

---

# MODELING OF LOGISTICS PROCESSES

## ACTIVITY #4

# Quality control station

---

dr hab. Daniel Kaszubowski, prof. PG

Department of Transportation Engineering



Co-funded by  
the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author or authors only and do not necessarily reflect those of the European Union or the Foundation for the Development of the Education System. Neither the European Union nor the entity providing the grant can be held responsible for them.



## 1. Objective and new skills

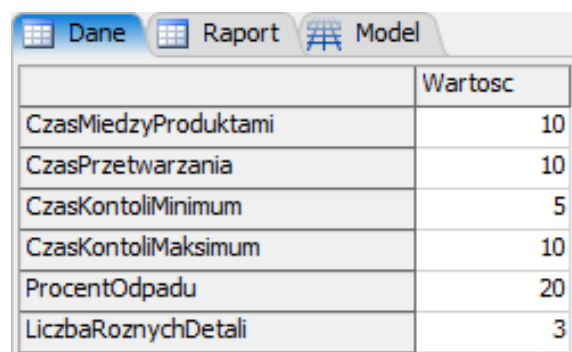
The task is intended to consolidate the ability to configure the logic of the flow of elements on the example of solutions simulating the operation of the quality control system. This allows for the introduction of callbacks in the model using conditional formulas and data saved in global tables.

New skills
Introduction of reverse flow logic in the model
Saving item statistics in global tables
Creating new types of graphs for analyzing simulation results

## 2. Assumptions and input data

1. Elements appear in the system according to an exponential distribution with a scale parameter value of 10.
2. Each type of product is processed at a dedicated service station. The processing time is fixed at 10 seconds.
3. After processing, the products are collected in a common buffer before the quality control station.
4. The quality control time of one element is between 5 and 10 seconds.
5. It was assumed that 20% of the products do not meet quality standards and must be reprocessed.
6. A product that fails to meet quality standards again is removed from the system.
7. All parameters are saved in the global table.
8. A register is kept of products that do not meet quality standards.
9. The load on buffers and machines will be analyzed.

The input data are collected in the global *Data table* (Fig. 1), while the target model layout is shown in Fig. 2.



The screenshot shows a software window with three tabs: 'Dane', 'Raport', and 'Model'. The 'Dane' tab is active, displaying a table with two columns: parameter names and their values. The parameters listed are 'CzasMiedzyProduktami' (10), 'CzasPrzetwarzania' (10), 'CzasKontoliMinimum' (5), 'CzasKontoliMaksimum' (10), 'ProcentOpadu' (20), and 'LiczbaRoznychDetali' (3).

	Wartosc
CzasMiedzyProduktami	10
CzasPrzetwarzania	10
CzasKontoliMinimum	5
CzasKontoliMaksimum	10
ProcentOpadu	20
LiczbaRoznychDetali	3

