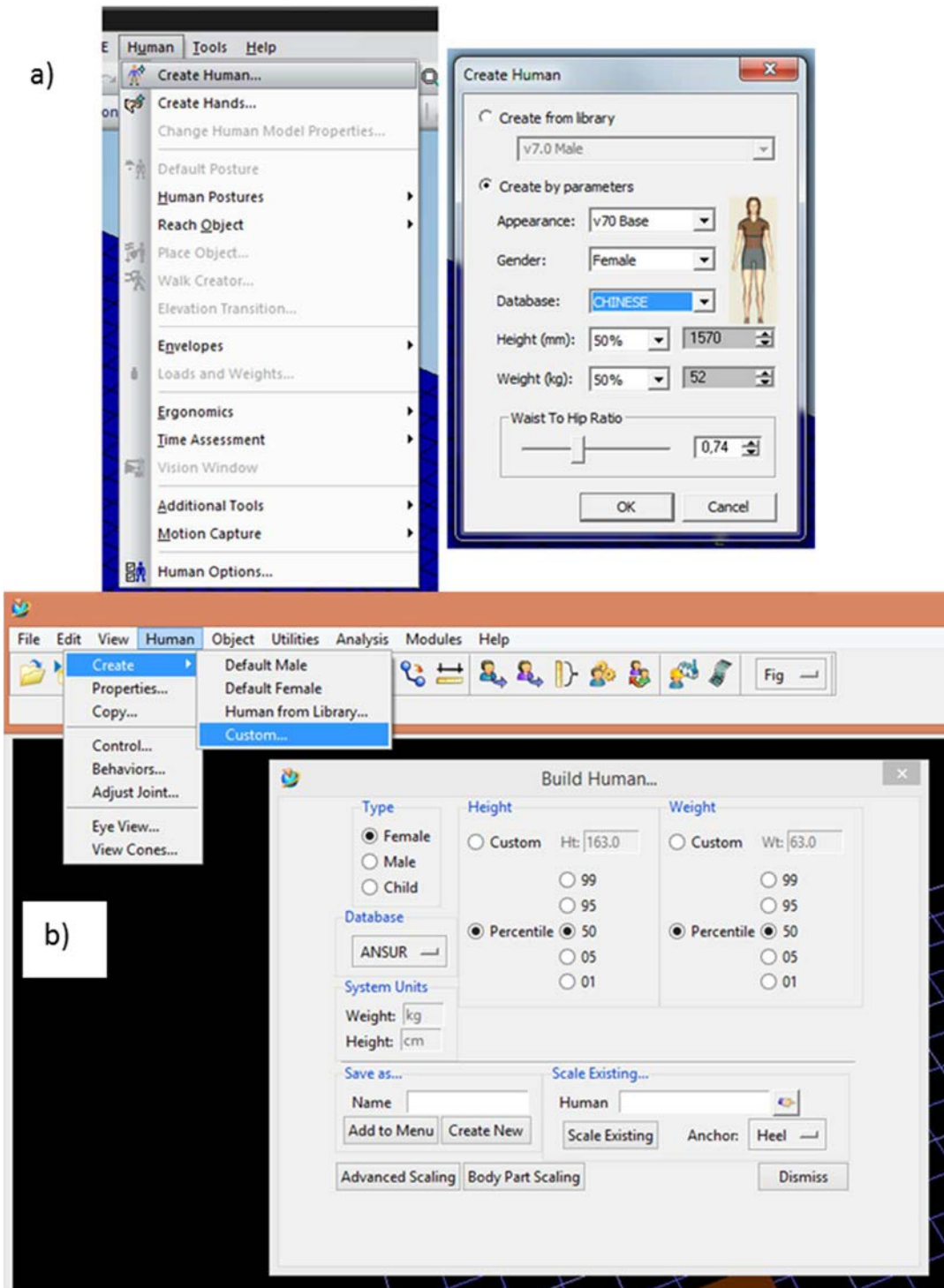


Figure 2 Create human in a) Process Simulate - Create by parameters; b) Tx Jack 8.2 – Human - Custom...

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Miriam Pekarčíková; Peter Trebuňa; Radko Popovič; Andrea Petříková; Marek Kliment

Table 1 Description of the figures

	Tx Jack/Jill	Process Simulate Human
Figure 1	It is showing the exact steps how to setup human model. (or posture library), colors of every part of human model (human body), user defined ergonomic reports and some other features.	
	Open Tx Jack, on the top menu Human_Create_Default – male, female.	Left click on the top menu Human and choose Create Human, we can see new window with option Create from library.
Figure 2	In the top we can choose if we want to create a human from the library. Also there is another way (create by parameters) how to create a human in the Process Simulate. In this second option you can choose from predefined parameters of the human model. We can choose clothes type, gender, nationality and also height and weight.	
	Customize the parameters of human Human_Create_Custom...	Create a human model which starts by clicking on the option Human from the main menu and selecting Create Human - Create by parameters where we can edit multiple attributes of a potential worker.
Figure 3	For basic human operation we can consider walking. Transfer of human position from one point to another point begins by choose in the both software differently.	
	It needs to click in the main menu Modules_Task Simulation Builder. It opens a working environment in which it is possible to create human movements that are in the menu - eg. Go, Get, Put, position, pose, touch, regrasp ATC.	Chose the requested human model in the graphics window and selecting Walk Creator - from the main Human menu. In the window Operation Walk - Jack there is a possibility to propose the walk operation by positions - either by entering the human target positions (Select Target), where human has to move, or selecting Path Creator and then entering a path along which go human model to the desired destination.
Figure 4	Selecting a human model and choosing option Posture Library is very similarly.	
	In work environment Task Simulation Builder_Modules by the option Pose is possible to choose from predefined human poses which is required, but also define other characteristics such as reach and grasp, loads and weights, adjust and joint.	From the main menu Human_Human Postures, the new window Posture Library - Jack will be open. There you can choose from one of the predefined human poses (working,-relaxing, sitting pose) as well as there is a possibility of fixing individual joints of human and edit the new requested poses. Subsequently, using the option Create Op. the new human pose will be created and saved with the selected positions of human model.
Figure 5	Object handling in terms of its grip can be made in both software is describe below. In both software, as regards the ways how to catch an object there are more of variant, for example using both hands, clutching automatic mode, grasping of selected objects from the workplace and permissions to change locations for a grasping an object	
	In this environment, it needs to select Get from the menu and define parameters it necessary for grasp of concrete object. For the location of the object needs to be defined further step and it is Put. This software allows you to define the work activities through the definition of individual tasks.	Select Auto Grasp from the main menu Human_Reach Object opens a new window Auto Grasp - Human, where it is possible to set multiple attributes of the object grasp.

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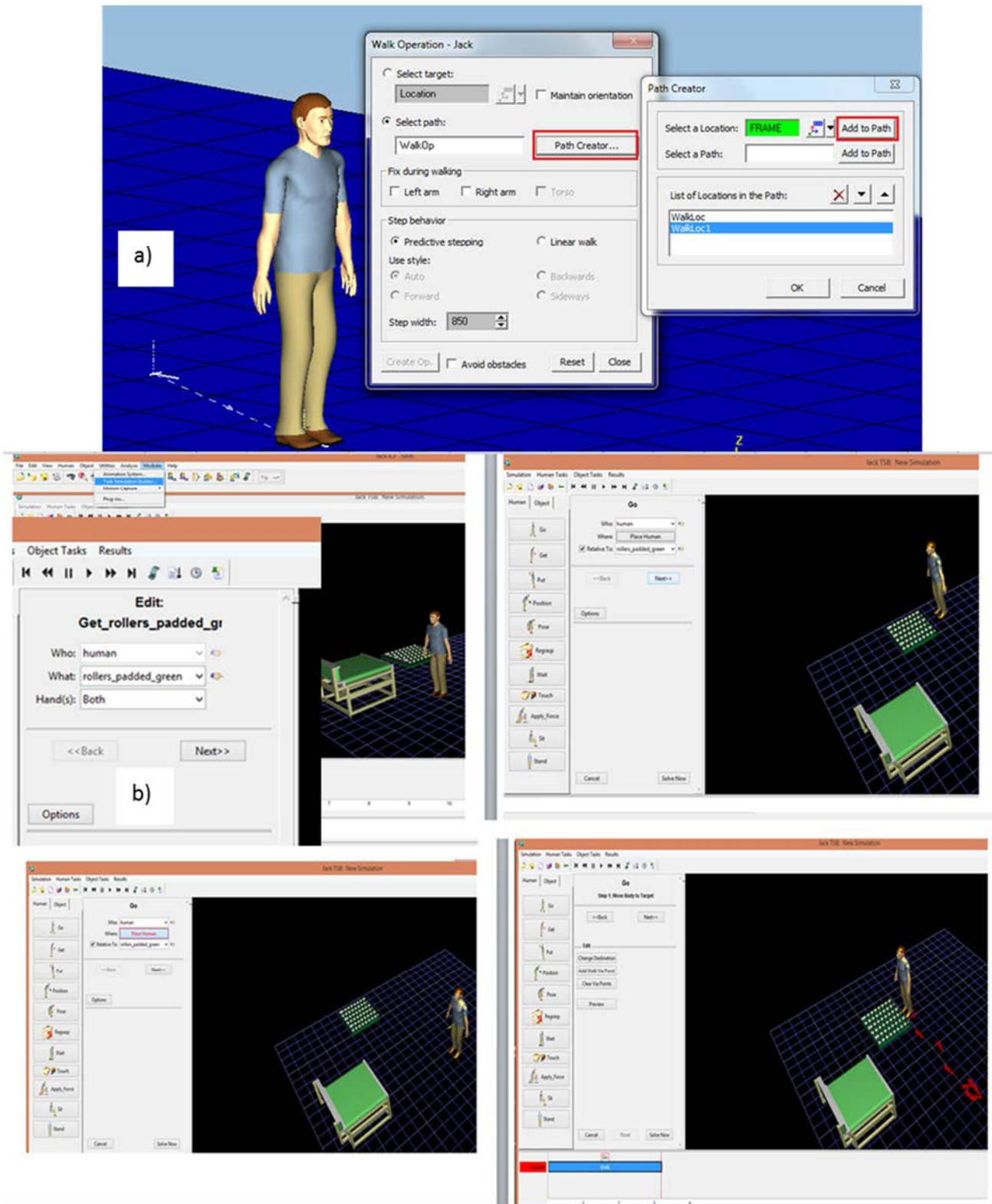


