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Simulation in Wood Industry. Part II

Simulacija u drvnoj industriji. Dio II.

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ABSTRACT • *The goal of this simulation is to introduce and realize a part of material flow of an international furniture manufacturing company. This simulation was made with a special process-simulation software, called SIMUL8. With SIMUL8 we could simulate the whole process under real circumstances, and obtain the actual values of specific parameters relevant for the company. This opportunity helped the company to develop its strategy - to maximize the production efficiency and to find out the possibble bottle-necks without making any investment, and to rearrange the workcenters effectively.*

Key words: *material flow, simulation, furniture industry*

SAŽETAK • *Cilj simulacije predstavljene u ovome radu bio je opisati i realizirati dio toka materijala u jednoj međunarodnoj tvrtki za proizvodnju namještaja. Simulacija je napravljena s posebnim softverom za izradu simulacija koji se zove SIMUL8. Upotrebom tog softvera moguće je simulirati cijeli proizvodni proces u stvarnim uvjetima i dobiti prave vrijednosti specifičnih parametara proizvodnje koji mogu biti vrlo zanimljivi upravi poduzeća. Ta mogućnost pomaže menadžmentu da kreira strateške odluke kojima će povećati brzinu toka materijala kroz proizvodnju i maksimizirati proizvodnju te uspješno otkriti moguća uska grla proizvodnje bez dodatnih investicija ili stvarnih promjena (premještanja strojeva) u tehnološkom procesu.*

Ključne riječi: *tok materijala, simulacija, industrija namještaja*

1. UVOD
1 INTRODUCTION

In general, we can say that a considerable part of companies in Hungary does not spend enough time and effort to collect proper data for making effective simulations. However, this should be done, because if the essential conditions of simulation are not real, the result will not be real either, of course. On the other hand, we have to mention that in many cases the data aquisition for making simulation needs special knowledge, that companies do not have, or it takes much time to collect data, and companies do not have enough (human) resources to accomplish the collection of data.

Because of that, we have collected the data for making the simulation in an international furniture manufacturing company, producing 8 m^3 timber/shift (shift quantity). The goals of simulation were:
– map the current state
– find out the current bottlenecks
– count the production parameters fluently during the simulation
– provide that further scenarios of company development can be analysed.

2 MATERIAL AND METHODS
2. MATERIJAL I METODE

2.1 Sampling of timber
2.1. Uzorkovanje piljenica

We examined about 600 pieces of boards (about 100 per each sample) wihtin a 4-day collection period, because we did not want to collect data on subsequent days.

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Table 1 Average values and standard deviations of timber length, timber width and timber thickness
Tablica 1. Prosječne vrijednosti i standardne devijacije duljine, širine i debljine piljenica

	Sample 1 *Uzorak 1.*	Sample 2 *Uzorak 2.*	Sample 3 *Uzorak 3.*	Sample 4 *Uzorak 4.*	Sample 5 *Uzorak 5.*	Sample 6 *Uzorak 6.*
$\bar{x}_L$, mm	3233	2918	2665	2645	3449	3298
σ_L, mm	110	95	45	40	39	39
$\bar{x}_W$, mm	332	320	390	354	397	329
σ_W, mm	53	78	16	48	74	63
$\bar{x}_T$, mm	30	40	40	40	40	40
σ_T, mm	0	0	0	0	0	0

$\bar{x}_L$ – average value of timber length, σ_L – standard deviation of timber length, $\bar{x}_W$ – average value of timber width, σ_W – standard deviation of timber width, $\bar{x}_T$ – average value of timber thickness, σ_T – standard deviation of timber thickness
$\bar{x}_L$ – srednja vrijednost duljine piljenica, σ_L – standardna devijacija duljine piljenica, $\bar{x}_W$ – srednja vrijednost širine piljenica, σ_W – standardna devijacija širine piljenica, $\bar{x}_T$ – srednja vrijednost debljine piljenica, σ_T – standardna devijacija debljine piljenica

It was necessary to get proper measurement samples. Had we collected data, for example, for 3 days one after another, the samples could not have reflected enough variousness, and the calculation would not have been correct.

In order to have a good simulation and to be able to create a proper simulation, you have to gather the right data from the real world. The main measured parameters were

- length
- width
- thickness
- standard deviation of length, width and thickness.

Some of the processed data are shown in Table 1.