Fig. 1. Model parameters in the *Data table*

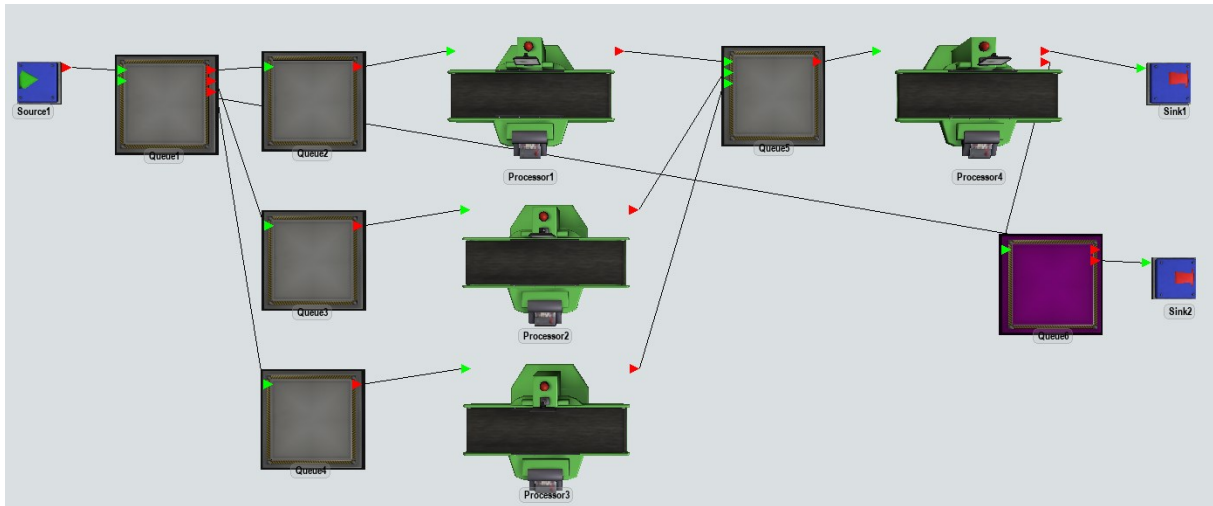


Fig. 2. Target model layout

### 3. Object parameters and flow logic

#### 3.1. Flow element

The model will use the standard *Box element*. Two numeric labels should be added to it (Fig. 3):

1. ProductType – the label will store the product number.
2. Number of Controls – the label records the number of tests on a given element.

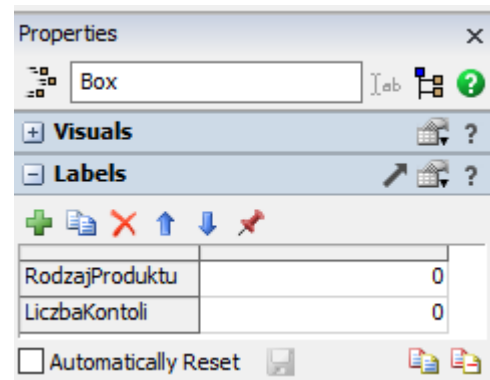


Fig. 3 Data labels

#### 3.2. Source

The source will generate flow elements according to the *Inter-Arrival Time option*. The default exponential distribution formula will be modified by inserting the scale parameter value from the *Data table*, row 1 (Fig. 4).

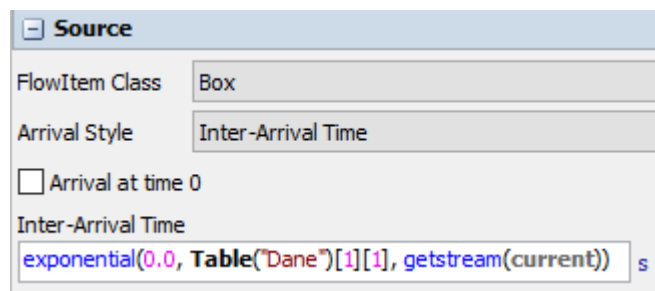


Fig. 4 Source settings based on the *Data table*

Next, go to the *Triggers* → *Data* → *Set Label and Color* section to assign a value to the **ProductType** label. The product color will be added automatically. The modification of the record will concern the formula in the *Value field*, where the number of different product types will be taken from the *Data table* (Fig.5).

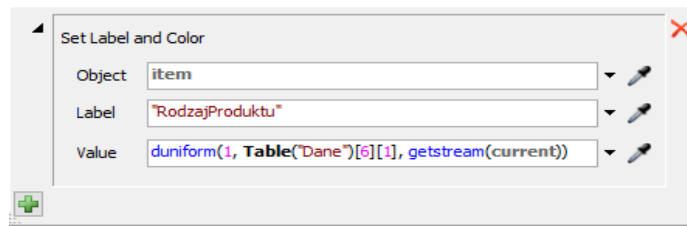


Fig. 5 Settings *Set Label and Color*

### 3.3. Product flow separating buffer

Directly behind the source is the *Queue1* buffer, which divides the stream of products. It is necessary because it allows for the reprocessing of products that did not meet quality standards. This can be seen in the list of input and output ports (Fig. 6). Both products generated in *Source1* and products that did not pass quality control on the *Processor4* machine and were sent for reprocessing can be sent to *Queue1*.