Figure 3 Definition of motion in a) Process Simulate - Walk creator
 b) Tx Jack 8.2 – Modules_Task Animation Builder

DIFFERENCES IN SIMULATION OF HUMAN OPERATIONS BETWEEN SIMULATION SOFTWARE PROCESS SIMULATE_HUMAN AND TX JACK

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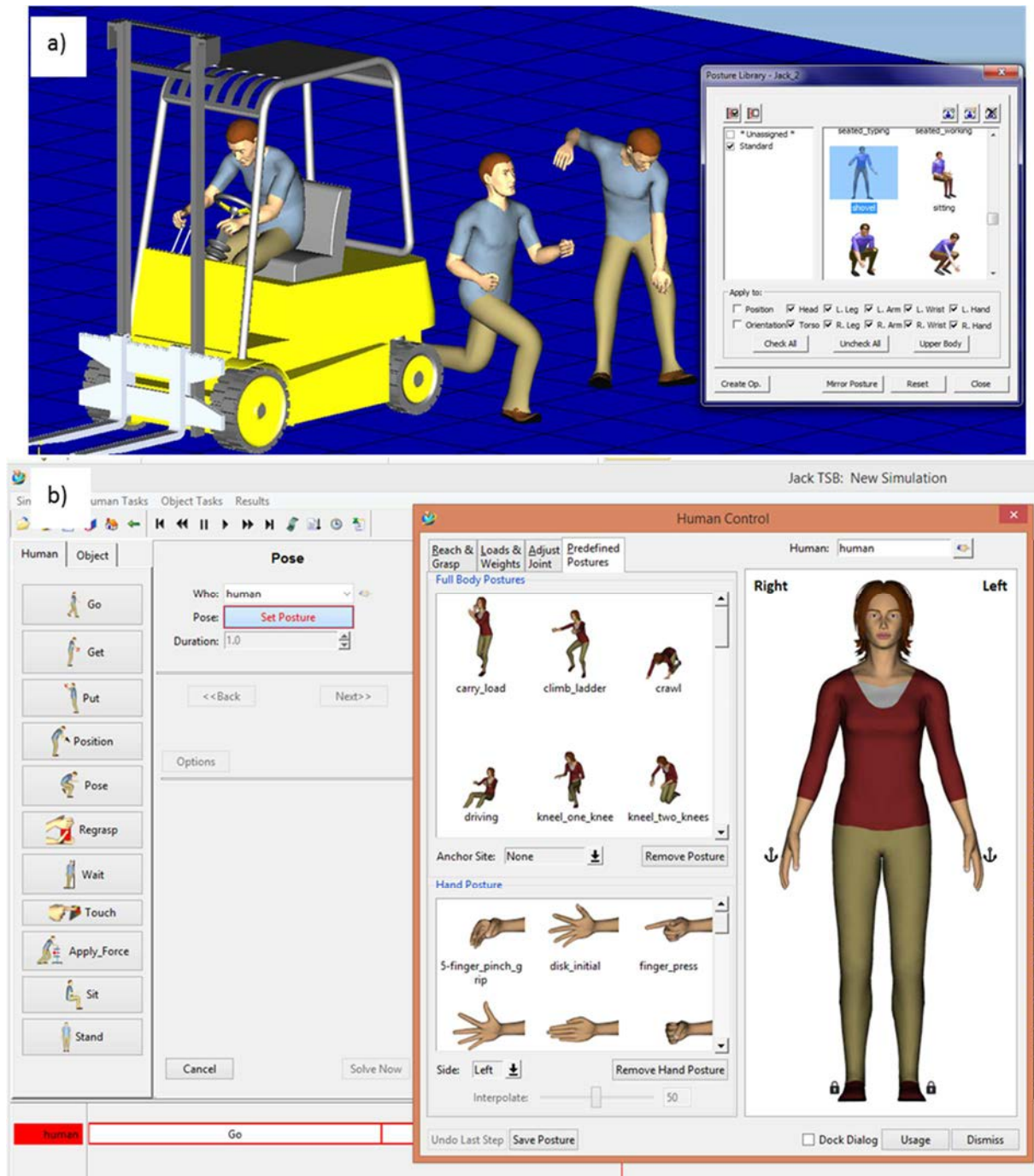


Figure 4 Posture library in a) Process Simulate Human_Human Postures
 b) Tx Jack 8.2 – Modules_Task Animation Builder

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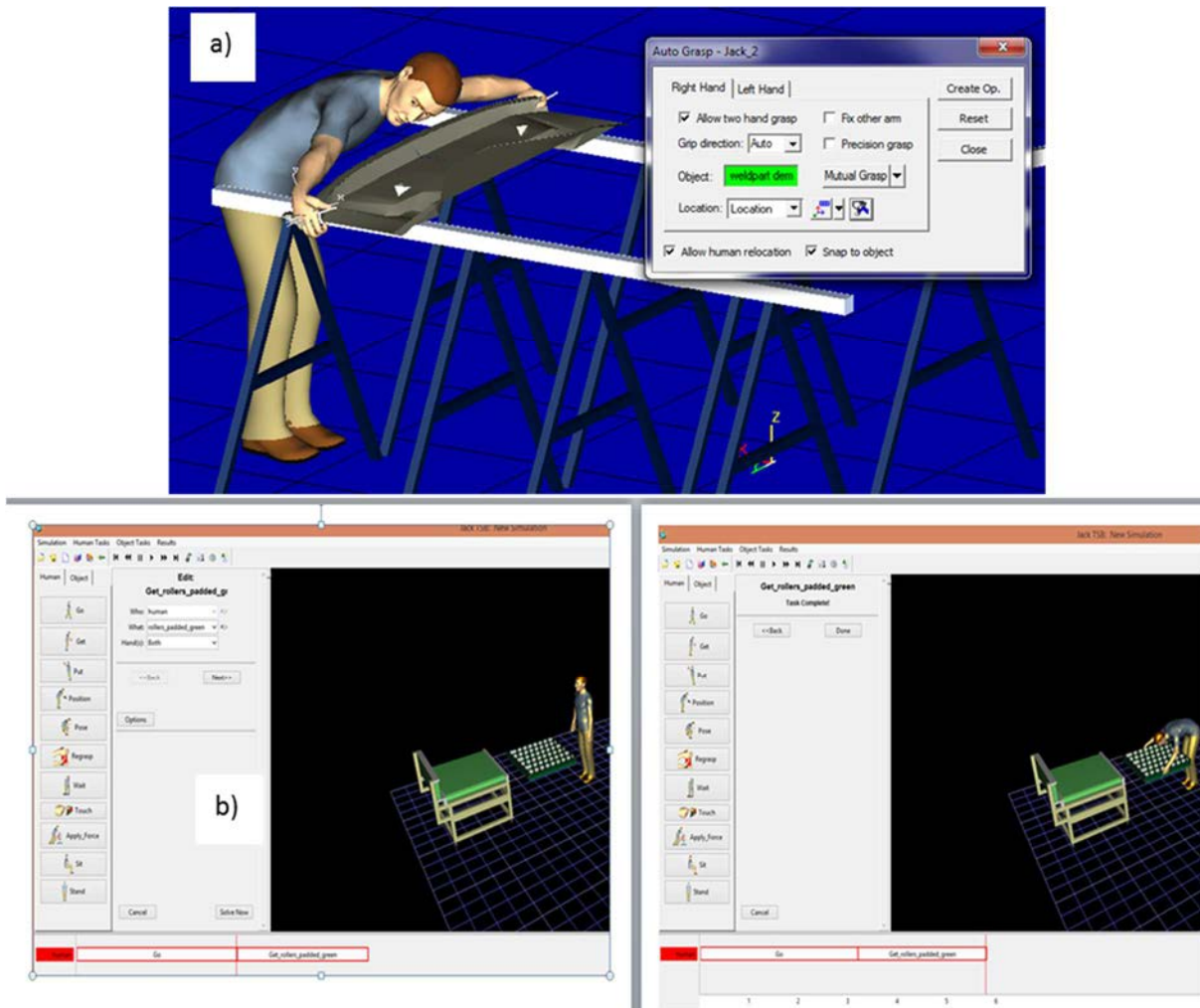


