

Modeling, Simulation and Optimization of a Robotic Flexible Manufacturing Packaging – Palletizing Cell

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Abstract— *One of the essential conditions underlying the optimal integration Industrial Robot in a technological environment starts from the realization of the interdependence between the general architecture of the workspace and the Industrial Robot and its correlative with the type of operations to be performed. This will take into account all technological equipment, components perirobotice, items handled, both in terms of construction, but mostly functional, because the functioning of all the components that participate directly in an application robot need to be mutually synchronized and controlled by sensors and transducers. Therefore, the choice of robot needed to be integrated defining its geometric characteristics, constructive, functional and its location in a technological environment involves the study prior to the arrangement of space, and functioning of all other components of the cell / island / line of production or palletizing. Program used Flexsim.*

Keywords— *Robot, cell, production, optimization, palletizing*

I. INTRODUCTION

The aim of the study is to simulate and optimize the flow of a flexible robotic manufacturing and packing palletizing cell. In the cell will pack coffee packets in boxes and boxes will be put on pallets to create a stack to be foiled and stored. The cell consists of 2 robots 5 conveyors, a pallet dispenser, a wrapping machine, a forklift and human operators.

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Packing and palletizing operation presented by the theme of the project, namely packaging boxes and packages in effective palletization of boxes is performed by a industrial robot that performs the next moves:

From the source S1 the coffee packets go into the buffer B1 and are taken by conveyor C1 and carried to the packing point MC1 .

From the sources S2 the boxes are arriving in buffer B2 and are taken by conveyor C2 and carried on the point of packing MC1 .

The R1 robot puts in six packs per box . After filling the box the robot R1 moves the box from the point of packing MC1t on to the conveyor C3 that leads to point packing Mc2 .

From the S3 sources the pallets are arriving in the buffer B3 and are taken by conveyor C4 and taken on the point of packing Mc2 .

The robot R2 puts eight boxes on each pallet and after filling the pallet the robot R2 moves the pallet (stack) on the conveyor C5 and puts it in the buffer B4 and then taken by a forklift and deposited in the storage system .

II. INTRODUCING THE ROBOTIC FLEXIBLE CELL FOR MANUFACTURING AND PACKAGING - PALLETIZING

Figure 1.1 and Figure 1.2 is an overview of the basic architecture of the cell, this architecture were created in Flexsim.and Inventor

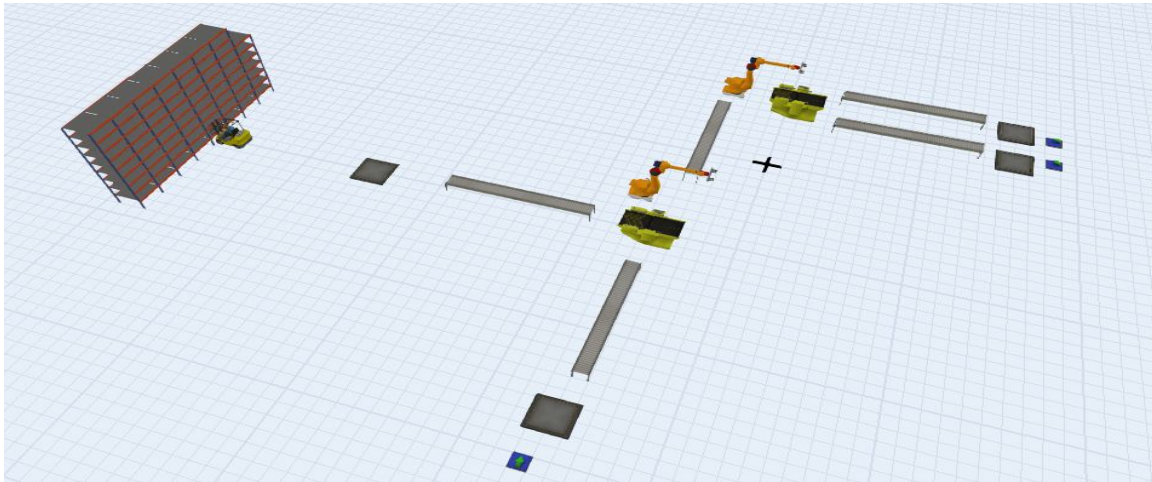


Fig 1.1 Cell in Flexsim

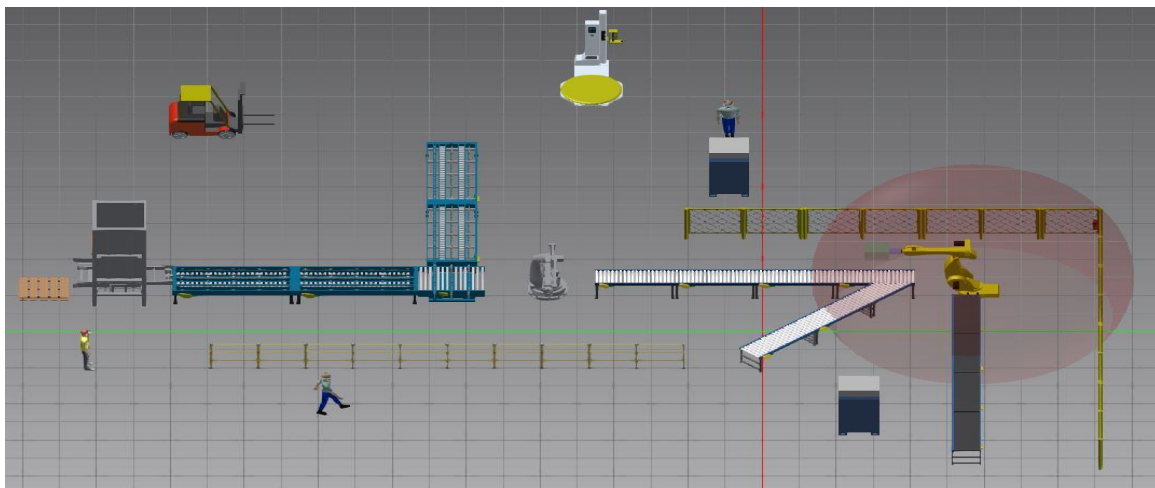


Fig 1.2 Cell in Inventor

In Figure 1.2 we can see the architecture created in Inventor, this architecture was used as a template to create architecture in FlexSim.

