

# INTERACTIVE CONTROL OF A VIRTUAL MACHINE

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## Abstract

The topic of this Master Thesis is simulation and control of a virtual machine with PLC-code for the machine control system. The main purpose of the simulation is to discover problems preferably in the mechanics and with the geometry, i.e. collisions. When the virtual machine is verified, the PLC-code can be post processed and downloaded to a real PLC.

Today the development of the mechanics and the control system of a machine is separated. Different software used might not be used together and this cause problems because several prototypes must be built and errors are not discovered until the real prototypes are built.

The project includes defining requirements of simulation software and a market survey of the simulation software market, decision of a simulation software and practical evaluation of the selected software. In the selected simulation software the geometries were imported from existing CAD-software and then the logics and kinematics were added.

A conclusion of this project is that it is possible to control a virtual machine with a virtual PLC. The virtual PLC is controlled by a virtual human-machine interface (HMI).

## 1 Background and task

Tetra Pak R&D develops packages and filling machines for the liquid food sector. They work with the whole process from in-feed of material to the package outlet via the filling process. In their development process it is needed to build up several prototypes. Due to problems in the mechanisms and geometry changes, rebuilding are often needed. [1] This costs time and money. To improve the development process and discover problems earlier, preferably before the prototype is built, Tetra Pak wants to investigate the possibility to control a virtual machine with a PLC.

This project will deliver a market survey of the simulation market and a practical evaluation of one selected software. The results from simulation of a virtual machine controlled by a virtual PLC will be compared with a real machine.

## 2 The project

The project consists of three parts; a market survey of the simulation market for this type of simulations, decision of a software best appropriated for this type of simulation and finally a practical evaluation of selected software.

### 2.1 Market survey

It is a new type of simulation to perform and the first task was to determine requirements for the software. The requirements were made in an iterative way in co-operation with the staff at Tetra Pak and were graded in three steps based on importance. Totally there were 31 requirements.

The survey was done in two parts, in the first part of the assessment there were ten software products available. They are listed in Table 1. They were assessed with some simpler requirements together with the general impression of the software.

**Table 1:** *The ten vendors with its respective software products in the first assessment.*

Vendor	Software product
Cimetrix	CODE
Cosimir	Cosimir PLC
Delmia	Delmia Automation
Fiebach-Datentechnik	E-control
Mewes & Partner	WinMOD
Mitsubishi	GX Developer
Rockwell	RSTestStand + RSLogix
Tarakos	TaraVRcontrol
Tecnomatix	eM-PLC
Woodhead	SST Pics

In the second part were four software products assessed against the 31 requirements. The four software products were Delmia Automation, WinMOD, RSTestStand + RSLogix and taraVRcontrol.

## 2.2 Decision of software

After the second part of the assessment a selection was done. The conclusion of the assessment was that Delmia delivered the best software product, and that this product met the requirements best and in addition got the most complete solution.

Delmia Automation use the SFC language defined in IEC 61131-3. It can import geometry from a CAD-software and it has collision analyze. It can handle sensors in a graphical way and got an internal virtual PLC to be used in debugging. Some of the other software that was compared can handle some of these features, but not as an integrated solution. So even if the selected software not is best on every function it can handle it.

## 2.3 Practical evaluation of the selected software

A simulation of a part of a machine from Tetra Pak have been accomplished to give an own opinion of the software and to do a correct evaluation of its advantages and disadvantages, how they work in practice and not how they are described by the vendors. To examine as many steps as possible during a simulation, a complex model has been avoided. This is due to the limitation of time for this project.

The complete simulation consist of three different parts; a mechanical model, a virtual HMI and a virtual PLC.

The simulated object is an idea of how to warm a package before it will be sterilized in a later step in the machine. The simulated object got sliders that can move the package and also a heating mechanism to heat the package.

### 2.3.1 The mechanical model

The geometry was imported to the software from the existing CAD-software, Pro/Engineer. Figure 1 shows the mechanical model used for the simulation.