Figure 5 Get object in a) Process Simulate - Auto grasp
b) Tx Jack 8.2 – Modules_Task Animation Builder

Conclusions

Choosing the right tool for the purposes of optimization is important for the desired output. Regarding the ergonomic optimization is therefore necessary to know what should be the content of the simulation. Whether it will be act as a simulation of work activities, then temporary staff and monitoring their physical stress, or a requirement to include simulation and workplace as a function part of the working environment, i.e. it is necessary to bestir not only workers but also workplaces. Software product Tx Jack allows to create simulation work activities, which bind to a specific worker. Regarding the software product Process Simulate there are greater opportunities for optimization, because Human is just one of the modules of this software product. One of the differences is also that Process Simulate has no library after installation in the PC. On the other hand Tx Jack has a basic library with some objects necessary for simulation and analysis, e.g. chairs, tables, conveyor, container, accessories.

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DIFFERENCES IN SIMULATION OF HUMAN OPERATIONS BETWEEN SIMULATION SOFTWARE PROCESS SIMULATE_HUMAN AND TX JACK

Miriam Pekarčíková; Peter Trebuňa; Radko Popovič; Andrea Petříková; Marek Kliment

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THE POSSIBILITY OF USING CONTROL CHARTS IN QUALITY CONTROL OF THE PRODUCTION PROCESS

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THE POSSIBILITY OF USING CONTROL CHARTS IN QUALITY CONTROL OF THE PRODUCTION PROCESS**Gabriela Ižaríková**

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Keywords: statistical process control, control charts, capability index**Abstract:** The article we will present on the use of control diagrams (charts) of the production process, specifically to assurance the quality on milling machine. The use and effectiveness in the application in the production process will be evaluated by comparing the waveforms in the diagrams. Various types of diagrams, which operate on different statistical characteristics, were selected as a statistical tool for regulating the detection and assessment of stability of the manufacturing process.**1 Introduction**

The production process should be continually monitored and controlled. It is therefore necessary to know and use methods, tools and techniques of statistical process control to improve and maintain the quality of products and processes that allow us to monitor and report on the process of quantification of image. Introduction of Statistical Process Control – SPC, using control charts and associated with the detection capability of the manufacturing process is carried out in retaliation, which are characterized by high accuracy. In general, control charts used to improve the quality parameters of production and in the prevention of errors in the output, in the production process. Help prevent unnecessary changeovers production lines, which could create downtime and will increase the cost of the production process.

Control chart indicates the possibility of the presence of discrete causes in the process when the point outside the regulatory borders. It should also follow some typical cluster points, none of which does not lie outside these limits, but which may also indicate the presence of a discrete causes [1], [2].

The measured values of X (product parameter) are characterized by their mean value and variability. Wednesday to regulate the distribution of measured values is used \bar{X} -chart (control means selection means) or *Mediagram* (regulation through the selection of the median). For controlling the variability in the distribution of measured values is used *R-chart* (control by tendering variation margin) or *s-chart* (control via sample standard deviation). In general, the chart contains a center line that represents the mean value for the in-control process [3], [4]. Two other horizontal lines, called the upper control limit (UCL) and the lower control limit (LCL), are also shown on the chart. These control limits are chosen so that almost all of the data points will fall within these limits as long as the process remains in-control. If the

monitored process operates only accidental causes, then all polygon points in a control chart are between LCL and UCL, UCL and LCL lines define the scope permissible variation value, approximately 99.7% (6 σ) values will lie within this zone. Then the process of statistically controlled state, that is the statistical right. USL (Upper Specification Limit) is the upper tolerance limit and LSL (Lower Specification Limit) is lower tolerance limits. Control charts work with the Type I error 0.0027.

Control charts for measurable quality characteristics required for the right application to verify four assumptions: normality of data, constant mean value, standard deviation and constant data independence. For the analysis of variable and attributive characters they have been developed various types of control charts. It is advisable to construct a pair of control charts, one for monitoring the variability of the character and quality second to monitor the centring of the character quality [5], [6], [7], [8]. Into classification of control charts is engaged STN ISO 8258:1995 generally there are two types of control charts:

- measurement control charts - data on measurable variable obtained by measuring and recording the character numerical values for each of the items in the subgroup,
 - comparison of control charts - data obtained in recording the presence or absence of a specific character for each of the items in the subgroup.
- For regulating measurement pairs are used:*
- charts for the average \bar{X} and standard deviation s
 - chart for average \bar{X} and range R ,
 - chart for the median Me and range R .

Control charts for data obtained by comparing (qualitative and measurable quality characteristics) (Control Charts for Attributes) are:

- chart for the number of nonconformities, defects,
- chart for number of nonconformities per unit,

THE POSSIBILITY OF USING CONTROL CHARTS IN QUALITY CONTROL OF THE PRODUCTION PROCESS

Gabriela Ižaríková

- chart for the share of nonconforming units.

For each of control charts, there are two different situations:

- core values are fixed (very unlikely in practice),
- core values are not established,
- core values are fixed (very unlikely in practice).

In this paper are used only control charts for measuring.

Process capability reflects the ability of the manufacturing process or equipment to achieve the prescribed quality requirements. To improve the process of stabilization is required, the stable process if it does not change the average or standard deviation. Statistically controlled process means that the process is operating only the effects of random and systematic causes of instability are eliminated. To evaluate the process are used different capability index which compare a prescribed allowable variability in a given tolerance limits to the actual variability observed character achieved a statistically controlled process. For monitoring process capability indices are used C_p , C_{pk} and C_{pm} who is allowed to count only upon proof that the process is in statistical mastery of state.

Capability index C_p is a measure of the potential ability of the process to ensure that the monitored quality feature lay within the tolerance limits. This work describes the process variability. Its disadvantage is that it does not consider the middle of the distribution of the measured values with respect to a desired target value, and to require the two tolerance limits. Take values from 0 to 2, and of the numerical value to determine the process capability. While the index C_p is an indicator of potential process capability, that is how the process could be, so the index C_{pk} is an indicator of the current process capability. Capability index C_{pk} takes into account not only the variability, but the location of the reference values of tolerance mark of quality in the field. Thus characterizes the true process capability to comply with the prescribed tolerance limits. The disadvantage of this index is that if the mean value μ moving away from the target value, and does not change its deviation σ , deteriorating. The index C_{pk} can take values from $(-\infty, \infty)$. Capability index C_{pm} called Taguchi capability index, removes some of the shortcomings and indexes

C_p and C_{pk} . This index compares the maximum permissible variation observed quality characteristic determined width of the tolerance band of the real variability around the target value. The value of this index will be calculated from the interval $(0, \infty)$.

2 Process measurement evaluation

For monitoring capabilities metalworking lathe (milling machine) comply with setting and maintaining the quality control charts were selected. Measured object was sprocket with an internal diameter of 28 ± 0.05 mm. The measurements were performed on a digital caliper MITUTOYO.

According to the standards of construction Shewhart control charts it is recommended to measure the products of approximately equal intervals and in groups, which consist of the same product to the same measurable units and the same number of values in each subgroup (STN ISO 8258:1995).

There have been five measurements every hour and included a total of 25 selections, ie the number of subgroups is $k = 25$ and range of subgroups $n =$ fifth The prescribed limits are 27.95 mm and 28.05 mm. Based on the measured values, the averages are evaluated. The measured values were tested for normality, from Figure 1 it is clear that they have a normal Gaussian distribution. Data normality was confirmed by the Shapiro-Wilco test, p-value is 0,1513 it is probably null-hypothesis is accepted at the significance level, $p > 0.05$, the population is normally distributed.

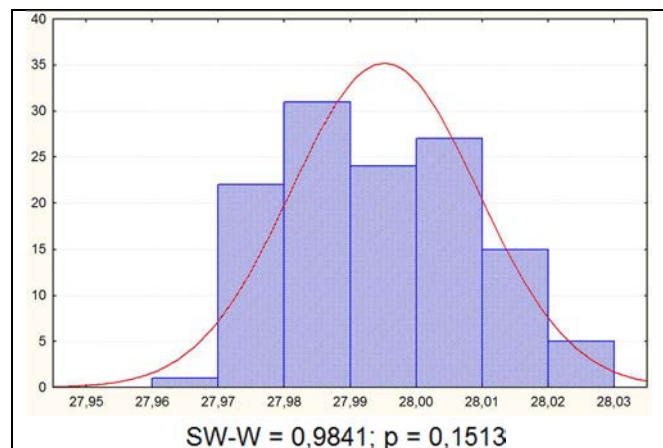


Figure 1 Verify data normality

In Table 1 are calculated in the final group of central tendency and variability needed to construct control charts.