THE DIFFERENCES BETWEEN INVENTOR VERSION VS FLEXSIM IN TERMS OF SYSTEM ARCHITECTURE AND SYSTEM COMPONENTS

Between the two versions created there are differences in architecture and their components:

- In the version created in Inventor appears a wrapping system, the 2 controller of the robot and a pallet dispenser.
- In the version created in FlexSim appear in addition the 2 packaging points. These components were introduced to show how the packages and boxes are packed and set the working time in Inventor version this stage was done directly onto the conveyor by the robots.

DESCRIPTION OF CELL AND MATERIAL FLOW

In Figure 1.3 are presented the flow cell and its components made in Flexsim.

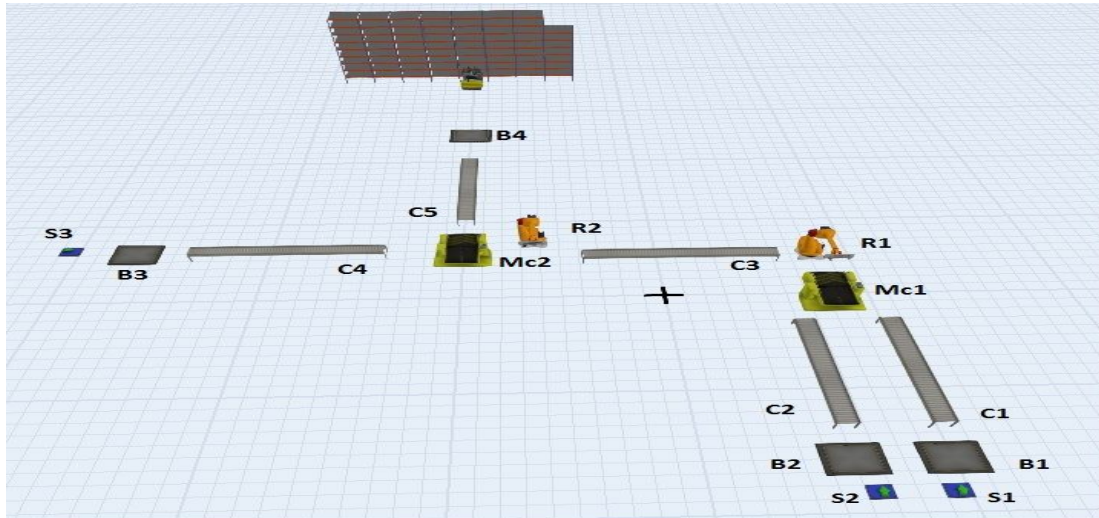


Figure 1.3 The flow cell in Flexsim

The cell is composed of three sources (S1 , S2 , S3) , four buffers (B1 , B2 , B3 , B4) , 5 conveyors (C1 , C2 , C3 , C4 , C5) , two robots (R1 , R2) 2 Points packaging (MC1 , Mc2) , a forklift and a storage system .

III. SPECIFY THE PRODUCT CHARACTERISTICS TRANSPORT AND PALLET POSITIONING SYSTEM

The cartons packs will be transported on palletson the conveyor,. The boxes will be at 500g packs , and each pack will contain 24 packs , resulting in weight 12kg / box . Each package with dimensions of 96x47x195mm (LxWxH)

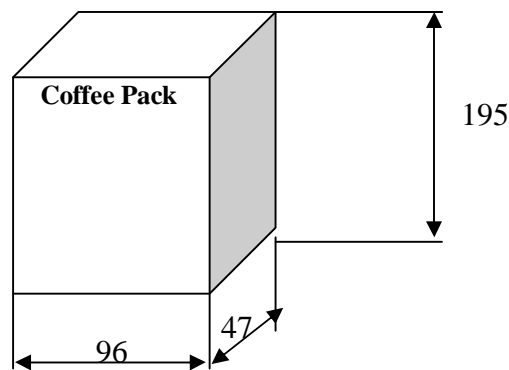


Fig 2.1 Coffee Pack

The size is 300x200x400mm box because it adds 10 mm thicknes of the plastic box .

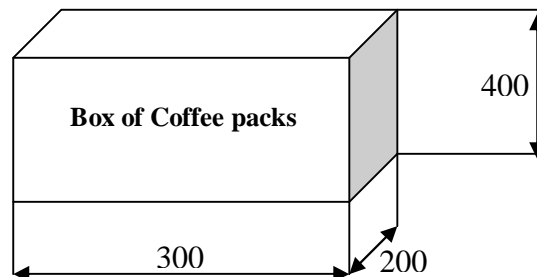


Fig 2.2 Box dimensions

The package will be arranged by 12 in a row , verticale, 3x4 structure , as shown below :

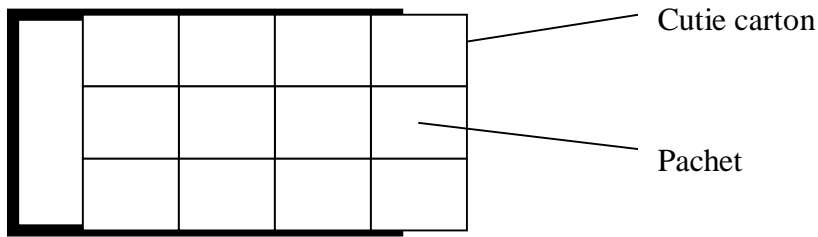
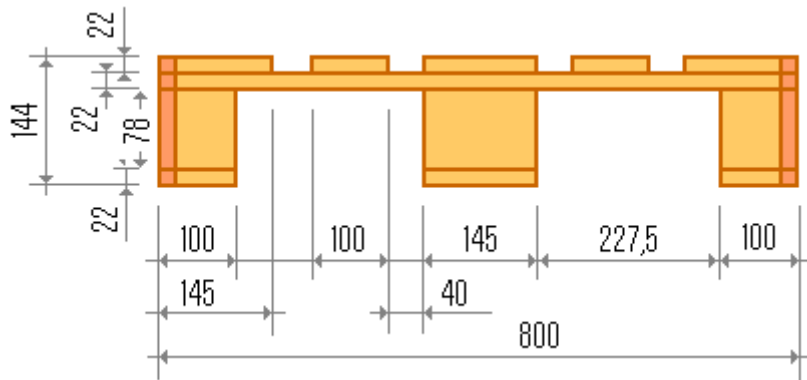