2.2 Mapping of plant and machinery
2.2. Slika pogona i raspored strojeva

The examination of plant and machinery is at least as important as the collection of the timber data. We have to examine the troughput, (human) resources needs, etc. In this case the examined machines were the following:

- Undertable cross-cut saw for comminuting timber (Figure 1)
- Rip saw for shaping cross section (Figure 2)
- Four-head planer for setting up cross sectional dimensions (Figure 3)
- Croos-cut saw for setting up longitudinal dimensions.

Speaking of machines, it is also important to determine what kind of products are produced by a given machine. This is essential, because these are the key elements of the simulation. Therefore, we determined the products produced by individual machines, as well as the producing priority of the products. This is unavoidable if we want to handle woodwaste recycling, which is a marginal concept of the simulation. The dimension preferences are shown in Table 2.

Figure 2 Rip saw
Slika 2. Kružna pila za uzdužno raspiljivanje

Figure 1 Undertable cross-cut saw
Slika 1. Podstolna poprečna kružna pila

Figure 3 Four-head planer
Slika 3. Četverostrana blanjalica

Table 2 Dimension preferences
Tablica 2. Postavke dimenzija piljenih elemenata

Four-head planer / *četverostrana blanjalica*				
Rank / *rang*		Length / *duljina*, mm		
1.		33		
Undertable cross-cut saw / *podstolna poprečna kružna pila*				
Rank/ *rang*		Length / *duljina*, mm		
1.		1170		
2.		770		
3.		540		
Rip saw / *kružna pila za uzdužno raspiljivanje*				
Length / *duljina*, mm	Width / *širina*, mm			
Rank/ *rang*	1.			
1170	50			
Rank/ *rang*	1.	2.	3.	4.
770	75	40	32	25
Rank/ *rang*	1.			
540	54			

2.3 Building the simulation
2.3. Izrada simulacije

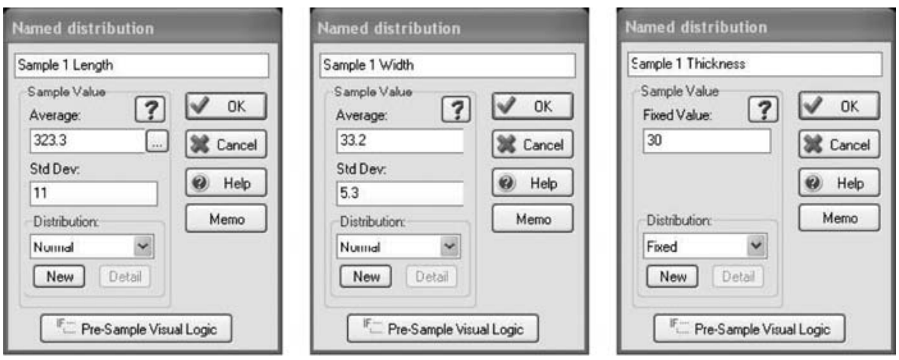
SIMUL8 is an integrated environment for working with simulation models. It enables you to create accurate, flexible and robust simulations quickly. It is a very felxible solution: parametrizable and programmable and insensitive to different kinds of input and output formats. It provides all of the essential simulation building blocks, including:

– Work Entry Points
– Storage Bins
– Work Centers
– Work Exits Points
– Workpiece

and other indispensable features, like:
– Connectivity (SQL, XML, COM)
– OptQuest and Stat::Fit for optimization to low cost or high income
– Ability to share models with people who do not have SIMUL8 licenses
– Ability to merge simulations
– Virtual Reality, to represent the simulation in a realistic 3D environment
– Enhanced debugging tools, e.g. value hover tips in Visual Logic, Monitor spreadsheets at runtime.
– ABC Costing
– Speed Analyzers
– Additional objects.

2.4 Applying sampled timber data
2.4. Primjena podataka dobivenih na uzorcima

The first step in building the simulation is to apply the sampled data on the simulation model. In this case, these values are presented in *Table* . *Figure 4* shows the 'SIMUL8 creating distribution pop-up window' with the *Sample 1* values. This step guarantees that SIMUL8 will generate boards with dimensions specified in the distributions. The generators of the boards are the Work Entry Points.



