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OPTIMIZING OF FLEXIBLE PALLETIZING LINES USING SIMULATION TOOLS

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ABSTRACT
Nowadays simulation becomes a very powerful tool for design and optimization problems. These tools enable the study and analyzing of system without interrupting the flow of production. They can also be used on an operational basis to generate production schedules for the factory floor.
This paper will focus on design and optimization of complex flexible Palletizing Lines, which consists of ABB industrial robots. In the first step, Robots will be simulated using 3D offline programming tool-RobotStudio. Using new robot virtual technology we can get the exact cycle time. The material flow will be simulated and optimized using the popular simulator –Arena.
Keywords: modelling, simulation, optimization, design.

1. INTRODUCTION
Simulation as a modern concept for system analysis, in particular for production systems are driven by rapid technological development of IT. Various experts have developed a numerous algorithms, archiving them in various programming languages. Nowadays engineer task is to teach the simulation philosophy in order to be released from very complex mathematical expressions, creating more space for individual creativity and engineering.
But, of course for the simulation process other knowledge is needed depending on field or level of research. If is needed to be a Decision Maker, high level concerning manufacturing decisions etc., then individual must have knowledge on statistics, theory of probability, and a number of other theories linked to buffering and services. Fortunately, the modern simulation programs are very advanced, and integrated program packages for statistical preparation of production data and automatic optimization of entire process are included on them. In many cases such simulation process for production system allows very fast and efficient analysis of the stability for the selection of its parameters.
A flexible palletizing system shown in this paper is a very sophisticated system. The core system consists of industrial ABB robots, palletizing stations, and transport system which connect this subsystem with another part of manufacturing system. There is one input conveyor for incoming of six different parts and one output conveyor for leaving pallets. The product Type I and II will be palletized from the Robot I. The product Type III and IV will be palletized from Robot II and finally the Product Type V and VI will be palletized from the Robot III. Pallets come to stations with AGV. They will be there an amount time. In this case each Robot has to take from incoming conveyor and to put at the pallet. After the predefined number of parts of the same Type was achieved the pallet will be released from system automatically. The Robot put them into outgoing conveyor. In order to minimize the entity flow time, the best input for each product must to be founded.

We solve this problem in two steps:

1. Finding the cycle time using the virtual controller on RobotStudio,
2. Using the cycle time founded previously into Arena we simulate the whole system and optimized them using OptQuest.