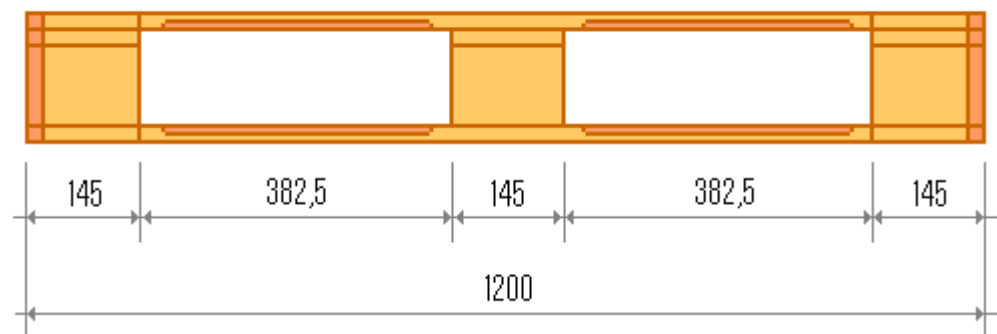
Fig 2.3 Boxed packages layout

The pallets for the transport of packages boxes have standard dimensions of 800x1200mm , as shown in Figure

a)



b)



c)

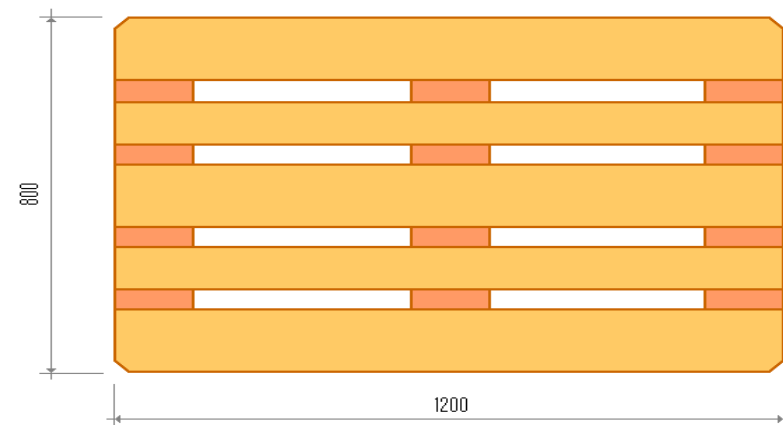


Fig 2.4 Europallet

On the pallet there will be placed 16 boxes per level, and the stack will consist of 4 rows, resulting in a total of 64 boxes, a height of 1600 mm and a weight of 768kg. Adding the weight of the pallet, 50kg, obtaining the total weight of 818kg

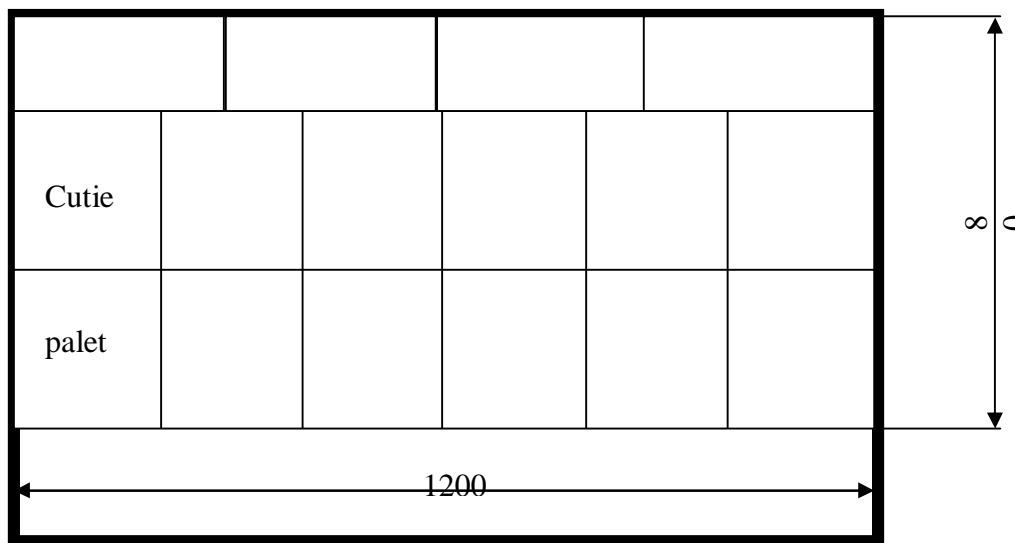


Fig 2.5 The arrangement of boxes per pallet

For stability of the stacks the layers will be rotated 180°

IV. OPTIMIZING FLOW

After simulation and reports problems were found downtime case expect to objects and / or objects generating too fast and thus the system crashes. After fixing these problems followed optimize processes for each item. At the end of optimization was performed a new simulation and generating new reports. In print sites will be presented following the changes made to some components and how these changes have influenced the final result.

NEW ITEMS CREATED TO OPTIMIZE PARAMETERS

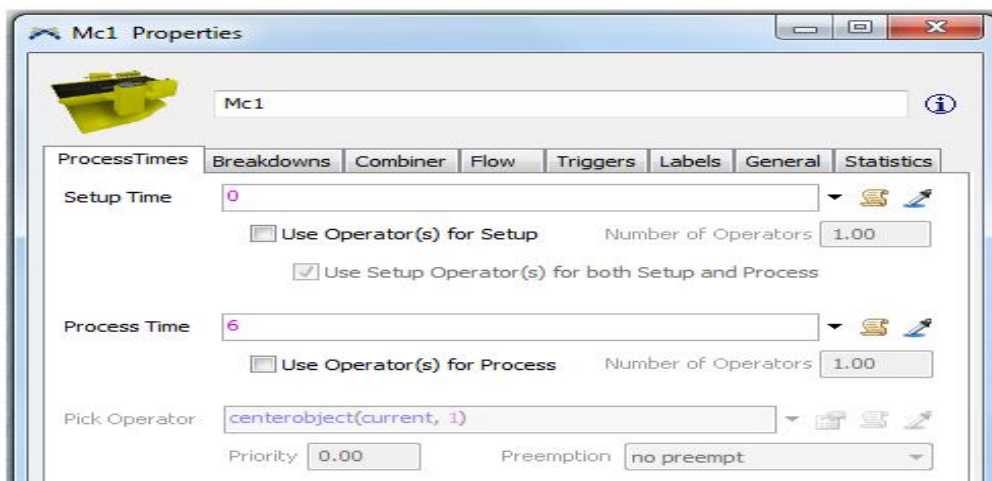


Fig 3.1 Packaging point MC1 with the setting of the processing time of 6 units of time.