Length Width Thickness

Figure 4 Applying *Sample 1* timber data on the simulation model
Slika 4. Primjena podataka za uzorak 1. na simulacijskome modelu

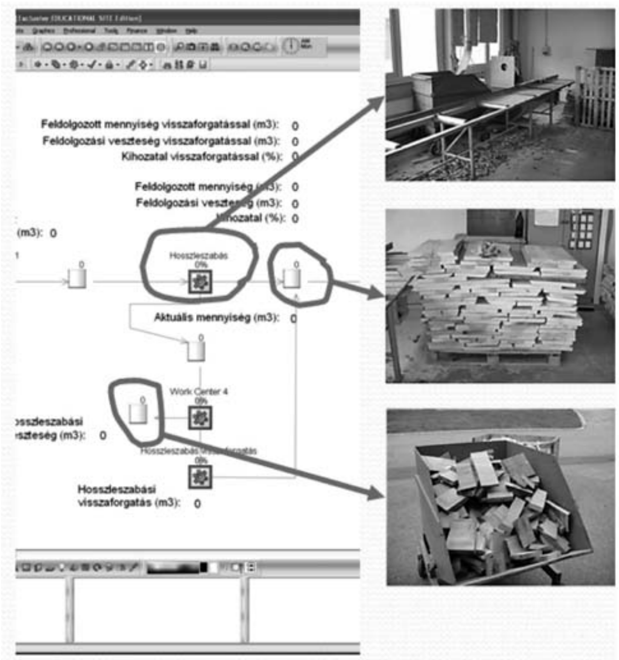


Figure 5 Process and output of undertable cross-cut saw in the simulation and in reality
Slika 5. Proces i proizvodi na podstolnoj poprečnoj kružnoj pili

2.5 Creating specialized simulation objects
2.5. Izrada specijaliziranih simulacijskih objekata

SIMUL8 has just a few types of objects to build a simulation, but it offers the opportunity to specialize any of them. It can be done by a simple, but powerful script language called *VisualLogic*. It enables any object to operate just like in reality.

It is not necessary to specialize objects for simple simulations, but as the job gets more complicated, it becomes unavoidable. SIMUL8 reckons everything in the simulation as an object. The objects can have different kinds of attributes of course and some of them (e.g. Work Centers) can handle events, too. It is very practical, because if you want to represent an attribute – like length, width, thickness – in the simulation, you just add these attributes as *Labels* to the Workpiece. From the time you have added these attributes, you can handle the workpiece trough these attributes of course.

The application of specialized simulation objects is presented bellow.

2.6 Description of simulation of machine work
2.6. Opis simulacije rada strojeva

Undertable cross-cut saw

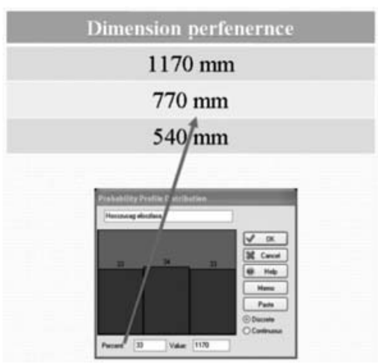
The main function of undertable cross-cut saw is to comminute the timber. There is a dimension preference that contains the actual cutting length. The waste can be of two types: effective waste and recyclable waste (Figure5).

Figure 6 shows the probability profile of the dimensions of products produced by the undertable cross-cut saw and a part of the simulation programme.

Rip saw

The main function of rip saw is to shape cross section of the timber. There is a dimension preference that contains the width preferences for different lengths of timber. The waste can be of two types: effective waste and recyclable waste. (Figure 7)

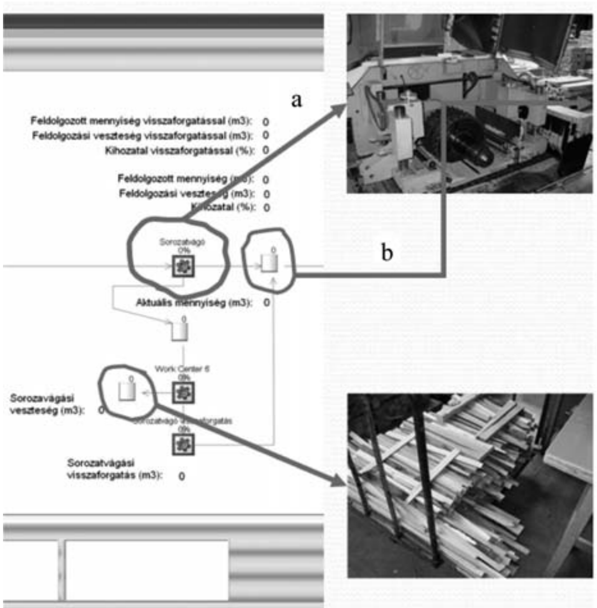
Figure 8 shows the probability profile of the rip saw in the simulation and a part of the simulation programme. There is a 3 fork IF condition that examines the




```
VL SECTION: Undertable cross-cut saw Route In After Logic

SET Newlength = Length distribution
SET Undertable cross-cut saw BatchOut =
TRUNC[[Length*10]/Newlength]
SET Undertable cross-cut saw.Batching Out Size = Undertable cross-cut
saw BatchOut
SET Length= Newlength
```

