BENCHMARKING the STAR Controller using Matlab

A MSC THESIS PRESENTED AT THE DEPARTMENT OF **Industrial Electrical Engineering and Automation** (IEA) of LTH at ***LUND UNIVERSITY***

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For the Degree of:	**Master of Science**
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Date:	**September 2006**

CHAPTER 1

Introduction

This chapter is a brief sight of the thesis; motivations, contributions, structure and objectives.
After reading this chapter the reader knows the contents of each point in this thesis, so it's important to know how to read it and where is each topic studied.

1.1 MOTIVATION

The treatment of the waste water is a complex process, process compound of several biological processes sensitive to the external disturbances, as can be the storm, the rain, the snow, the ice; all the climatological changes can affect the wastewater treatment process. The sensitive biological processes and the disturbances of the weather make difficult the control of the wastewater treatment process.

Through the new technologies the most avant-garde companies have tried to solve the problem of the complex control needed and the existing disturbances within the process. With the new sensors it is easier to measure the state of the process and try to design suitable control strategies. The possibilities of the new computers let this and more, but there is still one restriction: the dynamic of the biological processes.

With the new advances of the techniques sometimes it is forgot that the new techniques cant change the process, they are only developed to control it, to get a stable and controllable process. The dynamic of some biological process are so slow, it means that the results of an action control will be observed a long time after applying it. This difficult the control of the process more than it seems at the beginning, because when the controller tries to solve the mistakes of the strategies or the effect of the disturbances it is too late, and the process need double time to became stable again.

The task group formed by “Veolia Water System” (krüger, in Copenhagen, Denmark) and the department of “Industrial Electrical Engineering and Automation (LTH, Lund, Sweden) was formed to improve the wastewater treatment processes using sophisticate techniques to model the whole process including the sensors model, the controller model and the plant model. Within the group rose the idea of simulating the wastewater process plant in real time. What does this idea mean? How can the real time simulation of the WWTP improve the behaviour or the control of the plant?

The answer to these questions is the motivation of this thesis. If it is possible to implement a perfect model of the WWTP and the controller that is being applied in the real WWTP, and to start the simulation of the process from the values of the data measured in the real plant, it would be possible to have the progress of the WWTP at the same time as the progress of the model implemented, and it would be easy to compare the values of the state variables of the simulation and the state variables of the real process. Comparing these values would be suitable to find disturbances in the process or important features of the plant that are not included in the model used usually to check the control strategies in simulation time. By the other side, the values of the simulation in real time would let to see the progress of some state variables that the real measurements can not let due to the characteristics of the sensor: the noise, the error, the precision, etc.

1.2 OBJECTIVES

In the point before has been discussed the motivation of the present thesis, but there is not enough with motivations to developed a thesis. The motivation is the beginning, the main idea to solve a problem, to improve a process, to do anything.

The motivation says that it would be a good idea to simulate the model of the WWTP at the same time that the plant is working, with the same conditions, the same value of the state variables, the same control strategy, and after, to compare the results of the simulation and the measurements of the process. But now the motivation has to be translated to objectives, which will represent a concrete aims.

If we start to analyze the motivation, the purpose is to simulate a model while the WWTP is working. So the first objective will be the implementation of an application to simulate the model of the WWTP.

The controller has to compare the results of the simulation and the measurements of the WWTP. It points that it is need a communication between the application developed and the controller of the WWTP.

The application is simulating the model of the WWTP at the same time that the real plant is working, and the controller is transferring data from the real process to ensure the model of the simulation and the real plant have the same conditions. So not is only needed a communication between the application and the controller, the synchronization is needed too.

At last, the most important is the model. The model of the WWTP has to be developed. There are a lot of possibilities to implement a model of the WWTP, and only to model one part of the plant can be a master thesis. Here in this thesis in implemented the model of the batch process (see *chapter 2* to know what a batch process is) in one vessel. From the model exposed is possible to implement the full model of the secondary treatment in WWTP, but it will not be the aim of this thesis.

Summarising, the objectives of the present thesis are:

- Implementation of an automatic application to simulate a model of the WWTP in real time.
- To program the communication and the synchronization with the controller.
- To model batch process in one simple vessel and implement it.

1.3 CONTRIBUTIONS

There have been named the objectives of the thesis to get improve the control in wastewater treatment plants. To get these objectives is join to the techniques and applications that are going to be used for getting them.

The whole code programmed in this thesis and the user interface of the application has been programmed within Matlab package toolbox. Matlab is a powerful application that let the researchers to implement, simulate, check, program, control near all the things. There are a big number of packages to complement Matlab and let the user to execute different things or processes sharing the same workspace, thing that allows interconnect implemented applications in Matlab and simulations that are running at the same time, without translating the data from one application to another.

The thesis has each chapter divided in two virtual parts; the first one explain the abstract discussion of the topic that is going to be developed. After the abstract discussion, the second part is the implementation of the topic discussed in a real and operative code.

Starting from the paragraphs before, the contributions can be understood as:

- The design of an automatic application that simulate the model of the real WWTP in real time.
- The implementation of the automatic application in Matlab.
- The communication of the application with the controller through the Ethernet network. The basis and the implementation in Matlab.
- The synchronization of the controller and the implemented application, the design of several possibilities and the posterior implementation of it.
- The design of the batch process model, with the evolution of the equations along all the phases, and the translation of the equations into code to implement the model.

The contributions have been presented as independent works, but they can be read as a main big contribution, the contribution of implementing an application to get the combination between the abstract part of the control and the real part of the control in the process working together.

The abstract part would be the implementation of the model of the process that is going to be controlled, all the part of the code programmed dedicated to model and simulate the WWTP plants. And the real part would represent all the structures and devises that form the WWTP, the controller, the sensors, the actuators.

The implementation of this application is not the substitute for the first simulation and testing of the control strategies before applying it, it is like an automatic test of the control strategy in real time, a test to verify the control of the WWTP while it is working.

1.4 OUTLINE OF THE THESIS

The distribution of the thesis try to get the better way to understand the topic developed in. It tries to introduced and explain all the concepts used along the thesis, and to give the necessary bibliography to look for extra information if it is necessary for the reader, not only to better understanding the thesis, but also to increase the given information in the present work.

The thesis is divided in four parts:

1. Introduction.
2. Modelling the Wastewater Treatment Plant in Matlab.
3. Appendixes.
4. Bibliography.

Each part is divided in chapters that expose the topics developed along the thesis. The first and the second part form the work of the thesis, and the third and fourth part are complementary to read more about the topics developed in the first and second part.

The first part is an introduction about wastewater treatment processes, what they are, how to model, the parts of a WWTP plant, the previous knowledge to better understand the thesis. This part is divided in two chapters: *chapter 1* and *chapter 2*. The *chapter 1* is the current chapter. The *chapter 2* is an introduction about wastewater treatment plants, the description of the process, automation in WWTP and the basis of modelling WWTP.

The second part is that we can call the work developed. There are three chapters: *chapter 3*, *chapter 4* and *chapter 5*. The *chapter 3* contains the design and implementation of the main application and the user interface. In *chapter 4* is discussed and programmed the communication with the controller and the database and the synchronization with the controller. In *chapter 5* is designed and programmed the batch process model in Matlab.

The third part contains the appendixes to the chapters of the first and second part, and the last part is the bibliography used to develope the thesis.