The table in Figure 3.1 shows the packing point MC1 with setting processing time of 6 units of time.

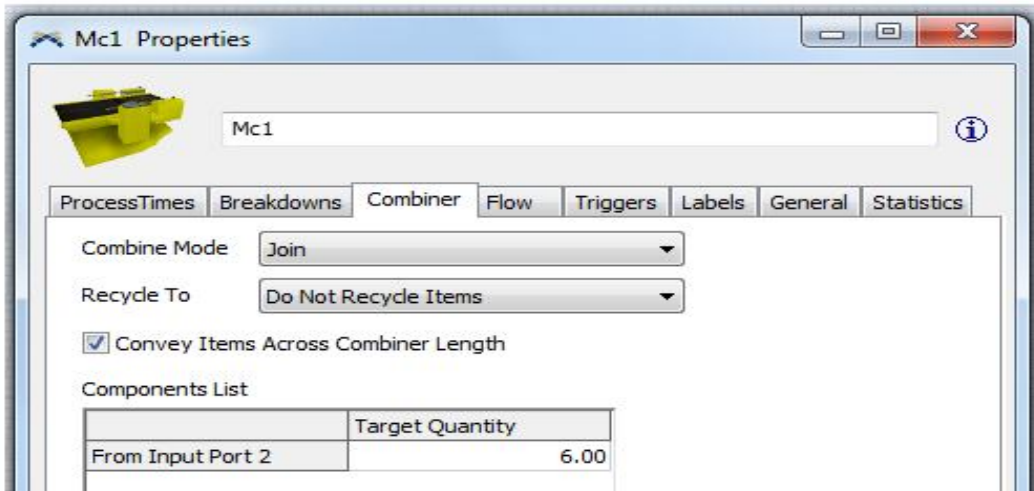


Fig 3.2 Packaging point MC1 having selected the type of operation (packing) and quantity, 6 pieces

The table in Figure 3.2 shows the packaging point MC1 having selected the type of operation (packaging) and quantity, 6 pieces

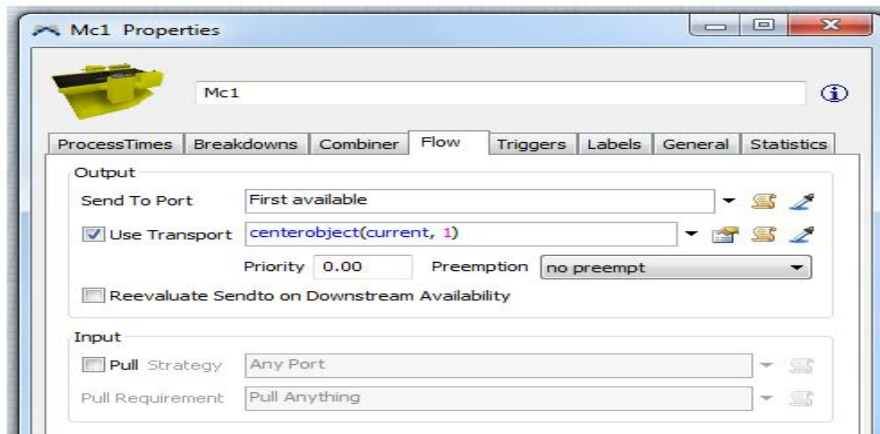


Fig 3.3 Packaging point MC1 having checked the setting of Use transport on output of the flow.

The table in Figure 3.3 shows the packaging point MC1 having checked setting of Use transport on output of the flow

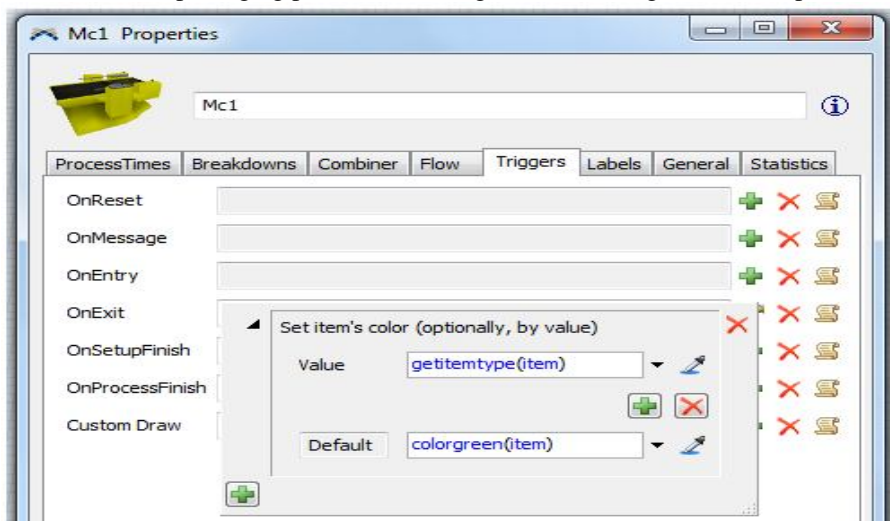


Fig 3.4 Packaging point MC1 having selected the object type and color of the box after it has been filld with packages (green).

The table in Figure 3.4 shows the packaging point MC1 of having selected the object type and color of the box after it has been filled with packages (green).