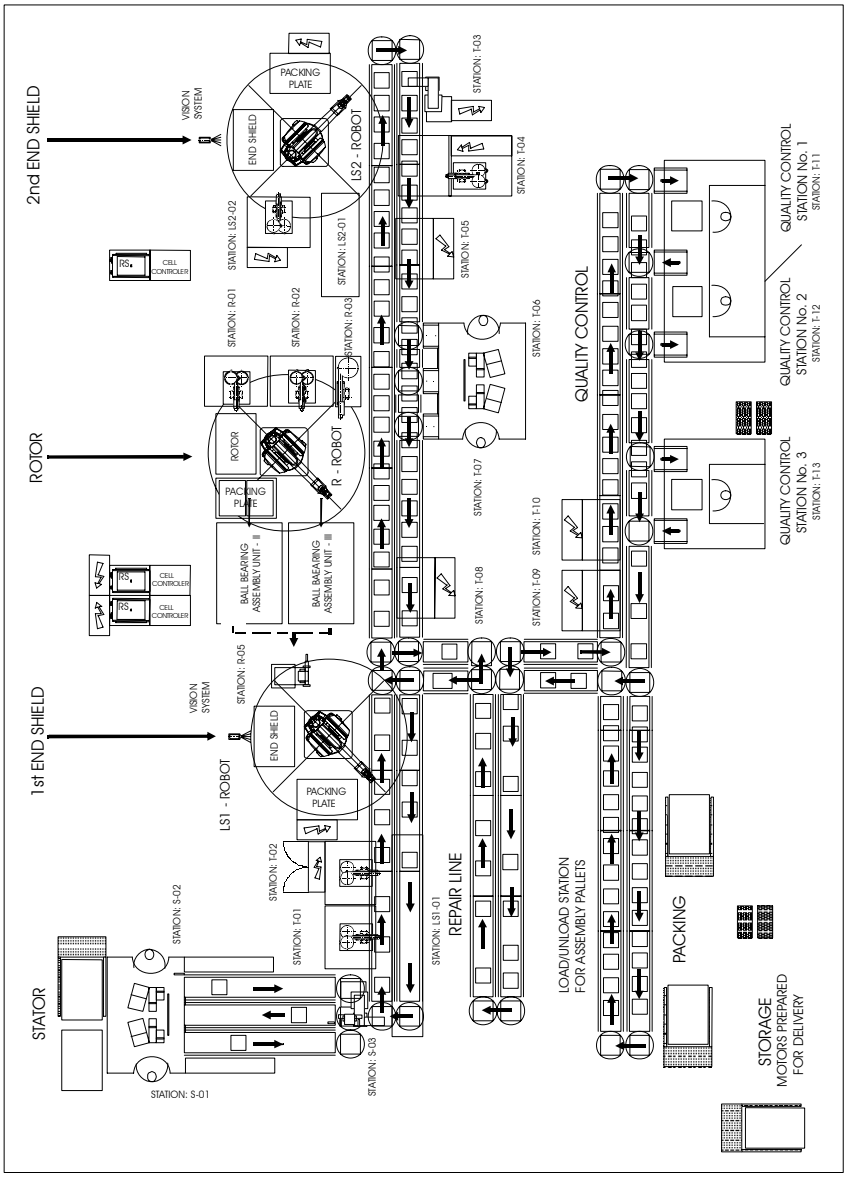

Figure 1. Flexible system of electromotor's assembling ATB-Austria

2. INTRODUCTION OF SIMULATION TOOL-ROBOTSTUDIO

To simulate and optimize the cycle time of manufacturing cell was used the simulation tool called RobotStudio. This tool was developed for the simulation of ABB robots and it is a very powerful tool for building a various scenarios for robot wrist paths. Using this tool enables the simulation analyst to take important decision about Layout planning, avoiding the collisions between robots and surrounding and so on. RobotStudio is built on the ABB Virtual Controller, an exact copy of the real software that runs a robot in production. Thus, it allows very realistic simulations to be performed,

using real robot programs and configuration files identical to those used on the shop floor. The Virtual Controller also contains a virtual Teach Pendant Unit.
This allows you to handle the simulated robot exactly the same way as a real robot. The RobotStudio installation also includes the ConfigEdit and ProgramMaker programs. ConfigEdit is an off-line editor for the robot's configuration files. ProgramMaker is an off-line editor for RAPID programs, integrated with RobotStudio. RobotStudio includes Visual Basic for Applications (VBA) that lets to customize and extend its functionality.

- Reduce time to market by programming the system without the need of the real work cell.
- Increase uptime by introducing and programming new parts without interrupting production.
- Higher part quality through creation of more accurate paths.
- Increase productivity by optimizing robot programs.

3. INTRODUCTION OF SIMULATION TOOL-ARENA

To simulate the different scenarios of manufacturing cell was used the simulation tool called ARENA. ARENA is designed for business consultants, business analysts, and engineers. Arena Basic Edition software lets you bring the power of modelling and simulation to business process improvement. Working with Arena's Standard Edition, it provides an interactive environment for building, graphically animating, verifying, and analyzing simulation models. The Arena Professional Edition is an advanced simulation system. With the Professional Edition, you can design a unique Arena template that is specific to your particular project, company, or industry. With Arena, you can:

- **Model** your processes to define, document, and communicate.
- **Simulate** the future performance of your system to understand complex relationships and identify opportunities for improvement.
- **Visualize** your operations with dynamic animation graphics.
- **Analyze** how your system will perform in its "as-is" configuration and under a myriad of possible "to-be" alternatives so that you can confidently choose the best way to run your business.