Table 1 Values for constructing control charts

Group	Average [mm]	Range [mm]	Standard deviation	Median [mm]
1	27,9854	0,0340	0,0148	27,9770
2	27,9968	0,0250	0,0114	27,9910
3	27,9978	0,0280	0,0107	27,9950
4	27,9944	0,0190	0,0081	27,9900
5	27,9892	0,0320	0,0145	27,9800
6	28,0022	0,0290	0,0120	28,0050
7	27,9846	0,0170	0,0069	27,9820

THE POSSIBILITY OF USING CONTROL CHARTS IN QUALITY CONTROL OF THE PRODUCTION PROCESS

Gabriela Ižaríková

8	27,9906	0,0350	0,0132	27,9880
9	27,9828	0,0280	0,0117	27,9770
10	28,0040	0,0390	0,0149	28,0010
11	27,9996	0,0410	0,0151	28,0030
12	28,0084	0,0270	0,0106	28,0050
13	27,9992	0,0590	0,0267	27,9980
14	27,9910	0,0280	0,0125	27,9940
15	28,0032	0,0200	0,0076	28,0010
16	27,9964	0,0260	0,0109	27,9910
17	27,9904	0,0310	0,0122	27,9920
18	27,9896	0,0540	0,0204	27,9900
19	27,9974	0,0370	0,0158	27,9900
20	27,9994	0,0210	0,0079	28,0010
21	27,9988	0,0290	0,0144	27,9900
22	27,9892	0,0420	0,0169	27,9830
23	27,9968	0,0270	0,0120	27,9950
24	27,9968	0,0340	0,0127	27,9930
25	27,9958	0,0520	0,0216	28,0010
Average	27,9952	0,0326	0,0134	27,9925

Before determining the central lines and control lines, it is necessary to calculate the central tendency and variability - each choice means \bar{x} , range R, standard deviation and median. Consequently, for these values, it calculates the average sample mean, the average variance, the average standard deviation and the average median (1) as:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i, \quad R = x_{\max} - x_{\min}, \quad s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2},$$

$$Me = x_{\left(\frac{n+1}{2}\right)} \quad \text{or} \quad Me = \frac{1}{2} \left(x_{\left(\frac{n}{2}\right)} + x_{\left(\frac{n+2}{2}\right)} \right),$$

$$\bar{\bar{x}} = \frac{\sum \bar{x}}{k}, \quad \bar{R} = \frac{\sum R}{k}, \quad \bar{s} = \frac{\sum s}{k}, \quad \bar{Me} = \frac{\sum Me}{k} \quad (1)$$

a) Control charts for average and range (\bar{X} , R)

• Central line: $CL_x = \bar{\bar{x}}$ a $CL_R = \bar{R}$.

• Control limits:

$$UCL_x = \bar{\bar{x}} + A_2 \cdot \bar{R} \quad LCL_x = \bar{\bar{x}} - A_2 \cdot \bar{R}$$

$$UCL_R = D_4 \cdot \bar{R} \quad LCL_R = D_3 \cdot \bar{R}.$$

b) Control charts for average and standard deviation (\bar{X} , s)

• Central line: $CL_x = \bar{\bar{x}}$ a $CL_s = \bar{s}$.

• Control limits:

$$UCL_x = \bar{\bar{x}} + A_3 \cdot \bar{s} \quad LCL_x = \bar{\bar{x}} - A_3 \cdot \bar{s}$$

$$UCL_s = B_4 \cdot \bar{s} \quad LCL_s = B_3 \cdot \bar{s}.$$

c) Control charts for median and range (Me, R)

• Central line: $CL_{Me} = \bar{Me}$ a $CL_R = \bar{R}$.

• Control limits:

$$UCL_{Me} = \bar{Me} + A_4 \cdot \bar{R} \quad LCL_{Me} = \bar{Me} - A_4 \cdot \bar{R}$$

$$UCL_R = D_4 \cdot \bar{R} \quad LCL_R = D_3 \cdot \bar{R}.$$

Coefficients A_2 , A_3 , A_4 , B_3 , B_4 , D_3 , D_4 , d_2 , C_4 are depended on the sample size and the tax table, for $n=5$ it is Table 2.

Table 2 Coefficients for calculating regulatory limits for the scope of subgroup $n = 5$

A_2	A_3	A_4	B_3	B_4	D_3	D_4	d_2	C_4
0,577	1,427	0,690	0,000	2,089	0,000	2,114	2,326	0,940

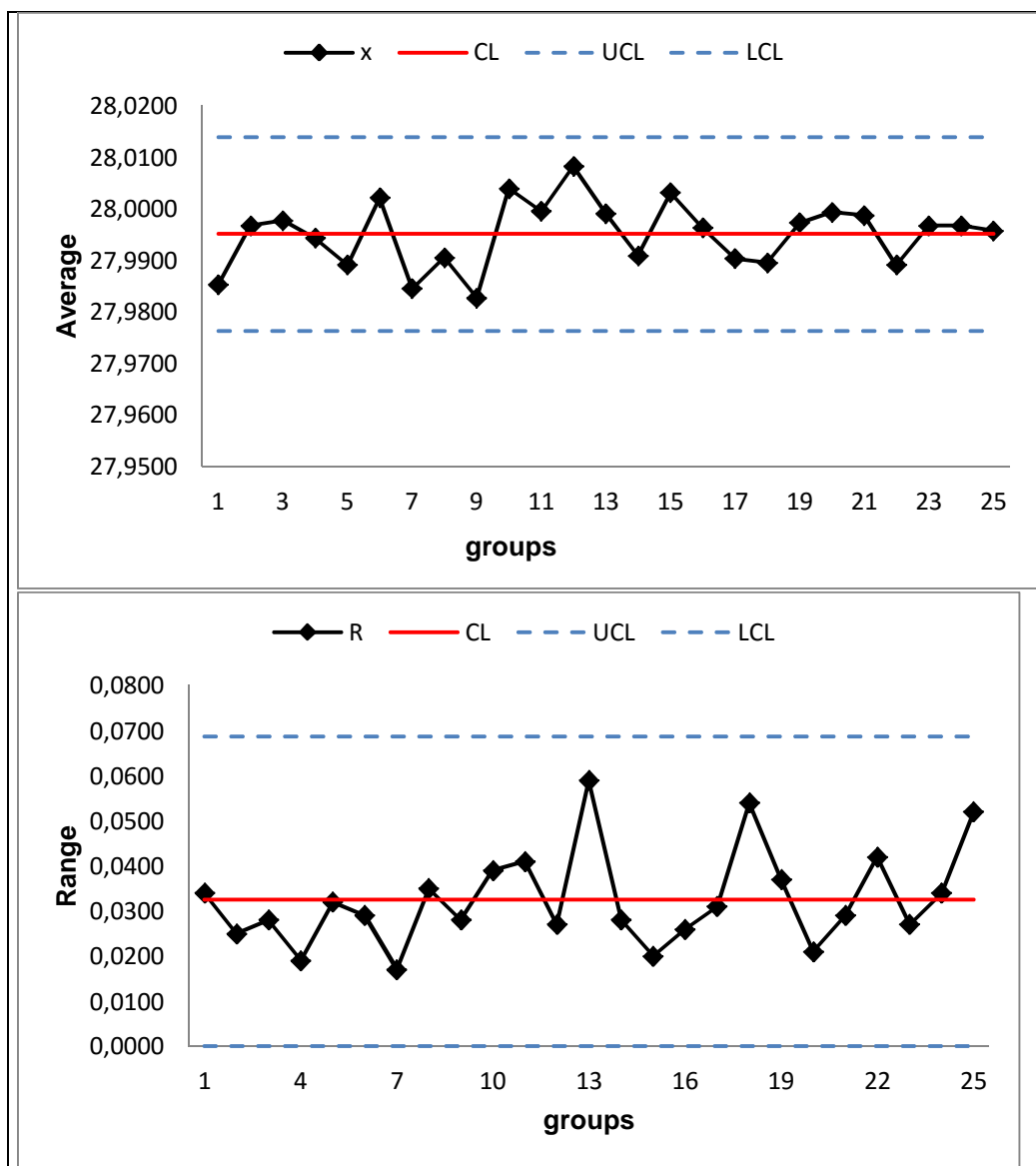
Statistical stability, we research it by control chart, the control chart, we find signs of instability: points beyond regulatory limits, 7 consecutive points above the center line, 7 consecutive points below the central line, 7 consecutive points in a rising line, 7 consecutive points in descending row.