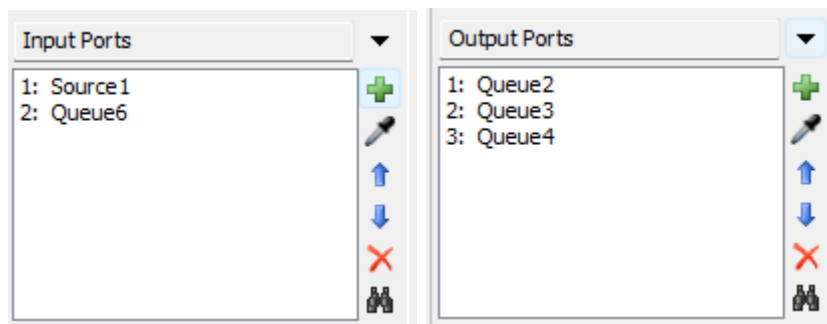


Fig. 6 Set Label and Color Settings

The rules for moving flow elements to subsequent objects can be set in *Send to Port* by entering the *item* entry. *ProductType* (fig. 7).

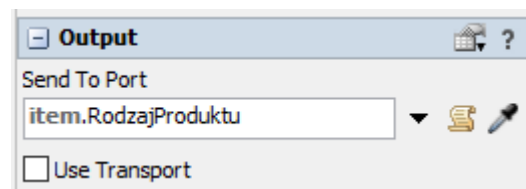


Fig. 7 *Send To Port* Setting

You can also consider using the *Conditional Port option* (Fig. 8). If the value of the *ProductType* label is less than or equal to 3, it goes to the output port with the number corresponding to the label value. Otherwise, the product goes to the first free output port (value "0" in the *False* field).

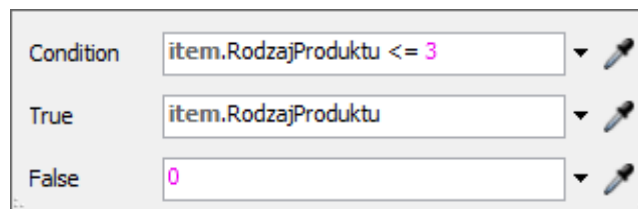
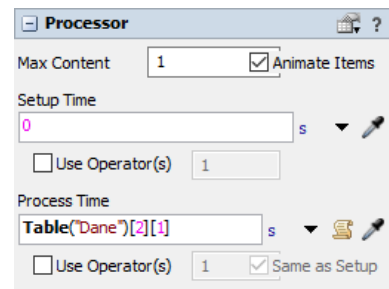


Fig. 8 Alternative *Send to Port* setting

### 3.4. Processing stations

The processing station settings only require entering a reference to the appropriate *Data* table cell in the *Process Time* field (Fig. 9).



Process Time settings

### 3.5. Quality control station

Quality control is performed on *Processor4* stations. Its time is set to 5 to 10 seconds. Select *Process Time* → *Statistical Distribution* → *Uniform*, i.e. uniform continuous statistical distribution. The value of the limit parameters is read from the appropriate fields of the *Data table* (Fig. 10).

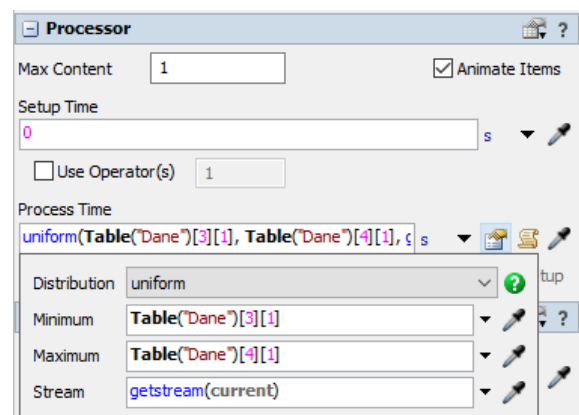


Fig. 10 Quality control time settings

Elements from the quality control station will be directed either to the system output *Sink1* or to be reprocessed to the *Queue1* buffer after defects are detected. Elements can be separated by using the *Send to Port* → *Random* → *By Percentage option*, where data from the *Data table* regarding the percentage of defective products (waste percentage) will be used (Fig. 11).