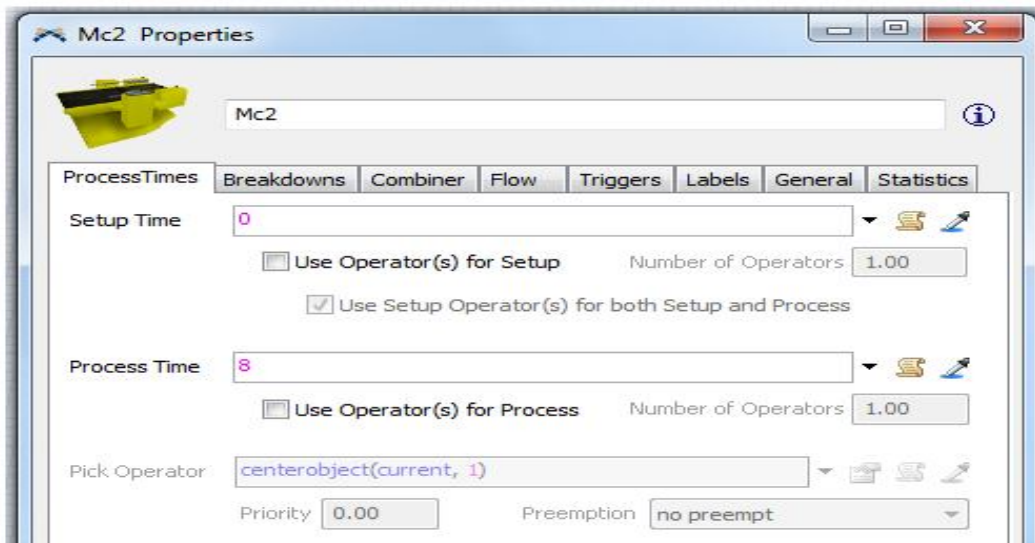


Fig 3.5 Packaging point Mc2 setting the processing time , 8 units of time

The table in Figure 3.5 shows the point of packing Mc2 setting processing time , 8 units of time.

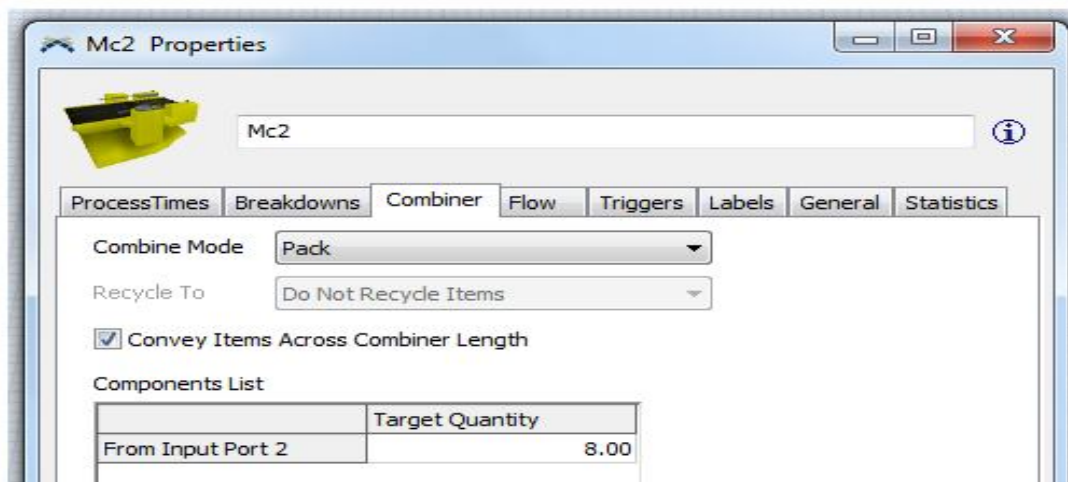


Fig 3.6 Packaging point Mc2 having selected the type of operation (palletizing) and quantity 8 pieces.

The table in Figure 3.6 shows the point of packing Mc2 having selected the type of operation (palletizing) and quantity, 8 pieces .

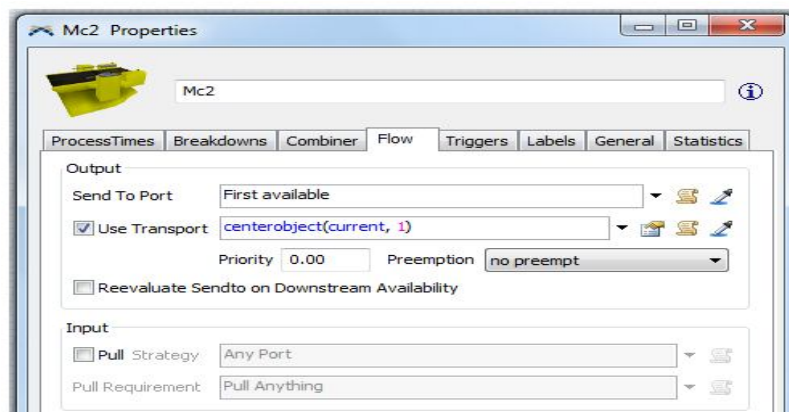


Fig 3.7 Packaging point Mc2 having checked the setting Use the transport output on the flow.

The table in Figure 3.7 shows the packaging Mc2 having checked the setting Use the transport output on the flow.



Fig 3.8 Robot R1 with the necessary settings .

The table in Figure 3.8 shows the robot R1 with the necessary settings that moves after a preset program.



Fig 3.9 Robot R2 with the necessary settings

The table in Figure 3.9 shows the robot R2 with the necessary settings that moves after a preset program.

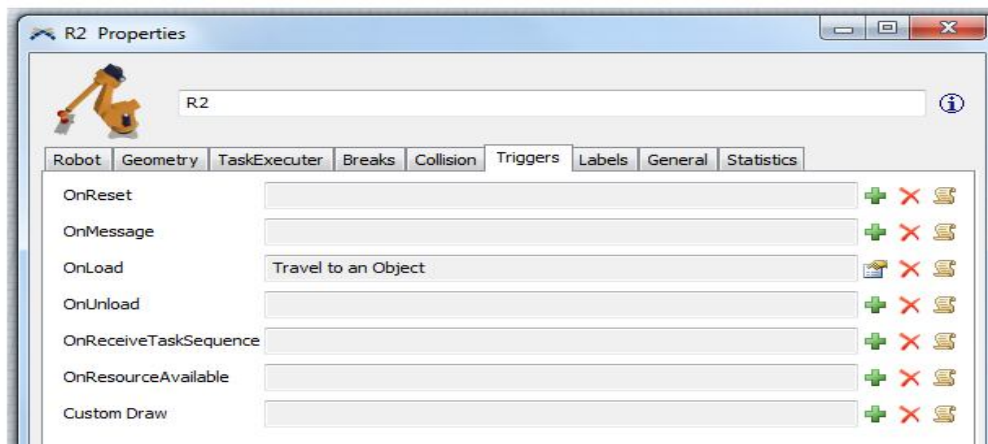


Fig 3.10 robot R2 setting the trigger on loading, moving the object .