Table 3 The regulatory limits and central lines for (\bar{X} , R)

Control chart for average [mm]		Control chart for range [mm]	
CL	27.9952	CL	0,0326
LCL	27.9764	LCL	0
UCL	28.0140	UCL	0,0688

THE POSSIBILITY OF USING CONTROL CHARTS IN QUALITY CONTROL OF THE PRODUCTION PROCESS

Gabriela Ižaríková


 Figure 2 Control charts (\bar{X} , R)

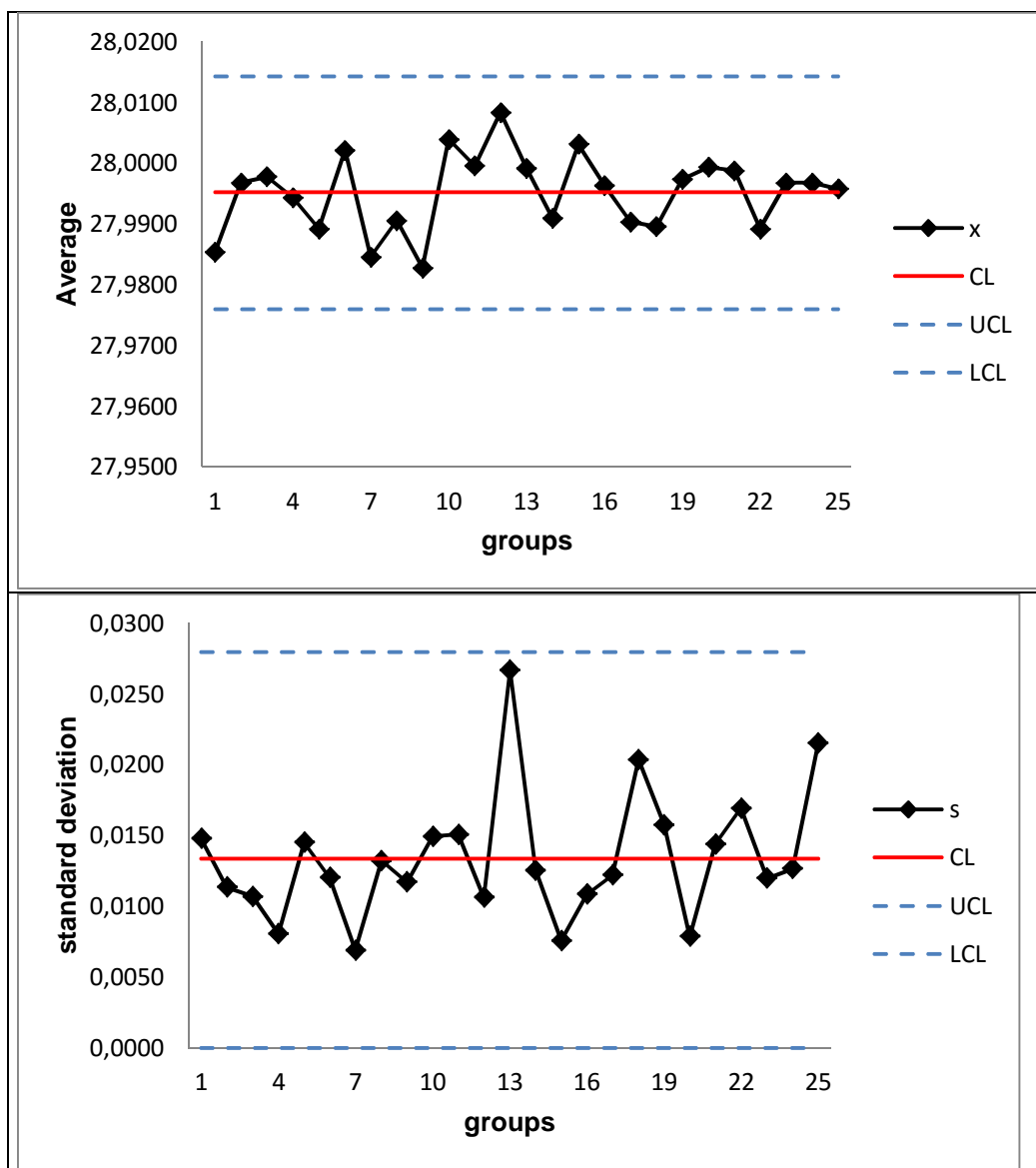
In Figure 2 are displayed one below the other control charts, and the range of diameters, and how is the range of diameters diagrams seen that the process is stable, since all points are between the upper and lower boundaries of regulatory.

 Table 4 The regulatory limits and central lines for (\bar{X} , s)

Control chart for average [mm]		Control chart for standard deviation [mm]	
CL	27.9952	CL	0,0134
LCL	27.9760	LCL	0
UCL	28,0143	UCL	0,0280

THE POSSIBILITY OF USING CONTROL CHARTS IN QUALITY CONTROL OF THE PRODUCTION PROCESS

Gabriela Ižaríková


 Figure 3 Control charts (\bar{X} , s)

In Figure 3 are shown below each other control charts means and sample standard deviations. Neither point calculated exceeded regulatory limits, so the process is stable. When analyzing control charts for the variability of the manufacturing process using statistical characteristics of the R and s can state a similar pattern of these curves.

 Table 5 The regulatory limits and central lines for (Me , R)

Control chart for median [mm]		Control chart for range [mm]	
CL	27.9925	CL	0,0326
LCL	27.9701	LCL	0
UCL	28.0150	UCL	0,0688

THE POSSIBILITY OF USING CONTROL CHARTS IN QUALITY CONTROL OF THE PRODUCTION PROCESS

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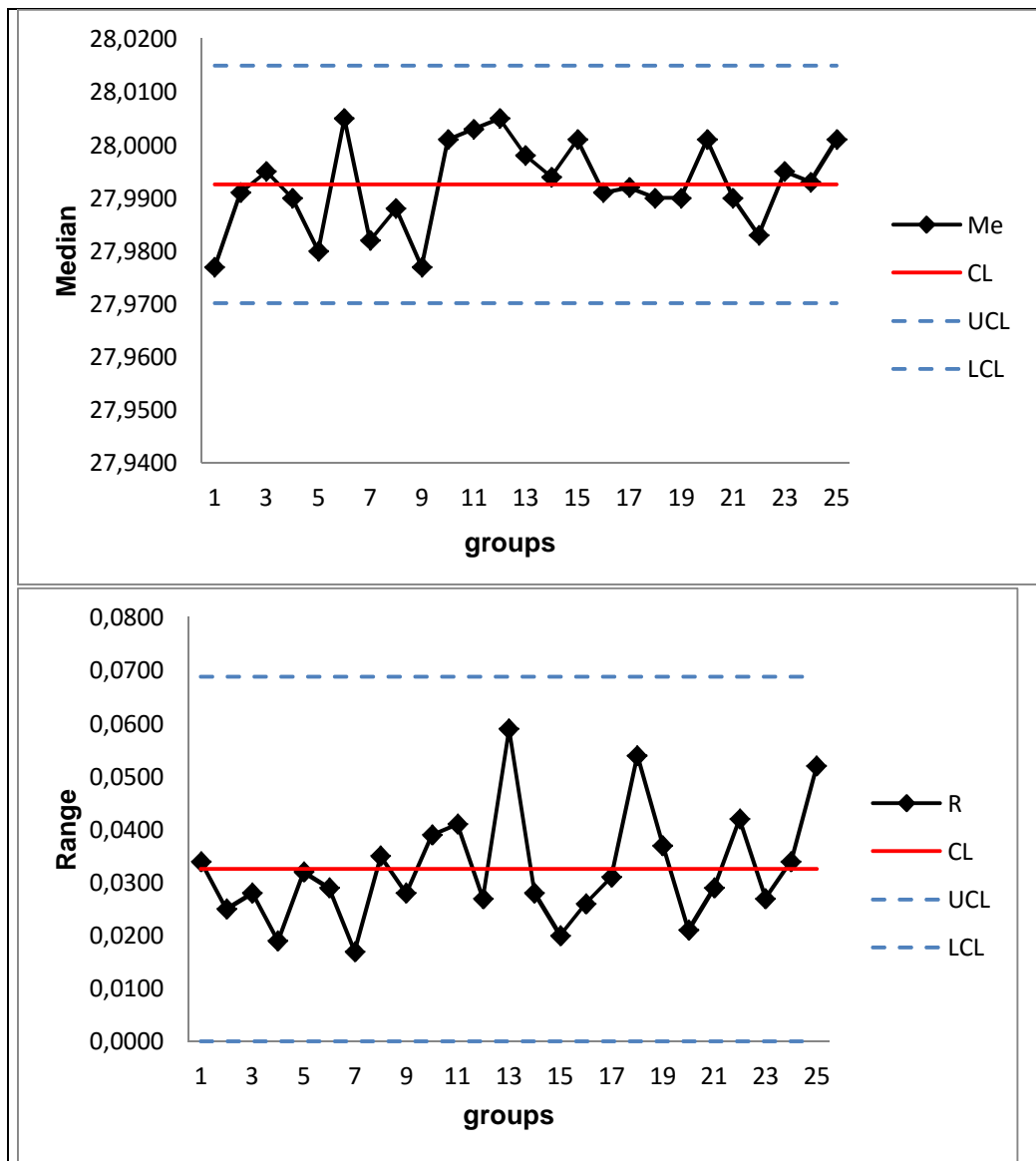


Figure 4 Control charts (Me, R)

In Figure 4 are shown below each other control charts for median and range. As shown in the figure there are not visible from a trend or a group of points that would signal the presence of a discrete causes of variation. The process is stable.