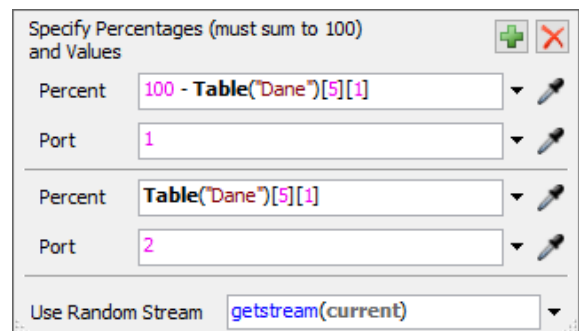


Fig. 11. Quality control station output settings

The quality control system requires marking of already checked items. As indicated in the assumptions, products that fail quality control again are removed. Each product has a label *Number of Controls*, which will be updated after passing the quality control station. Select *Triggers* → *On Process Finish* → *Data* → *Increment Value*. Then you need to select the *Labels option* expression to be increased along with the increase value specified in the *by field* (Fig. 12). The final formula is shown in Fig. 13.

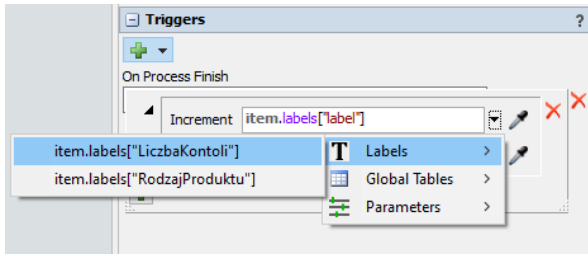


Fig. 12. Increment Value option settings

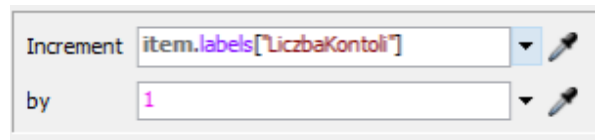


Fig. 13. The final form of the formula

#### 4. Register of defective products

A table (register) will be created in the model, where information about defective products will be recorded. It will be created in the same way as the *Data* table, i.e. in *Toolbox* → *Global Table*. The new table should be named *Report* (Fig. 14). Three columns will store information about:

1. the time at which the defective product appeared,
2. type of product,
3. number of quality tests for this product.

	Czas	RodzajProduktu	NumerTestu
Row 1	0	0	0

Fig. 14 Table *Report*

The table will be filled in dynamically during the simulation. For this purpose, it is necessary to indicate the moment (object) at which information about defective products will be collected. Knowing the principles of the model and its target structure, it seems reasonable to indicate either the re-entry of the defective product to the *Queue1* separating buffer or its exit from the *Processor4* control station. However, each of the indicated events applies to both correct and defective products.

Therefore, a simple solution to the problem is to add an auxiliary object that collects information about defective products. This will be *Queue6* between the control station and *Queue1*. This object acts as a virtual element of the model introduced solely for analytical purposes (Fig. 15).