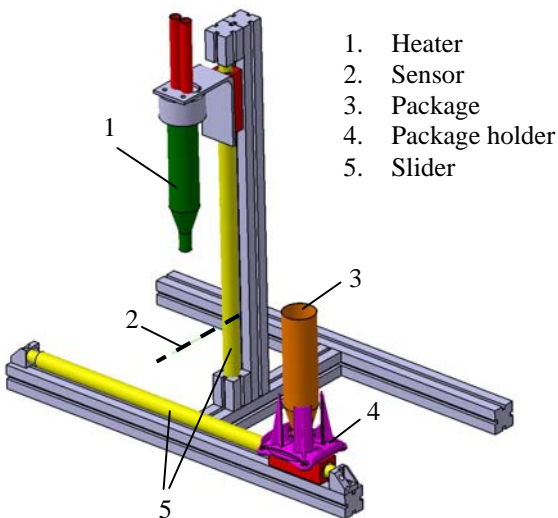


Figure 1: The mechanical model used for the simulation.

Kinematics was added in Delmia Automation and minor adjustments were needed to do to perform mechanisms in a right way. To the model was internal logic added. The internal logic handles the machine and how it should react on different input signals, in this project where and when parts should be moved. It will also handle an emergency stop signal. The internal logic is written in SFC-code and is structured in levels by using macros. One macro, which handles emergency stop, homing and main loop, is showed in Figure 2.

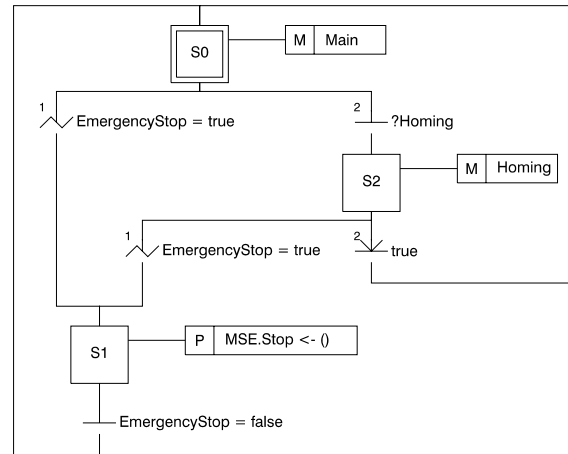


Figure 2: One macro in the internal logic of the mechanical model.

### 2.3.2 The virtual HMI

To control the virtual PLC a virtual HMI was created, in Delmia Automation there is a module for this. The machine got three different modes and the HMI can control them all. The HMI is showed in Figure 3. The internal logic for the virtual HMI was, as for the mechanical model, created in SFC.

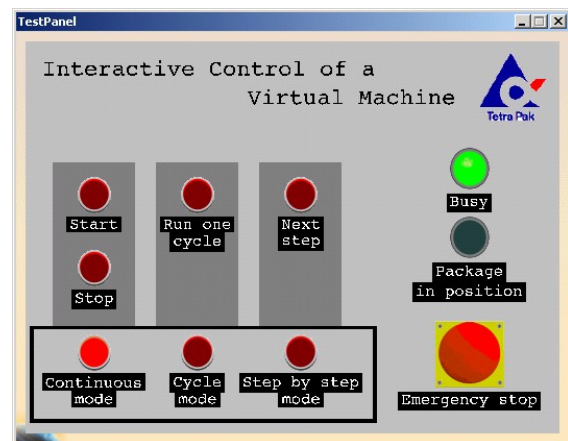


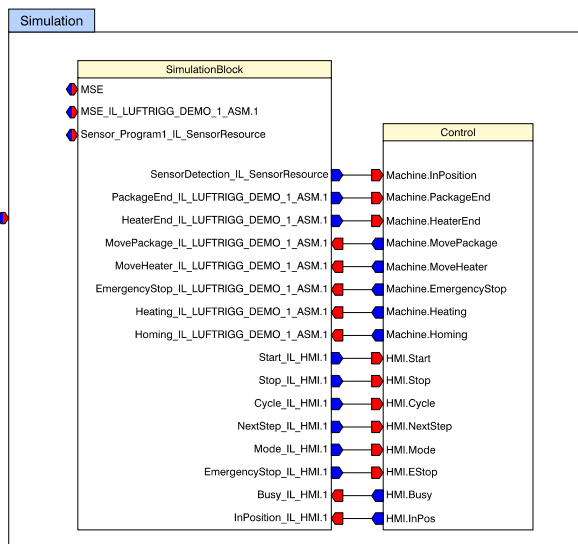
Figure 3: The virtual HMI to control the virtual PLC.