Indicators for capacity control charts (\bar{X} , R) (2) are:

$$C_p = \frac{d_2(USL - LSL)}{6\bar{R}} = 1,1906$$

$$C_{pk} = \min\left\{\frac{d_2(USL - \bar{\bar{x}})}{3\bar{R}}, \frac{d_2(\bar{\bar{x}} - LSL)}{3\bar{R}}\right\} \quad (2)$$

$$C_{pk} = \min\{1,3051, 1,0761\} = 1,0761.$$

The index value $C_p > 1$, $C_{pk} > 1$ say that it is the compliance of the production process. Valid $C_{pk} < 1,25$ account of the process is a good fit for standard products.

Conclusion

Identification of the problems associated with poor quality products, identifying the causes of and continuous improvement is key to maintaining and improving the quality of processes and products are essential. The article is an example of using control charts for monitoring capabilities milling machine comply with setting. Control charts are used to routinely monitor quality. A control chart represents a picture of a process over time. A control chart tells you if your process are in statistical control. The ideas above apply to more than just manufacturing processes. We can use run charts and control charts to monitor waiting times for bank

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customers, numbers of complaints, customer satisfaction ratings, delivery times, and so on.

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Review process

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PROPOSAL OF PRESSING PLANT ORGANIZATION USING PROCESS DESIGNER

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Keywords: production process, optimization of space, Process Designer

Abstract: This contribution is focused on optimizing the usage of space in the production process using software Process Designer. The aim of this contribution is to suggest possible improvements to the existing layout of the selected production process. Using the software Process Designer was chosen production process created in the 3D environment. Subsequently, we have proposed the possible solution of weaknesses in production and this proposal was again created in the 3D environment.

1 Introduction

Production, deployment and optimization of workplace are an important part of the production enterprise. Today every enterprise is trying to optimize and improve the production. Through these processes enterprise becomes faster. [2, 9] The aim of this paper is to optimize the workplace through Tecnomatix – Process Designer.

2 Characteristics of pressing plant and component for optimization

Automotive Plant is a major part of the automotive industry chain, where is performed the production of different vehicles types in certain production facilities. Production of vehicles, i.e. basic principles and procedures in production are relatively uniform across all producers. Automotive Plant consists of the following operations [7]:

1. Pressing Plant,
2. Welding Plant,
3. Paint shop,
4. Assembly,
5. Control.

We focused on one part of the production facilities, on the Pressing Plant. Pressing Plant is the first operation in the Automotive Plant (Figure 1).

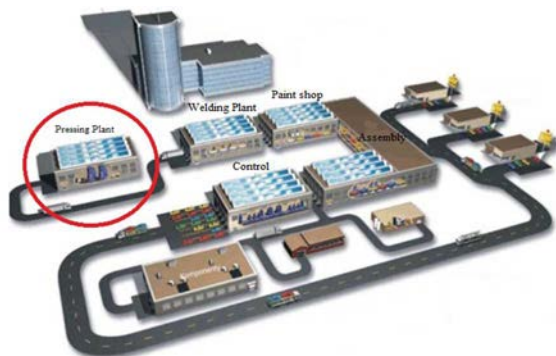


Figure 1 The main operations in the automotive industry

In this operation there are produced different body parts either external or internal, for example roof, doors, flooring parts, splash-board, etc. [6].

The main inputs and outputs in the production process of the front splash-board are shown in figure 2 [4].

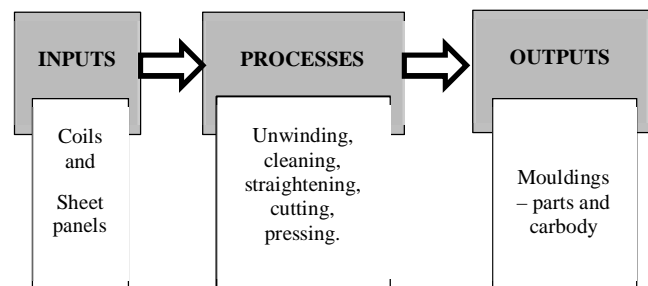


Figure 2 Inputs and outputs of production process

The front splash-board is the part of car body, whose function is mainly to cover up part of the inner wheel curve and splash-board and to protect bogie components against external influences. From an aerodynamic point of view it is very important the panel, which by its shape and location serves the function of bypass air abstraction when the car is in motion, because around wheel curves and wheels themselves are places with a strong division and resistance to air flow. In figure 3 it is shown a 3D model of the outside front splash-board for Audi A6.

PROPOSAL OF PRESSING PLANT ORGANIZATION USING PROCESS DESIGNER

Peter Malega


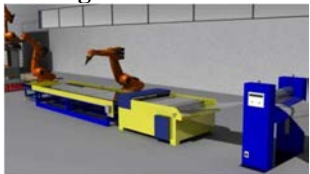
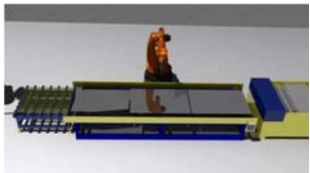




Figure 3 3D model of the outside front splash-board

3 Technological process of production and material flow

Technological process of production of the outside front splash-board from aluminium alloy Al – Mg with marking 5050 is shown in table 1 [8].

Table 1 Technological process of production of the outside front splash-board

<p>Sheet straightening</p> 	<p>Sheet straightening on the levelling devices due to the persistence of shape deformation after sheet unwinding.</p>	<p>Levelling machine</p>
<p>Cutting</p> 	<p>Sheet metal cutting to size 1250 (w) x 1800 (l) by table shears embedded in the straightening machine.</p>	<p>Table shears</p>
<p>Precision cutwork</p> 	<p>Cutting the profile of semi-product for further laser beam processing.</p>	<p>KUKA HA – 100 (High Accuracy)</p>
<p>Sheet metal forming</p> 	<p>Sheet metal forming through mechanical forming technology.</p>	<p>Press ŽDAS – EBS and DBS</p>

<p>Precision trimming</p> 	<p>Trimming allowances of for forming.</p>	<p>KUKA HA – 100</p>
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Material flow comprising the production of components consists of the stages shown in figure 4.

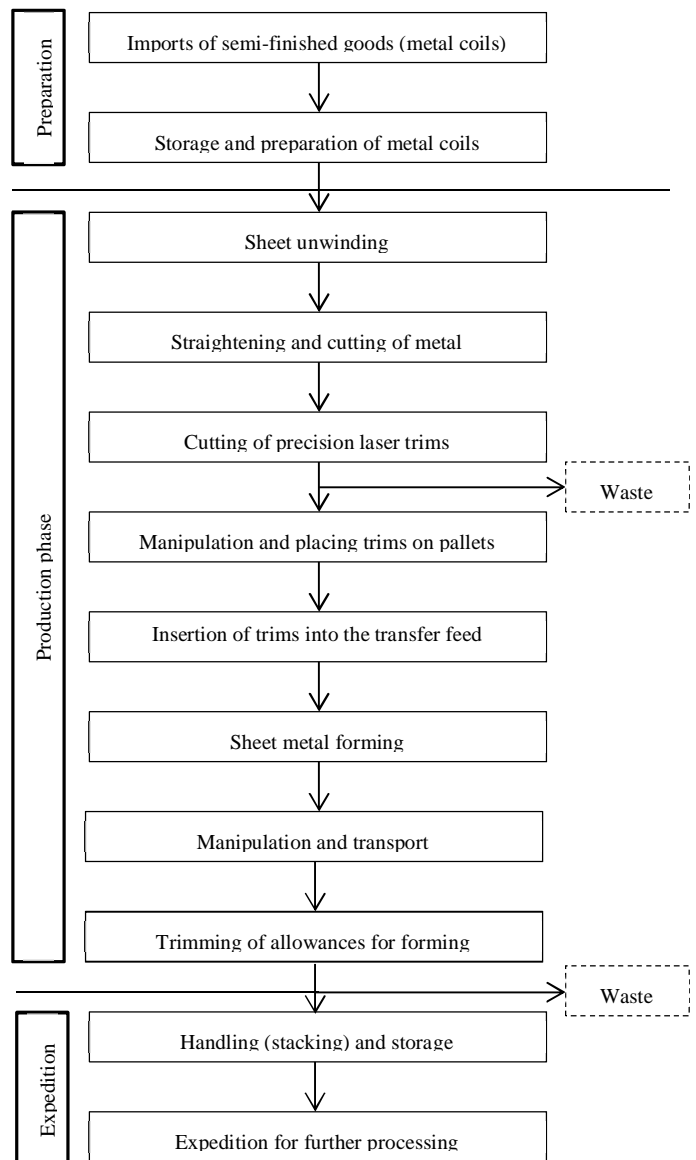


Figure 4 Material flow

PROPOSAL OF PRESSING PLANT ORGANIZATION USING PROCESS DESIGNER

Peter Malega

4 Layout of the enterprise

Material flow in this case starts with import (resp. delivery) of sheet metal rolls into the production plant, where they are stored and prepared for future operations. After delivery and preparation of the semi-finished product are sheet metal rolls with the unwinding devices unwind and they are then straightened in the straightener.

