ABSTRACT

Many industries make use of fermenters for the production of meal stuffs, alcoholic liquids, vaccines, antibiotics, biofuels and many others. Fermentation of substances often bring about the formation of foam and launch of gases. Foam formation depends on numerous elements which include, the speed of blending of broth, the amount of protein content present in the aggregate, the pH value of broth and so on. On addition of anti-foaming agents, the froth stage in bio-fermenters is managed. When the broth is alkaline in nature, the formation of foam is more, which is decreased with the aid of adding acidic anti-foaming agent. When the addition of anti-foaming agent exceeds a restrict, it destroys the residing micro-organism which helps fermentation of broth. In batch fermenters, the destruction is tolerable to a positive volume, whereas in continuous fermenters, this may result in trade in product pleasant and uniformity. When this foam formation is left unnoticed, it could rise and come in contact with the surface of the fermenter, sensors or ports of entry and exit of substances leading to contamination of the broth which are unwanted in the case of continuous fermenters. The microorganisms may float along with the foam, leading to decrease in productivity.

The main objective of this work is to lessen the running cost of continuous fermenters by minimizing the level of contamination of the broth. By keeping the extent of the broth inside the fermenter lesser than the extent at which the hardware are fixed, prevention of foam coming in contact could be achieved. This work analyses the effectiveness of different control strategies for the indirect control of froth level within the continuous bio-fermenter systems. To achieve this goal, different controllers such as PID controller, Fuzzy controller, Adaptive PID controller, Model Reference Adaptive Controller, Internal Model Controller, Model Predictive Controller, and Sliding Mode Controller are designed and their performances are

analyzed. PID control shows terrible manage performance for structures with delays. It does no longer atone for mismatches in modelling, disturbances and ranging system dynamics.

Fuzzy control brings ambiguous statistics and consolidate heuristic control in the shape of if-then policies. A combinational PID and soft computing technique is employed, which enables effective tuning of the PID gains, based on the fuzzy rules and the system performance. This controller is strong, but it isn't capable of taking advantage of the nonlinear plant characteristics.

For nonlinear plant traits, model reference adaptive controller is designed. It provides adaptation of any variations and does not need much information about the plant. Its disturbance rejection functionality is less and it isn't capable to cope up with the time delay. To compensate time delay, internal model control is designed. It is able to handle delays, but any mismatches in system model are pondered inside the controller's overall performance.

A model predictive controller which anticipates the system performance primarily based at the past and present information, lets in, time delays, inverse reaction, and inherent non linearity is designed. It isn't always strong that, adjustment of the tuning parameters leads the system to instability.

A robust sliding mode controller is designed to make the controller robust. It has two controls: an equivalent control and a switching control. The switching control is varied in five different ways and the controller performance in all different schemes are analyzed and adaptive sliding mode control is determined to outperform the other controllers and is also robust. However the shortfall is its delay dealing ability.

A combination of a predictive and sliding mode controller is designed which handles the time delay and is powerful with short rise time and settling time, with minimal overshoot. The shortcoming is that, it does not maintain the level at its set point. So a modified predictive sliding mode controller is designed, that's found to be more strong and has no offset, or oscillation with quick rise time and settling time. These control techniques are carried out in three commonly used continuous bio-fermenter structures namely the cylindrical fermenter, the conical fermenter and the cylindroconical fermenter.

All actual systems suffer from time delay, which may be due to numerous reasons like transportation of raw materials from one stage to other, sensor delay, actuator delay and lots of others. Delay plays a prime role in the implementation and overall performance of the controllers designed. So, all three structures have been analyzed for three specific cases:

Case 1: ideal case, while delay isn't always taken into consideration
Case 2: when delay is approximated using Pade’s first order approximation
Case 3: whilst delay is approximated using All pole approximation

While the system is approximated using Pade, it produces inverse response and disturbs the inner stability of the system. All pole approximation overcomes the problem of inverse response and stability.

Model predictive control, sliding mode control, predictive sliding mode control and modified predictive sliding mode control are implemented in real time and their performances are compared for a cylindrical and a conical system. It is observed from the results that, the modified predictive sliding mode control offers a higher manipulate action in all the cases. These types of performance indices reflect within the performance of the bio-fermenter whose simple requirement is to keep the running situations consistent and preventing foam from coming in contact with the hardware, thus avoiding contamination and minimizing the running cost.