The table in Figure 3.10 shows the robot R2 trigger setting that moves the robot to retrieve an object

V. MAKING A NEW SIMULATIONS AND GETTING NEW REPORTS

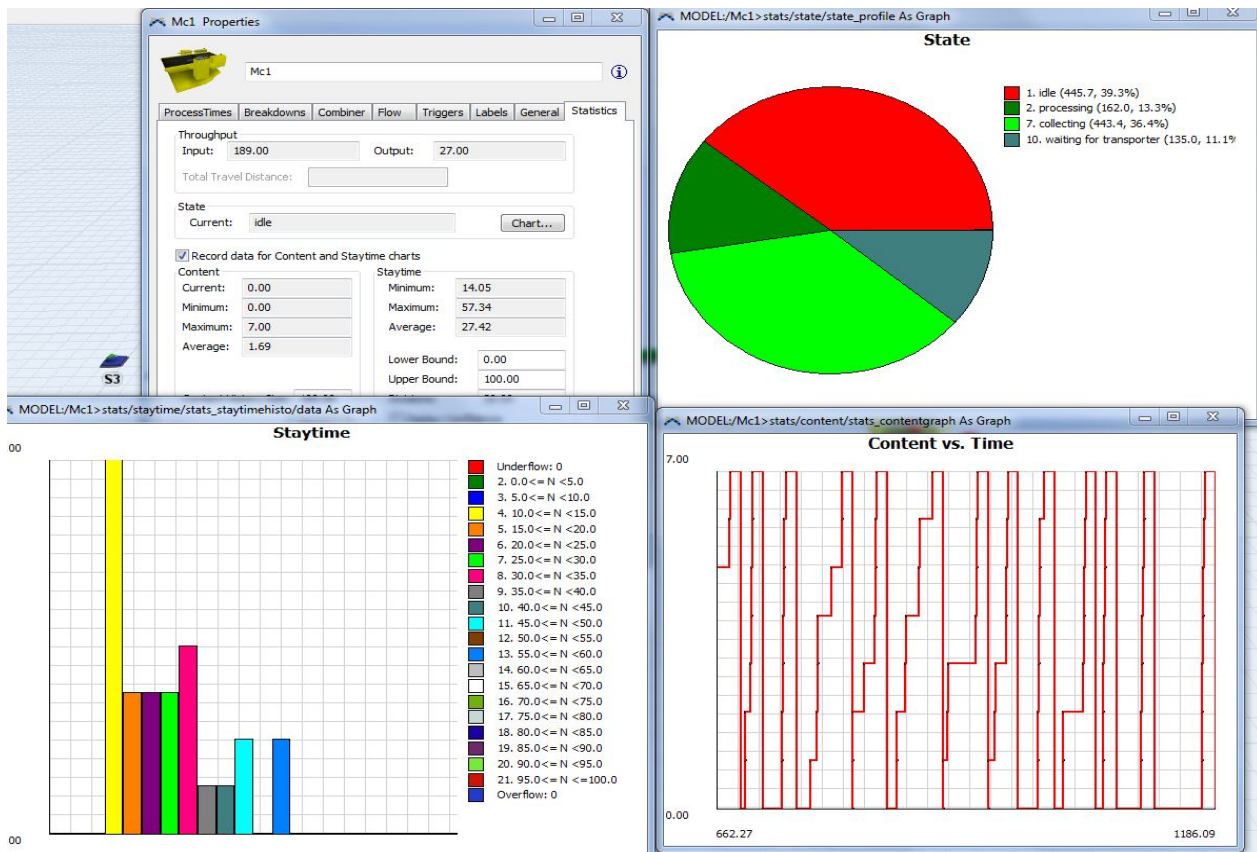


Figure 4.1 Report packaging point MCI

In Figure 4.1 is shown packing point MC1 that stores products in 36.4 % of the time, and processed 13.3 % of them in time, awaits a transport in 11.1 % of the time and in the remaining 39.3 % of the time is waiting.

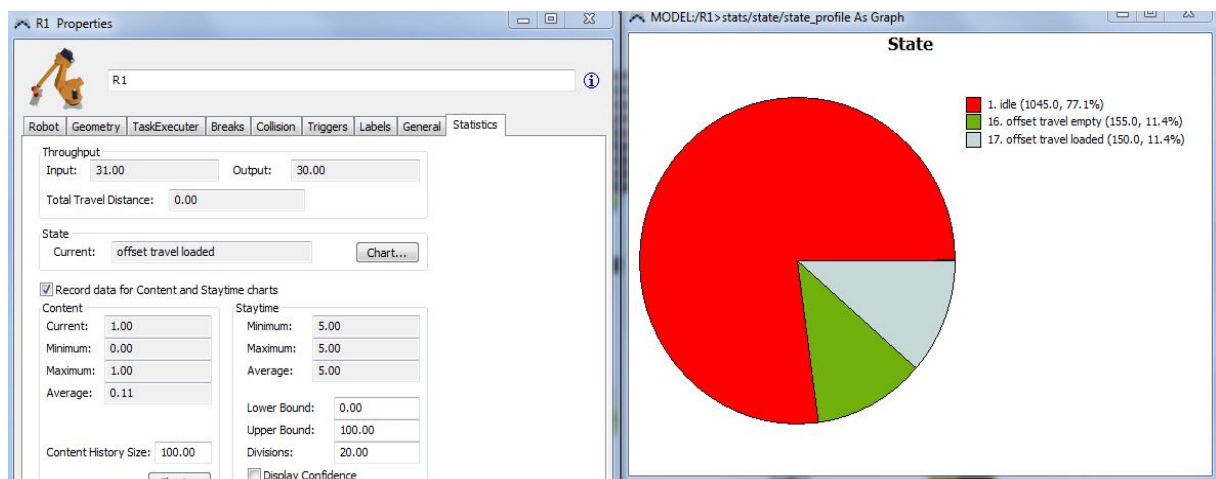


Fig 4.2 Report Robot R1

The robot R1 shown in Fig 4.2 which is moving loaded in 11.4 % of the time, 11.4 % of the time moving empty and the rest 77.1 % pending.