Figure 6 Probability profile of the dimensions of products produced by the undertable cross-cut saw
Slika 6. Profil vjerojatnosti dimenzija proizvoda izrađenih na podstolnoj poprečnoj kružnoj pili



(a) rip saw / *uzdužna kružna pila*
(b) product of rip saw / *proizvod*

(a) rip saw waste / *otpad*

Figure 7 Process and output of the rip saw in the simulation and in reality
Slika 7. Proces piljenja i proizvodi dobiveni na kružnoj pili za uzdužno piljenje

length label of the incoming workpiece, and depending on its length it completes the adequate job in 4 steps:

1. Gets a new width value, according to the set distribution
2. Divides the incoming board to the number of slat to be reached by the given width
3. Sets the outgoing number of slat of the work center
4. Sets the new width label value on the newly created slat.

Four-head planer

The role of the four-head planer is to shape the final cross-section of the workpiece. There is only effective woodwaste here, as the rejected number of workpieces are not taken into consideration (Figure 9).

The control script of the four-head planer is simple. For a given length, it chooses a width from the table of Width Preference. The thickness is the same for each workpiece.

The part of the simulation program is as follows:

```
VL SECTION: Four-head planer Route In After Logic
  IF Length = 1170
   SET Width = Distribution of width 1
 ELSE IF Length = 770
   SET Width = Distribution of width 2
 ELSE IF Length = 540
   SET Width = Distribution of width 3
  SET Vastagsag = 33
```

Croos-cut saw for setting up the longitudinal dimensions

Its role is to shape the final length of the workpiece. There is only effective woodwaste here, as the rejected number of workpieces are not taken into consideration. Figure 10 shows the probability of the products to be produced on the croos-cut saw for setting up the longitudinal dimension.

The recycling routine is also simple. If the incoming workpiece had some dimension or quality defects, it would be withdrawn. However, in order to decrease the loss, you have to examine what happens if you do not

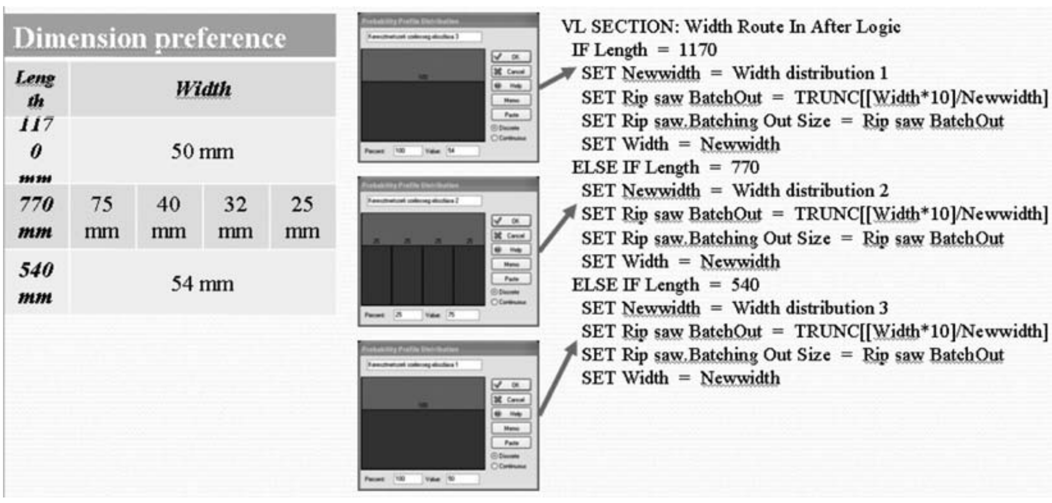


Figure 8 Probability profile of rip saw in the simulation (both graphical and logical representation)
Slika 8. Profil vjerojatnosti dimenzija proizvoda na kružnoj pili za uzdužno piljenje (grafički i logički)