### 2.3.3 The virtual PLC

To control the simulation with the virtual machine was a virtual PLC used. Programming of the virtual PLC is like creating internal logic. The control logic is created in SFC. It handles input signals from the other parts of the virtual machine and dependent of the signals and in what state the virtual PLC is, it will set different output signals.

### 2.3.4 Connect the parts to a complete machine

The last step in creating a complete model is to connect the created parts to each other in a new product, the virtual machine. The parts in this simulation are the mechanical model and the virtual HMI. Next will be to add the control logic, the virtual PLC for this project. The inputs and outputs will be connected to each other in a graphical way, see Figure 4.



**Figure 4:** Connecting inputs and outputs in the virtual machine. The internal logic in the parts is to the left and the control logic is to the right.

### 2.3.5 Running a simulation

When the complete virtual machine is finished and all signals are connected in a right way a simulation can be run. During the simulation all the signals between the PLC and the simulation object can be monitored. The signals can also be forced to a value to test how the simulation will react on it. It is possible to change the step size during a simulation and the graphical update can also be changed i.e. the graphic will only be updated every second step. This due to the graphical update often will slow down a simulation.

## 3 Results

The first result is that it is possible to create and run a simulation.

Delmia Automation is a new software on the market, and during the creating of the virtual machine many more or less serious problems have appeared.

One problem was the handling of the geometry. It could be imported from competitors CAD-software in a neutral file format, but if the geometry was changed it could not be updated. It must be imported again and the model must be rebuild from the origin. If the CAD-software Catia is used for the CAD-models this is not a problem due to it is from the same company group and got full compatibility with Delmia Automation.

It is possible to create a virtual HMI to control the virtual PLC and the simulation. This is user-friendly and will facilitate test of the code.

It is possible to create videos of a simulation and because the model is in 3D the video can be recorded from an optional view and in an optional zoom.

To run a simulation is very demanding for the hardware and a powerful computer is needed to get good results.

It is not possible to create a motion profile for a mechanisms motion. Instead predefined positions are used and time is set to move between these positions.

During a simulation collision checks of the model can be made. This is very useful to discover problems in the geometry and with the mechanisms.

## 4 Conclusions

The main conclusion is that simulation of machines behavior together with the PLC code of its control system can be done and is very promising. This can save a lot of time and a lot of money. But to do this type of simulations is very demanding, powerful computers are preferred.

There are some major requirements that Delmia Automation today not fulfilled, such as motion profiles, and for that reason it can be hard to entirely implement it in Tetra Pak's development process at this stage.

This project has only treated a small part of the subject to simulate and control of a virtual machine. Therefore it is necessary to proceed further in this subject.

## 5 Future works

There are several subjects of interest in future. One of the most interesting is to control a virtual machine from a real PLC and compare it with controlling a real machine with a real PLC. This in order to see the difference between the real machine and the virtual machine and how close their behaviors are.

Today a motion can only be done between predefined positions in predefined times, and with a constant velocity. To get a good approximation of the reality the control of the motion profile must be analyzed and with a number of parameters, so a more complex model can be done.

Another interest aspect that not is connected to the technical subject is to investigate how a simulation tool,

such as Delmia Automation, can be implemented in the development process at Tetra Pak.

These are some of the questions that are needed to be answered before this kind of simulations makes its breakthrough.

### **Acknowledgements**

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### **References**

[1] Interview with Istvan Ulvros, Senior Technology Specialist, Tetra Pak R&D, Lund, Sweden, 2005-03-07