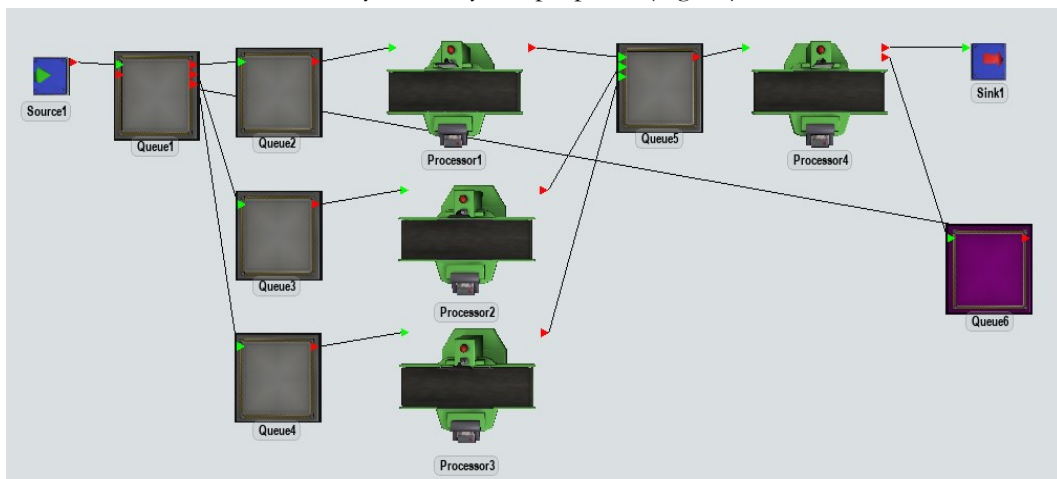


Fig. 15. Helper object *Queue6*

On *Queue6* you need to choose *Triggers* → *On Entry* → *Data* → *Add Row and Data to Global Table*. Each time a product hits this buffer, another row will be added to the selected table. The configuration of the function (Fig. 16) consists of indicating the name of the modified table (*Table*) and adding the appropriate columns, in this case *item.ProductType* and *item.ControlNumber*. Option *Model.time* is the default reference that returns the event time. The result of the function is shown in Fig.17. It is worth remembering to select the *On Reset* option in the *Report* table settings → *Delete All Rows*. The table updates automatically, but without resetting the results of subsequent simulations would be added as additional rows to the end of the table.

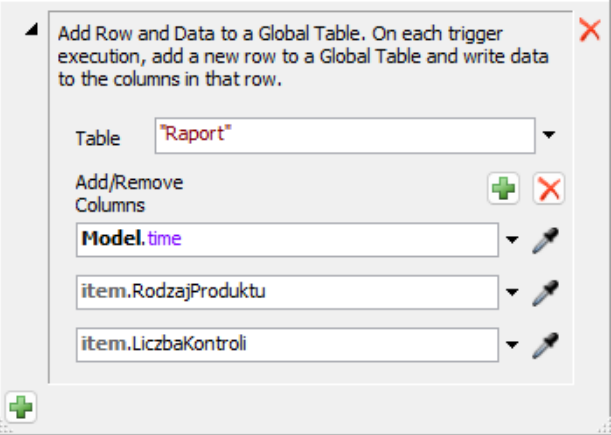


Fig. 16. Table completion function

	Czas	RodzajProduktu	LiczbaKontroli
	38.49	3	1
	147.86	3	1
	179.49	3	1
	187.47	3	2
	202.78	1	1
	209.45	2	1
	222.91	1	1
	236.99	1	2
	270.96	1	2
	323.55	1	1
	340.44	3	1
	357.32	1	2
	413.45	2	1
	418.65	1	1
	473.49	2	1
	482.30	2	1
	488.26	1	1
	755.08	3	1
	791.59	3	1
	942.18	1	1
	1041.91	2	1
	1056.93	2	2
	1101.59	2	1
	1126.43	2	2
	1140.76	2	1

Fig. 17. Fragment of the completed *Report* table

The last stage of building the model is to remove from the system products that have failed to meet quality standards again. This can be easily solved by adding a second output *Sink2* to the auxiliary queue *Queue6*, which will allow for the division of the stream of elements. The flow logic on this buffer will be defined as *Send to Port* → *Conditional Port* (Fig. 18).

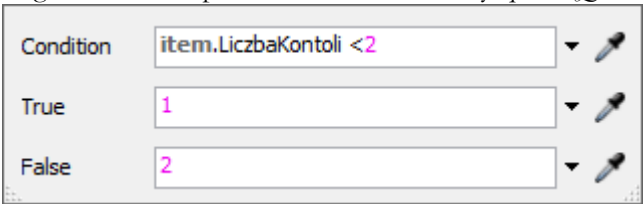


Fig. 18. Output setting on *Queue6*

## 5. Analysis of simulation results

### 5.1. Buffer Occupancy

The model will be run for 8h (28800 sec). The analysis will include buffer occupancy and the number of products removed from the system. First, you need to add a new *Dashboard* → *Add Blank Dashboard*, which will display charts for all buffers.