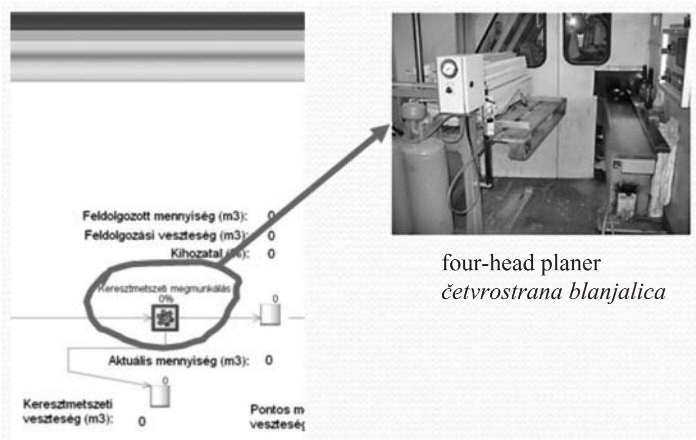


Figure 9 Four-head planer in the simulations and in reality
Slika 9. Četverostrana blanjalica u simulaciji i u stvarnosti

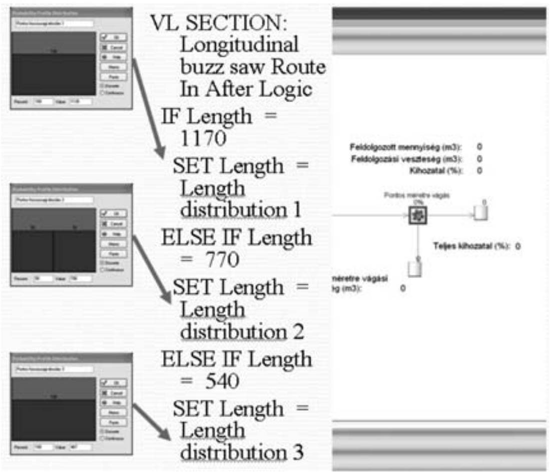


Figure 10 Probability of the products to be produced on the croos-cut saw for setting up the longitudinal dimension
Slika 10. Vjerojatnost izrade određenih proizvoda na kružnoj pili za dimenzioniranje duljine

cut these workpieces to their nominal dimension but to a smaller dimension. In case of smaller dimensions they will be faultless so it is worth a while to cut them to a smaller dimension. Choosing the proper dimension is simple: you have to choose the greatest dimension among the smaller dimensions and not the nominal dimension. If it fits, the workpiece can be used for further processing. If it does not fit, you have to try with a smaller dimension. If the smallest dimension does not fit, then the workpiece should be really withdrawn.

The recycling routine is:

```
VL SECTION: Recycling Route In After Logic
  IF Length = 770
   IF Width = 80
    SET Width = 46
   ELSE IF Width = 46
    SET Width = 40
   ELSE IF Width = 40
    SET Width = 33
```

3 RESULTS AND DISCUSSION
3. REZULTATI I DISKUSIJA

The main concept – when creating a simulation – is how to develop a simulation model for the desired values, principals. When the model is accurate enough, these values enable us to predict which production strategy will be the most successful. Some of the most important values we want to get can be seen in Table 3.

Table 3 Some output parameters of the simulation
Tablica 3. Nekoliko izlaznih veličina simulacije

I.	
Processed quantity with waste recycling / *Proizvedena količina s reparacijom*	9.32137 m^3
Waste with recycling / *Ostaci s reparacijom*	1.52262 m^3
Yield with recycling / *Iskorištenje s reparacijom*	83.66532 %
Processed quantity / *Proizvedena količina bez reparacije*	8.65572 m^3
Processed waste / *Ostaci*	1.47726 m^3
Yield / *Iskorištenje*	82.93315 %
II.	
Waste / *Ostaci*	0.6203 m^3
III.	
Recycleable waste / *Ostaci koji se mogu reparirati*	0.67795 m^3
IV.	
Total yield of system / *Ukupno iskorištenje sustava*	42.11745 %

