Buffer Management Strategies for Improving Plant Availability

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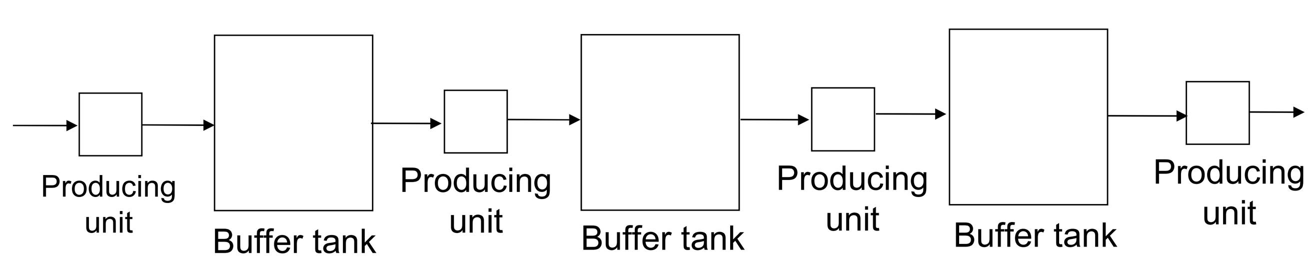
Master's thesis work done at the Department of Automatic Control in Lund in collaboration with Perstorp AB.

In an industrial plant availability is an important factor since increased availability often gives an increase of final production which in many cases means an increased profit for the company. The purpose of using buffer tanks is to increase the availability either by separating production units from each other or by minimizing flow variations. However, the methods for achieving these goals are not trivial, and depend on the specific characteristics of the problem. This thesis contributes to structuring the general buffer management problem and suggests methods for solving some specific problems.

Compexity of the problem

A buffer tank is a simple integrating process, which in general is easy to control. However, in a real plant we often have a production line with several producing units with buffer tanks between some of these units as shown in the figure below. Here it is not evident how to choose tuning and set point for the buffer tanks in order to maximize the availability in the production line.



Furthermore, the topology of the production line could be more complicated, possibly containing recycle flows from one buffer tank to another, which will affect the optimal solution to the buffer management problem.

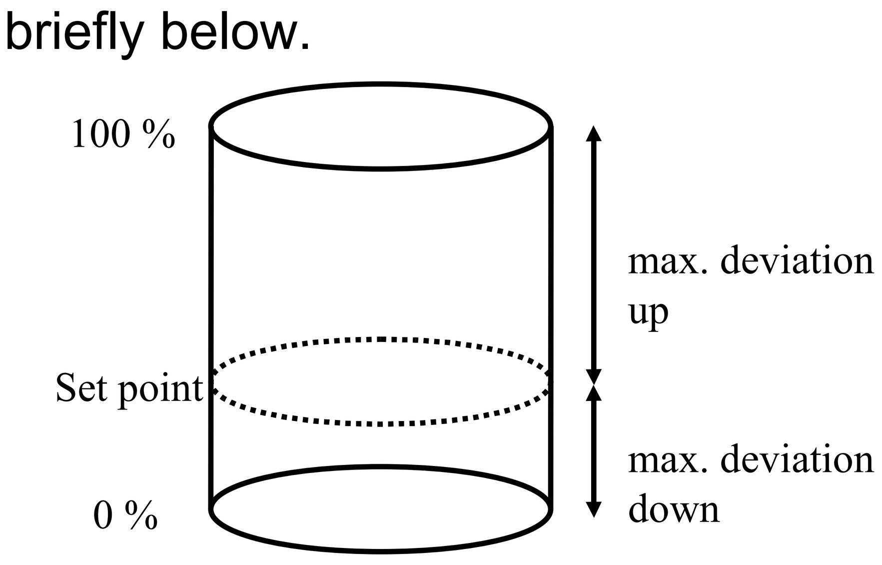
An important choice when defining a buffer management problem is the choice of optimization criterion. In many cases it is defined as the final production (output) of the studied process section. However, in some cases it is preferable to define the criterion as throughput in the bottleneck unit.

Many more choices will have to be made when defining the problem, for example choice of disturbance model, definition of flow variations and maximum and minimum constraints on flows. The control strategies to be considered also have to be defined.

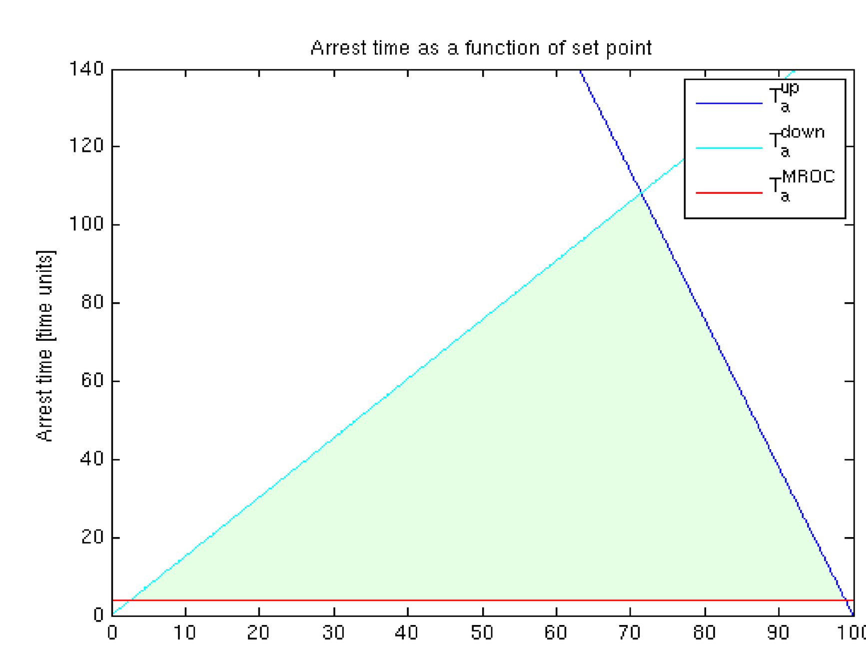
The solution to a specific buffer management problem depends on the choice of how to define the above stated variables which makes the problem very complex. What has been done today is to solve the problem for a number of combinations but there are still many gaps to be filled. This Master's thesis contributes to filling in some of the gaps.

Tuning method for level controllers

In the thesis a method for choosing tuning and set point for a level controller in a buffer tank is developed. The method is described briefly below.



A PI-controller tuned using the Ta-tuning rule controls the outflow of the buffer tank. Suppose that the level of the buffer tank has to stay within the limits 0 % to 100 %. Given the size of probable disturbances upwards and downwards in the inflow of the tank and the set point for the level controller, a certain maximum deviation from the set point can be tolerated. This will give upper bounds on the arrest time for the level controller, i.e. bounds on how slowly tuned the level controller is allowed to be for a given set point. A lower bound is given by the maximum tolerated rate of change (MROC) of the control signal. The bounds are illustrated in the figure below.



All combinations of arrest time and set point that are located within the triangle in the figure are allowed. The best choice of combination of set point and arrest time depends on the probability of larger disturbances than specified versus the effect on downstream processes when having rapid changes of the control signal.

This method for choosing combination of arrest time and set point was tested at a Perstorp plant in Warrington with good results.

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