Together in the straightener are integrated table shears, with which material is divided into metal sheets with a thickness of 0.7 mm and dimensions 1250 x 1800 mm. After cutting, occurs laser cutting of trims, which are then fed into the press feeder, where trims are shaped. After forming, the mouldings are trimmed and cut out to

the exact shape, from which are then exported for further processing. The layout of the Pressing Plant is shown in figure 5.

Given the character of the contribution we will not further describe each step to create workplace in Process Designer, while workplace, i.e. Pressing Plant and distribution of individual workplaces can be seen in figure 6.

The last part of this program is the creation of Pert Viewer for the selected department (Pressing Plant). This diagram shows the duration of the splash-board production, respectively the duration of every workplace (stations) and their individual operations (Figure 7).

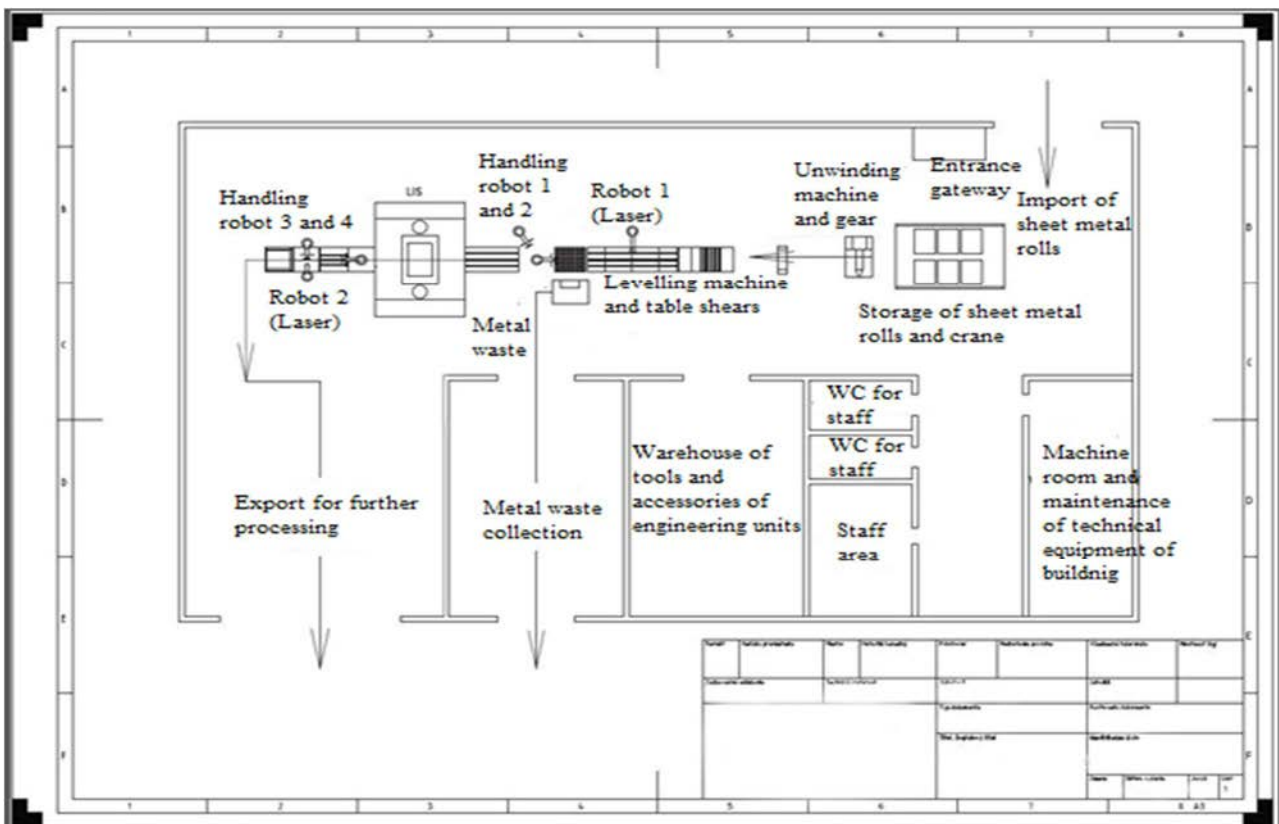


Figure 5 Layout of Pressing Plant

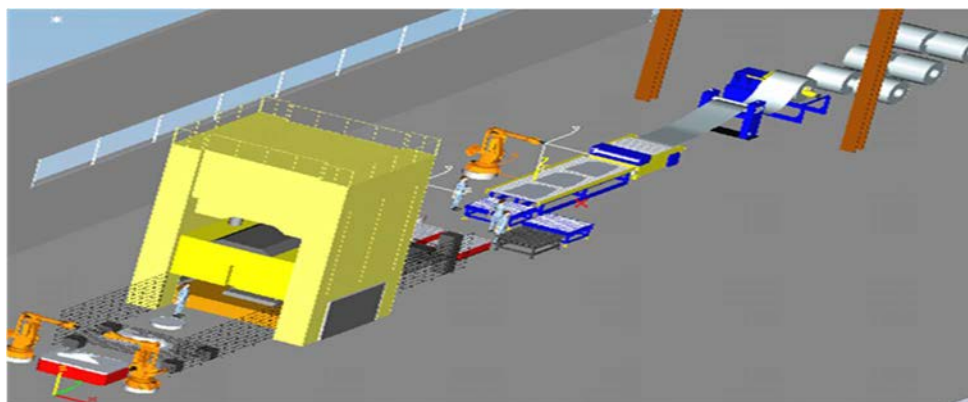


Figure 6 Pressing Plant in Process Designer

PROPOSAL OF PRESSING PLANT ORGANIZATION USING PROCESS DESIGNER

Peter Malega

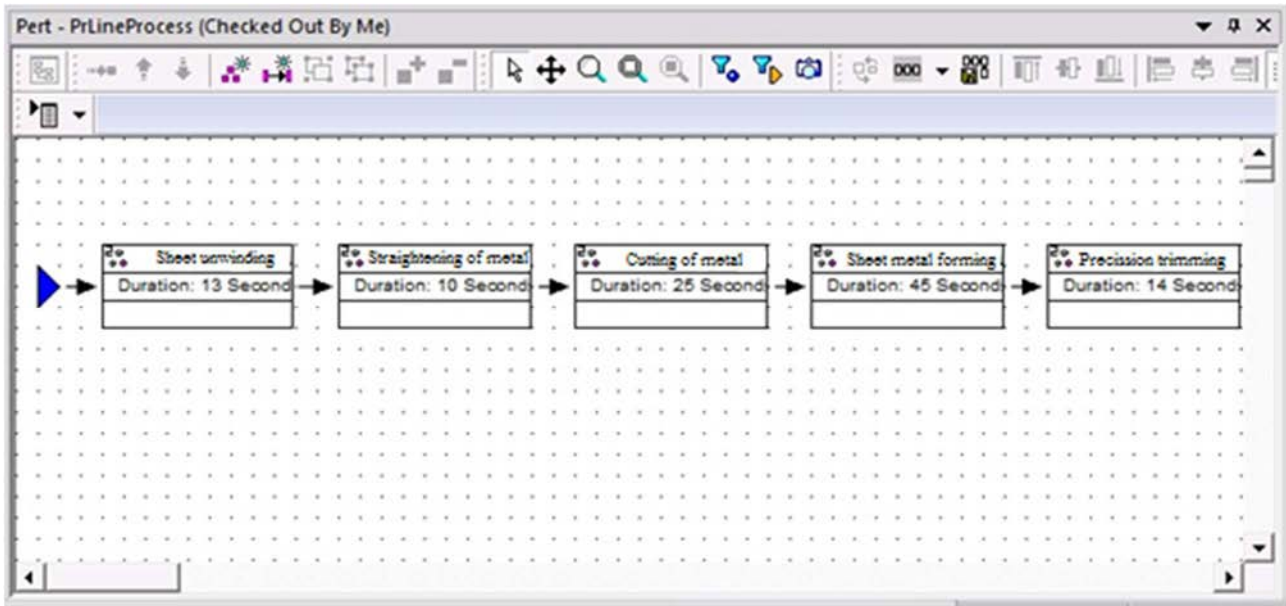


Figure 7 Pert Viewer – before optimization

5 Proposal of workplace optimization

As the Pressing Plant is not fully automated, and at individual workplaces are located workers, the production time of the splash-board is longer than with fully automated lines. On the non-optimized workplace is the duration of the production of the front splash-board 107 seconds. On the Pert Viewer (Figure 7) we can see, that the longest duration is on the station of sheet metal forming, i.e. concretely 45 seconds. Therefore, optimization will be focused on this station.