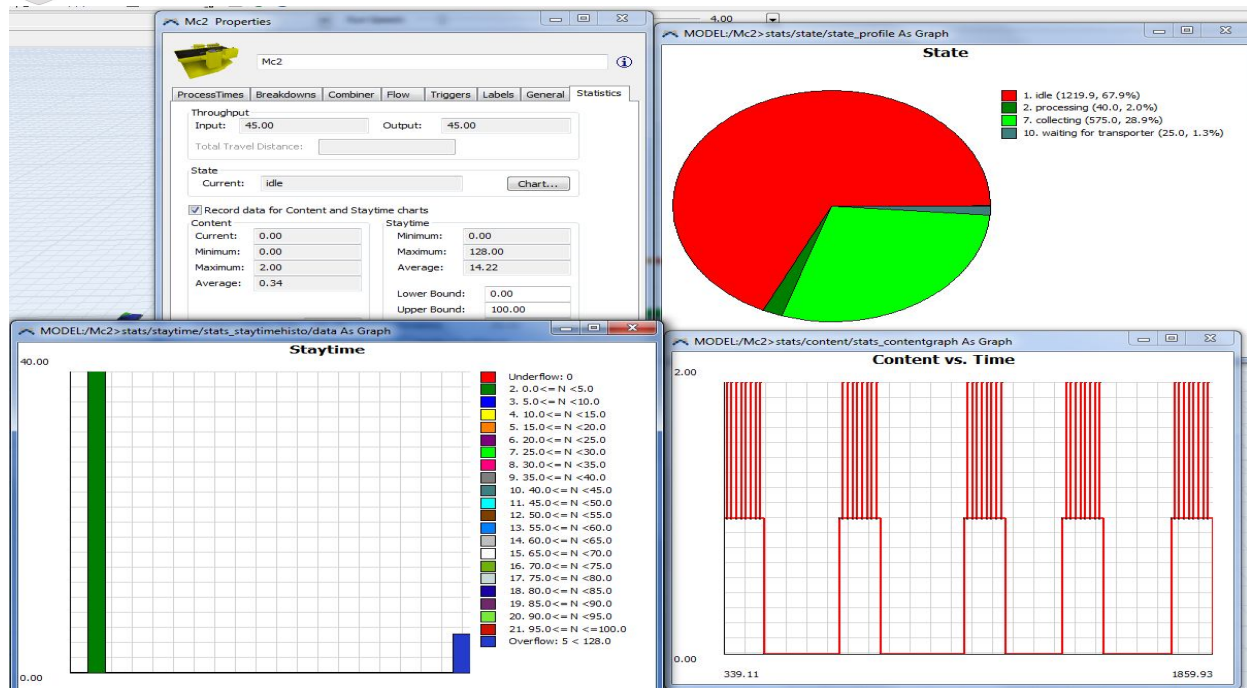


Fig 4.3. Report Packing point Mc2

In Fig 4.3 shown the Packing point Mc2 packaging produce 28.9 % of the time , processes them in 2.0 % of the time , the awaiting the transport 1.3 % of the time and in the remaining 67.9 % of the time is waiting.

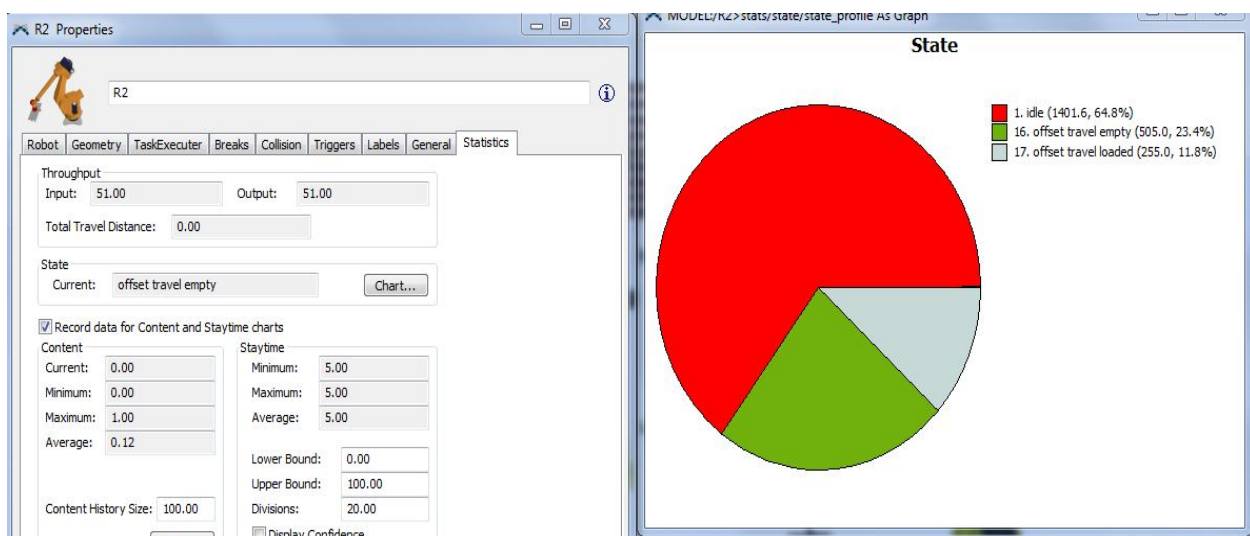
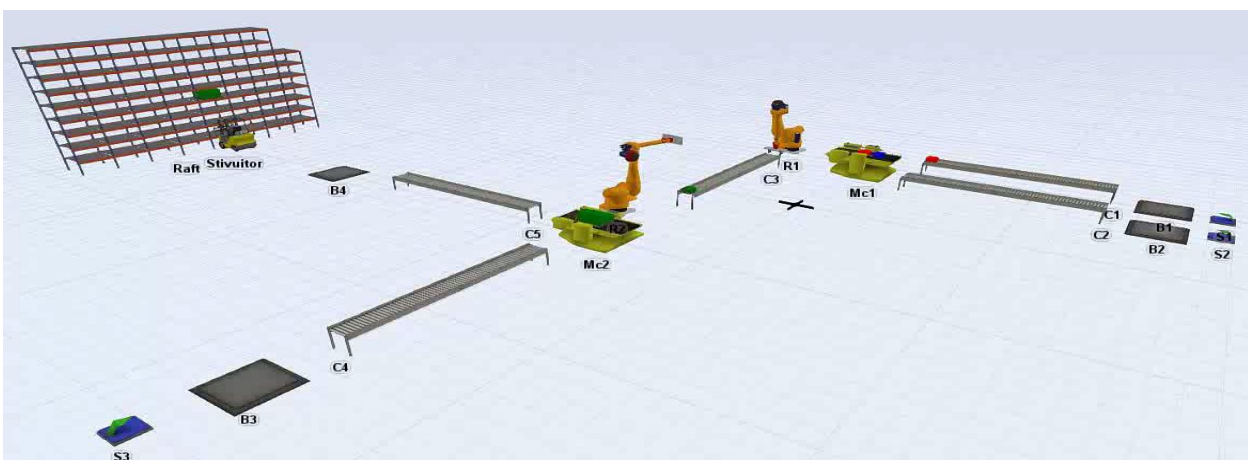
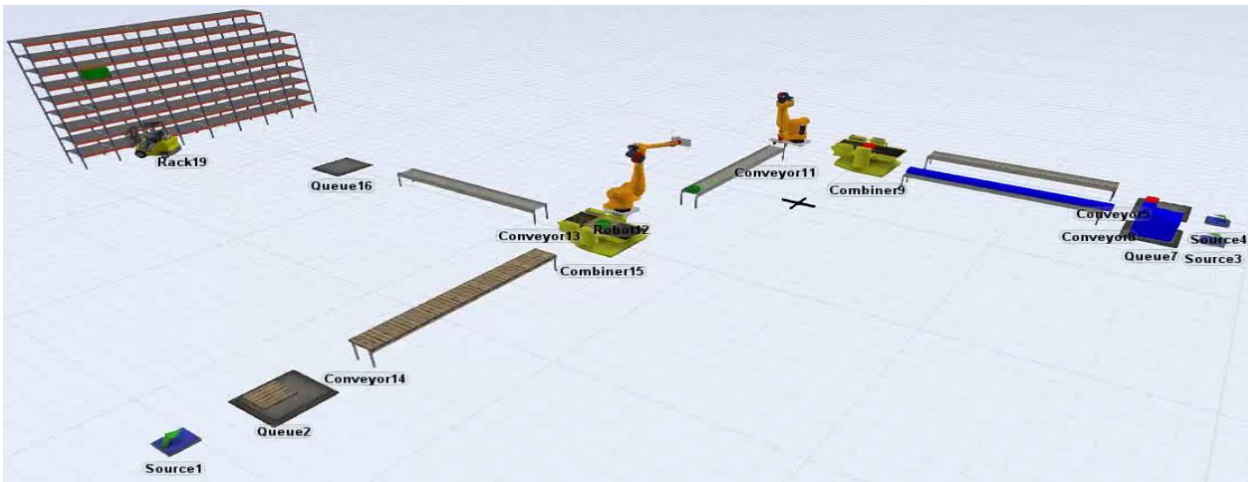