Then, from the *Content* group, select *Content* → *Line Chart*, add it to the *Dashboard* panel, change the name and add the appropriate object to the chart (Fig. 19). The name is changed in *Properties*, while objects are added in *Options* using the green cross.

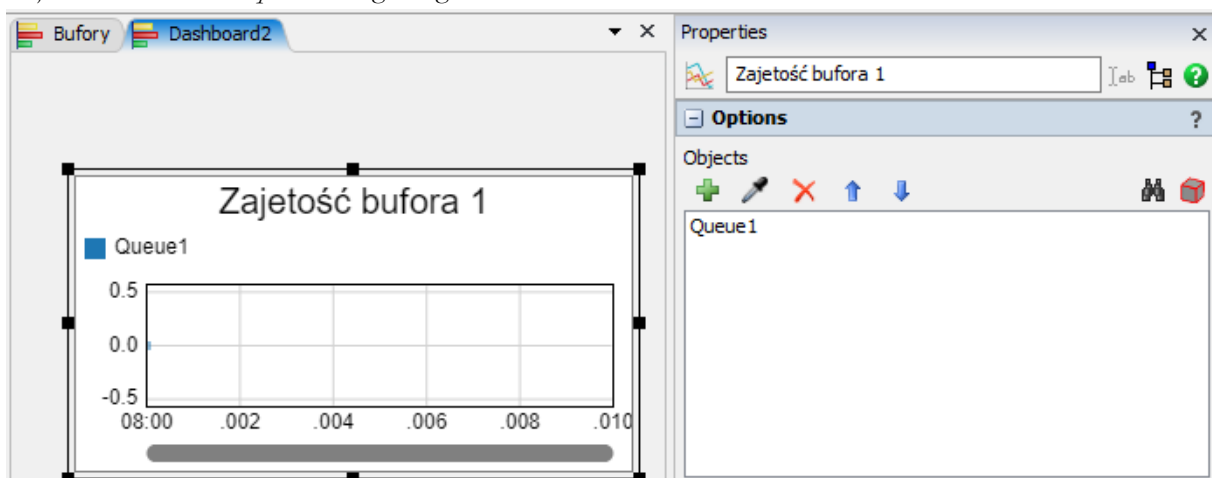


Figure 19. Buffer usage line graph settings

After repeating the described steps for all buffers in the model and running it, the simulation result is shown in Fig. 20.