For this reason, we propose the replacement of workers with robots and then the unification of conveyors.

This change will have a positive impact on the whole production process of the front splash-board. The replacement of workers with robots will mean that the duration of the sheet metal forming will be about 20 seconds shorter. This can be seen in figure 8.

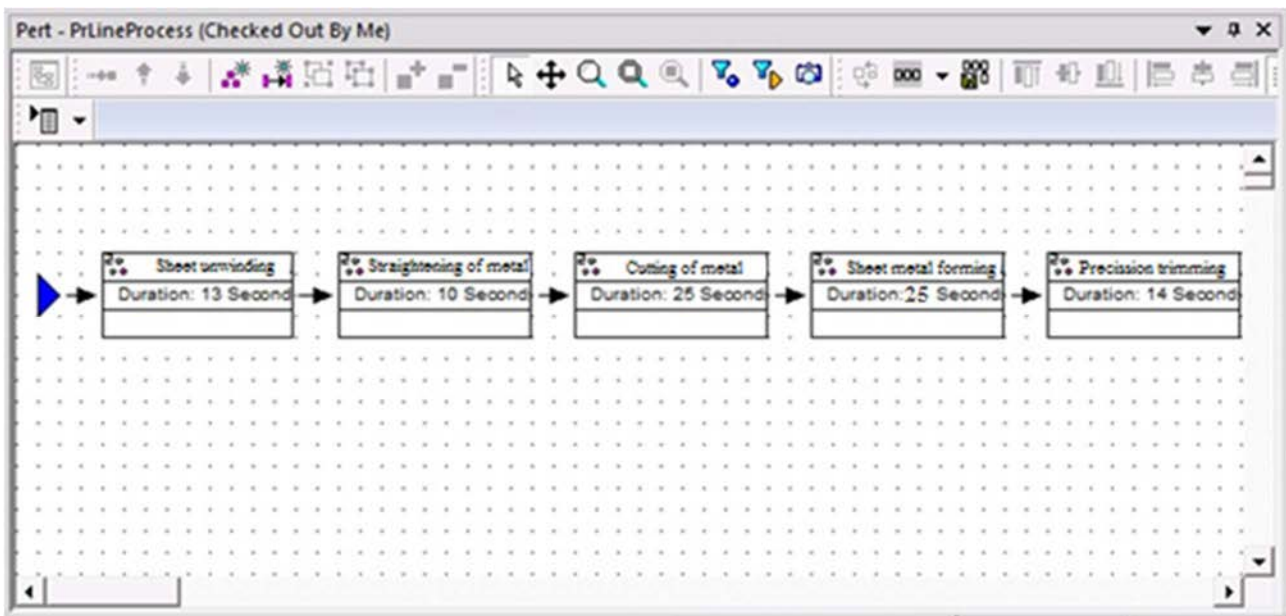


Figure 8 Pert Viewer – after optimization

PROPOSAL OF PRESSING PLANT ORGANIZATION USING PROCESS DESIGNER

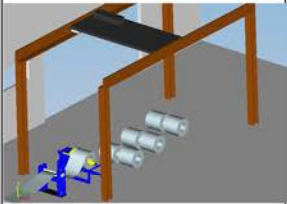
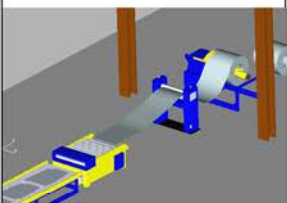
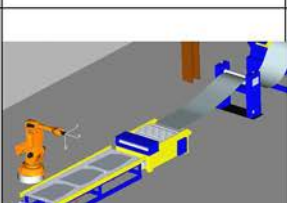
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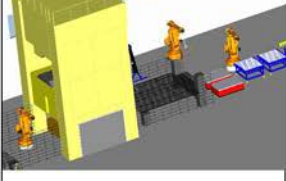
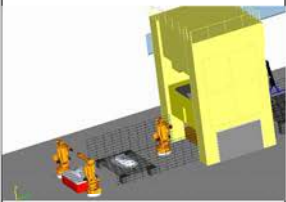
In this workplace we had to create a place for two robots and uniform conveyors. With the realization of this change we have achieved:

- Increased productivity.
- We removed defections associated with the production.
- Production is flexible.
- We reduced the operation duration in the workplace

Table 2 shows the individual workplaces, in which are realized certain operations, operation visualisation and duration of operation before and after the workplace optimization. From Tab. 2 we can deduce that the optimization in terms of workplace layout and the replacement of workers with robots resulted in shortening of the production time of the front splash-board in the Pressing Plant about 20 seconds [8].

Table 2 Duration of operations before and after optimization

Workplace	Visualisation of operation	Duration of operation	
		Before	After
Sheet unwinding		13	13
Straightening of metal		10	10
Cutting of metal		25	25

Sheet metal forming		45	25
Precision trimming		14	14

The parts of optimized workplace are shown on figures from figure 9 to figure 12.

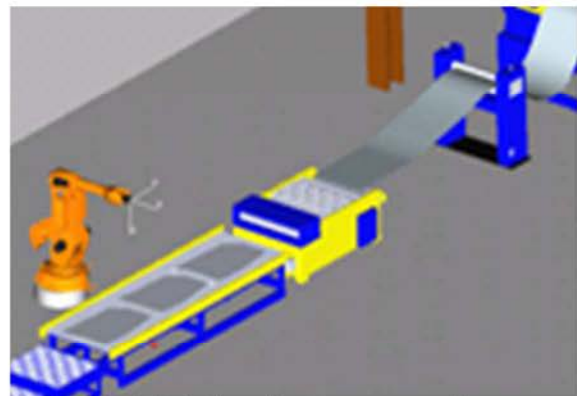


Figure 9 Workplace after optimization – first part

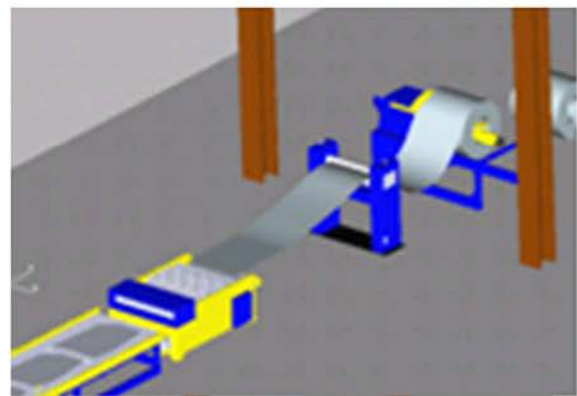


Figure 10 Workplace after optimization – second part

PROPOSAL OF PRESSING PLANT ORGANIZATION USING PROCESS DESIGNER

Peter Malega

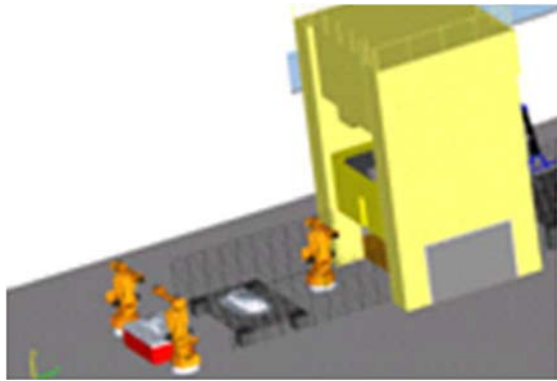


Figure 11 Workplace after optimization – third part

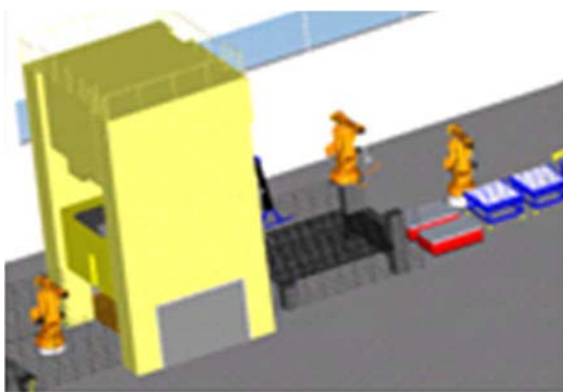


Figure 12 Workplace after optimization – fourth part

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Review process

Single-blind peer reviewed process by two reviewers.

Conclusion

Based on the proposal, which was presented in the previous part of this article – e.g. better placement of conveyors and replacement of workers with robots – it is possible to notice that this application can contribute to more efficient production, time reduction and faster and more fluent production of front splash-board. With these changes we optimized the production in that way that the production time is shorter about 20 seconds.

Acknowledgements

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