4. OPTIMISATION USING ROBOTSTUDIO

The first our task is to model the robot cell in 3D in RobotStudio and to simulate the robot paths. In figure 2 are shown each robot paths. Robot makes two paths for each part. Takes the part from incoming conveyor and puts to pallet. An in the finish he take the pallet and puts into outgoing conveyor.

$$T_{part\ 1} = T_a + T_b \quad \ldots(1)$$

$$T_{part\ 2} = T_c + T_d \quad \ldots(2)$$

$$T_{Ri} = T_{part\ 1} + T_{part\ 2} \quad \ldots(3)$$

T_1 Time needed to transport the workpiece from incoming conveyor to pallet1.
T_2 Time needed to transport the workpiece from incoming conveyor to pallet2.
T_3 Time needed to transport the pallet1 from Station1 to outgoing conveyor.
T_4 Time needed to transport the pallet2 from Station1 to outgoing conveyor.

The objective of RobotStudio was to minimize the robot cycle time. In that case is

$$\text{minimize}\left\{\sum_{i=1}^{n}\sum_{j=1}^{m}(T_{ij})\right\} \quad \ldots(4)$$

Where $m=4$ for each Times explaining above,
and $n=3$ for each Robots.

After few numbers of simulations the optimal cycle time for each path was founded. That means there was founded the new positions of components on palletizing cell and the optimal position of robots too.

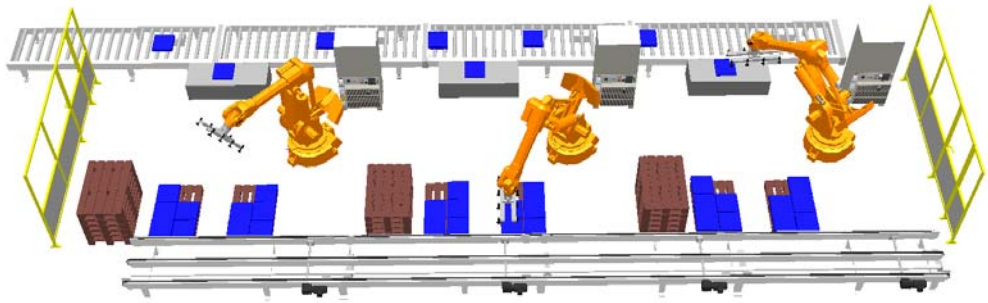

Figure 2. Flexible palletizing line – Layout

5. OPTIMISATION USING OPTQUEST FOR ARENA

In Arena was modelled the whole palletizing system. That means the system was modelled 1-1. The key data are taking from RobotStudio and are included in simulations model. Our goal of this study was to find the optimal:

1. **Interarrival time** between the each part of same type.
2. **Scheduling** of incoming part types under the considerations of all technologically constraints and our profit.

In order to launch this data in OptQuest for Arena this two parameters are modelled as system variable. OptQuest is powerful toolbox of Arena, which allows automatic search a set of parameters. There are is possible to define all constraints and the Objective of optimization model. Basically we can define only one Objective. In this case study our Objective was:

$$\text{minimize}\{Entity - Flowtime\} \quad \text{... (5)}$$

After a lot of simulation runs in very short amount of time are achieved the optimal system parameters.

6. CONCLUSIONS

Primary, the aim of this Paper was to introduce the power of the software tools during solving industrial problems. These tools give the modern engineer the ability to control and manipulate the enormous number of production parameters on a very easy way. The combination of such tools is a very desirable when you deal with designing of production system, that means when the system even doesn't exist. Using ABB virtual controller was calculated and optimized a robot cycle time. These important data are taken in Arena. In that environment was optimized the flow time of parts and they arrival sequence. Without real cycle time the results of our simulation study will be wrong. For long simulation time we goat cumulative a worst results. The triangle distribution used traditionally when the cycle times of robot paths are unknown will give a very poor results.

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