Fig 4.4 Report Robot R2

In Fig 4.4 is shown robot R2 is moving loaded in 11.8 % of the time, 23.4 % of the time moving empty and in the remaining 64.8 % is waiting

VI. CONCLUSIONS



In conclusion following the initial simulations and comparing with the final reports we conclude that by changing the time parameters and trigger- s to generate packets , boxes , pallets and packaging points we obtained a continuous flow without locking system .

EXAMPLES COMPARISON BETWEEN THE ORIGINAL AND THE OPTIMIZED REPORTS:

- Source S3 non-optimized pallet-source was generating only 13.4% of the time in the remaining time being blocked. Source S3 optimized pallet generating 100% of the time.
- Buffer 1 non-optimized collected items 52.7% of the time and the rest is empty, after the process of optimizing buffer 1 gather items 56% of the time and the rest is empty.
- Buffer 2 non-optimized released items 47% of the time and the rest is empty, and after optimization buffer 2 is empty.
- Buffer 3 non-optimized releases 93.2% of the time items and the rest is empty, and after optimization buffer B3 is empty.
- Conveyor 1 non-optimized carries items 20.4% of the time, 17.9% of the time is empty and the remaining 61.7% of the time is blocked, and after optimization conveyor C1 is transporting objects in 38.3% of the time, 16.2 % of the time is empty and the remaining 45.5% of the time is blocked.
- Combiner 1 non-optimized gathers products in 80.5% of the time, processes them in 9.4% of the time, awaiting transport in 7.9% of the time and the remaining 2.2% of the time is waiting, and after optimization packaging point Mc1 gathers products in 36.4% of the time, processes them in 13.3% of the time, waits a carrier in 11.1% of the time and in the remaining 39.3% of the time is waiting.
- Combiner 2 non-optimized products in 96.4% of the time, processes them in 0.8% of the time, awaiting transport in 0.5% of the time and the remaining 2.2% of the time is waiting, and after optimization packaging point Mc2 gathers



- products in 28.9% of the time, processes them in 2.0% of the time, the carrier expects a 1.3% of the time and the remaining 67.9% of the time is waiting.
- Robot1 Non-optimized is moving loaded in 8.2% of the time, moving empty 8.2% of the time and the rest 83.6% in waiting, and after optimization is moving robot R1 11.4% loaded of the time, 11.4% of the time moving empty and the rest 77.1% in tune.
 - Robot 2 non-optimized is moving loaded in 8.8% of the time, 17.6% of the time moving empty and the rest 73.6% in waiting, and after optimization is moving robot R2 loaded in 11.8% of the time, 23.4% of the time moving empty and the rest 64.8% in tune.
 - The forklift non-optimized is moving loaded in 0.4% of the time, moving 1.1% of the time empty and the rest 73.6% in waiting, and after optimization the forklift is moving loaded in 0.5% of the time, 1.2% of the time while moving empty and the rest is waiting.

REFERENCES

- [1]. Nicolescu, A. industrial robots - Vol.1 subsystem and component assemblies. The structure of numerically controlled axes RI, ISBN 973-30 - 1244-0, Didactic and Pedagogic RA 2005, Bucharest
- [2]. Nicolescu, A. - Design and Operation of Industrial Robots, lecture notes and design methodologies, UPB, 2011
- [3]. Nicolescu, A. - Implementation of Industrial Robots in production systems, lecture notes and design methodologies, UPB, 2011
- [4]. www.kuka.com
- [5]. www.flexsim.com