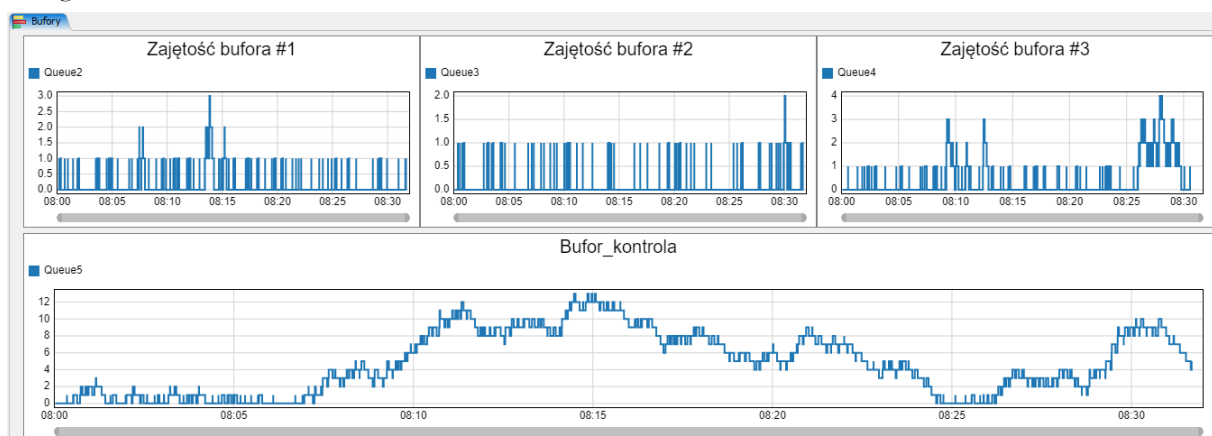


Figure 20. Results of buffer occupancy analysis during simulation

## 5.2. Machine load

The load of machines will be presented in a pie chart. You should add another *Dashboard window*, then *the State* → *State* → *Pie Chart group*. The statistics of all machines will be placed on one diagram after adding them in the *Objects options* (Fig. 21). The simulation result is shown in Fig. 22

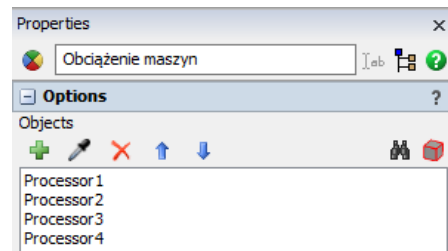


Fig. 21 Machine Load Chart

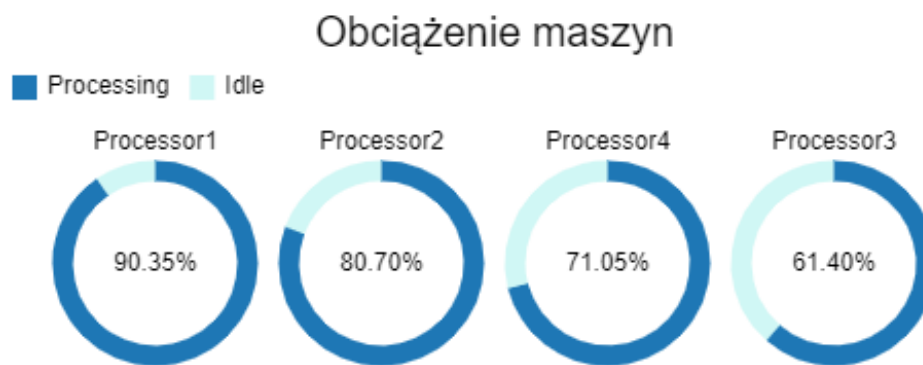



Fig. 22. Simulation result – machine load statistics

## 5.3. Defective products

The following values should be analyzed:

1. The number of products generated without the need for correction.
2. The number of products generated for which correction was required.
3. Number of invalid (rejected) products.

 Products generated by the source can be read from its statistics and transferred to *the Dashboard*. In the section *Statistics* → *Throughput* → *Pin to New Dashboard* → *Output* → *Table*. After the simulation is finished, the result will look similar to Figure 23.

Wygenerowane produkty	
Object	Throughput
Source1	2790

Fig. 23. List of generated elements

In a similar way, you can read how many items were transferred to *Sink1* (correct products) and *Sink2* (rejected products). In the *Output tab* you must select the category of the same name and then the *Table format*.

Wyjście z systemu	
Object	Throughput
Sink1	2668
Sink2	119

Figure 24. List of system outputs

The total number of objects that left the system (2787) is smaller than the number of generated objects (2790). This is due to the fact that part of the element at the time of the simulation ending is still on objects, e.g. workstations.

Another issue is the number of items that required correction. This can be read from the statistics of *Queue1*, i.e. the separating buffer (Fig. 25). It produced 3336 items, which, with 2790 generated by *Sink1*, gives 546 products requiring correction. This can also be confirmed by subtracting the number of rejected items (119) from the total number of entries in the reporting table (665), where information about all items requiring correction, both once and repeatedly, was recorded.

Statistics				
State: empty				
Throughput				
Input		Output		
3336.00		3336.00		
Content				
Curr	Min	Max	Avg	
0.00	0.00	1.00	0.00	
Staytime				
Min	Max		Avg	
0.00	0.00		0.00	

Fig. 25 Queue1 statistics