Table 4 Detailed results of simulation
Tablica 4. Prikaz detaljnih rezulata simulacije

Simulation results (shortened) / *Skraćeni prikaz rezultata simulacije*										
Simulation object *Object simulacije*	**Measured variable** *Mjerena veličina*	**Worst case** *Najlošiji slučaj*			**Actual case** *Stvarni slučaj*			**Ideal case** *Idealan slučaj*		
		-95%	Ave	95%	-95%	Ave	95%	-95%	Ave	95%
Undertable cross-cut saw *Podstolna poprečna kružna pila*	Waiting, % / *zastoj, %*	47.26	49.07	50.89	47.26	49.07	50.89	47.26	49.07	50.89
	Working, % / *rad stroja, %*	48.42	49.76	51.09	48.42	49.76	51.09	48.42	49.76	51.09
	Average use *srednja iskoristivost stroja*	0.48	0.52	0.57	0.48	0.52	0.57	0.48	0.52	0.57
	Total yield, % *iskorištenje, %*	81.66	84.41	87.17	81.85	84.42	87	82.67	83.26	83.84
Rip saw *Kružna pila za uzdužno raspiljivanje*	Waiting, % / *zastoj, %*	69.45	71.03	72.62	67.61	69.31	71.02	64.67	65.65	66.63
	Working, % / *rad stroja, %*	26.78	28.37	29.96	28.43	30.09	31.75	33	33.75	34.51
	Average use *srednja iskoristivost stroja*	0.28	0.31	0.33	0.27	0.32	0.37	0.29	0.34	0.4
	Total yield, % / *iskorištenje, %*	66.72	68.88	71.03	79.7	81.21	82.73	99.08	99.21	99.35
Four-head planer *Četverostrana blanjalica*	Waiting, % / *zastoj, %*	75.32	77.10	78.88	71.34	73.52	75.69	64.22	65.53	66.85
	Working, % / *rad stroja, %*	20.74	22.26	23.79	23.95	25.62	27.29	32.54	33.45	34.36
	Average use *srednja iskoristivost stroja*	0.17	0.23	0.28	0.185	0.26	0.33	0.21	0.31	0.4
	Total yield, % / *iskorištenje, %*	51.00	54.50	58.00	70.49	72.44	74.39	69.99	70.94	71.88
Cross-cut saw for setting up longitudional dimensions *Kružna pila za dimenzioniranje duljine*	Waiting, % / *zastoj, %*	98.99	99.05	99.11	98.76	98.82	98.88	97.35	97.89	98.44
	Working, % / *rad stroja, %*	0.88	0.94	1.00	1.11	1.17	1.23	1.48	1.52	1.55
	Average use *srednja iskoristivost stroja*	0.00	0.01	0.03	0	0.01	0.02	0.01	0.03	0.05
	Total yield, % / *iskorištenje, %*	65.67	67.80	69.92	88.76	89.21	89.66	88.36	89.08	89.79
Total yield of system, % / *Ukupno iskorištenje, %*		28.90	30.55	32.19	40.42	42.25	44.07	55.10	55.52	55.95

As we mentioned before, the basic data are always one of the most important parts of a simulation. If the basic data are not accurate the result will not be accurate either. Inspite of that, simulations provide the possibility to take examinations without having to make any investment, or rearrange the technology. With SIMUL8 it is possible to create very detailed customized reports.

Table 4 shows the report of this simulation. It consits of 3 cases, the *worst case*, the *actual case*, and the *ideal case*. In the worst case we assumed that the company buys timber of relatively poor quality. This implies that the machine utilization is high, but the yield is low because of a high timber loss. In the actual case we applied the sample values that were actually used. In the ideal case we assumed that the company buys good quality timber. The results clearly show that the yield is very high, while the loss of wood is very low.

Now, having the results of the 3 cases (worst, optimal, ideal), the company has the opportunity to decide what type of buying policy should be followed.

4 CONCLUSION
4. ZAKLJUČAK

The basic data are always one of the most important parts of a simulation. With SIMUL8 we could simulate the whole process under real circumstances, and obtain the actual values of specific parameters relevant for the company. This opportunity helped the company to develop its strategy - to maximize the production efficiency and to find out the possibble bottle-necks without making any investment, and to rearrange the workcenters effectively. With the simulation results, the company has the opportunity to decide what policy of production and company development should be followed.

5 REFERENCES
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