Sequential Batch Reactor in Sewage Treatment

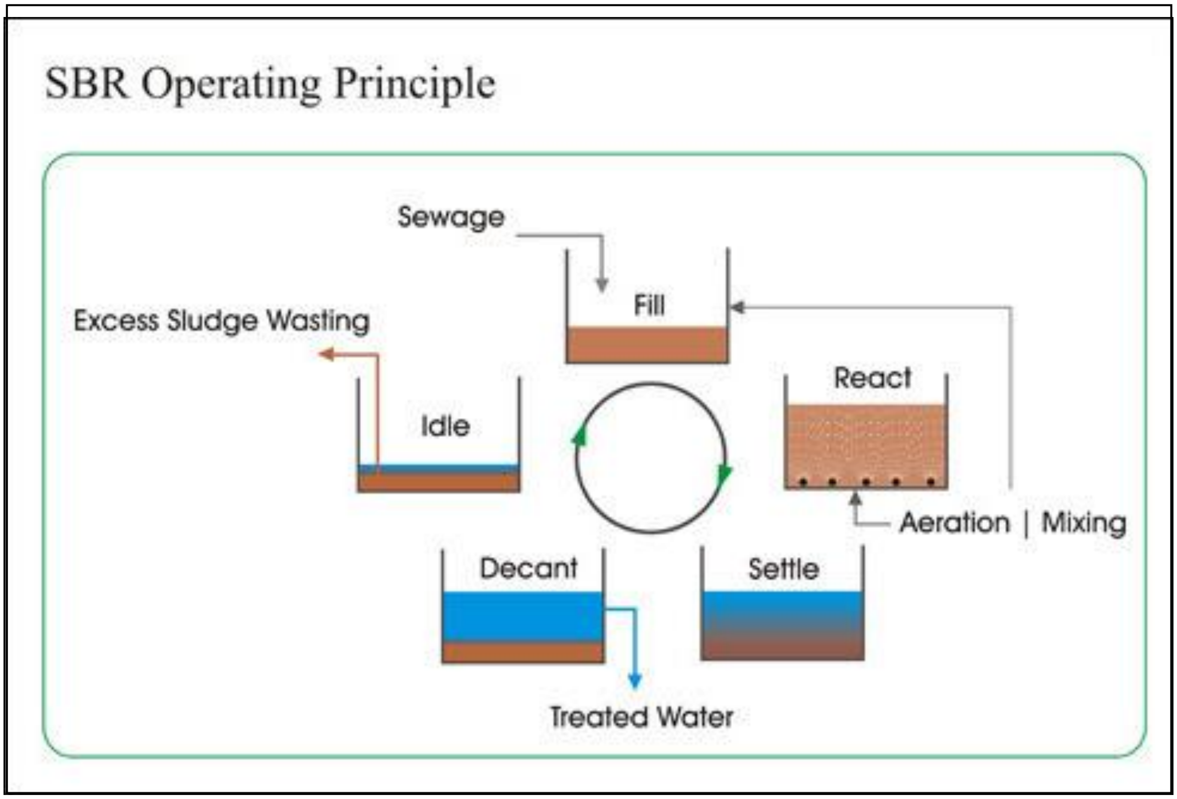
Sequencing batch reactors (SBRs), due to its operational flexibility and excellent process control possibilities, are being extensively used for the treatment of wastewater which nowadays is fast becoming contaminated with newer and more complex pollutants. It is also possible to include different expanding array of configurations and various operational modifications to meet the effluent limits which are also continuously getting upgraded. This article provides basic description of SBR process along with its functional and physical variants that lead to improve the removal of nutrients and emerging contaminants. The significance of selectors and various recent advancements in the application of SBR has been discussed along with the possibilities held by SBR process in the treatment of wastewater of different origins and composition to produce effluent of reusable quality.

The environmental discharge standards are getting more and more stringent, the traditional continuous flow-based biological wastewater treatment process faces severe challenges. The sequencing batch reactor (SBR) technology is a modification of the much popular activated sludge process (ASP). Such a conversion of the continuous nature of the ASP-based treatment process to a batch process as in SBR helps introduce various process flexibilities and alternatives in process controls and design so as to better achieve the latest effluent discharge standards. The term SBR was originally coined by R.L. Irvine

Opposed to the common belief of SBR being a new technology, the SBR-like fill and draw processes were popular during 1914–1920. The revival of interest in SBR technology in its present form occurred during the late 1950s and early 1960s due to the improvement in technology related with aeration and process control. In its initial years, SBR technology was mainly used by small communities for sewage treatment and for the treatment of high strength industrial wastes.

Due to the design flexibility and better process control that can be achieved by the modern technology, the use of the SBR process has not been limited to the field of sewage treatment only; it has also found wide acceptance in biological treatment of industrial wastewater containing difficult-to-treat organic chemicals. As the SBR process can be effectively automated, it is known to save more than 60 % of the operating expenses required for a conventional ASP and is able to achieve high effluent quality in a very short aeration time. In densely populated countries such as India and regions such as Europe, SBR is being considered as a preferable technology due to its low requirement of area as well as manpower for operation. The SBR process is often preferred over continuous flow process (CFP) due to reduction in energy consumption and enhancement in the selective pressures for BOD, nutrient removal, and control of filamentous bacteria. Due to these reasons, SBR process is gaining immense popularity in the recent years. The SBR technology has been undergoing several minor and major modifications over the past few years to be able to effectively treat the exponentially increasing number of new pollutants in wastewater. This article provides an insight into the technology as well as reviews the recent advances in the design and application of SBR technology.

Process Flow for Sequential Batch Reactor



Fill:

During the fill phase, the basin receives influent wastewater. The influent brings food to the microbes in the activated sludge, creating an environment for biochemical reactions to take place. Mixing and aeration can be varied during the fill phase to create the following three different scenarios: Static Fill – Under a static-fill scenario, there is no mixing or aeration while the influent wastewater is entering the tank. Static fill is used during the initial start-up phase of a facility, at plants that do not need to nitrify or denitrify, and during low flow periods to save power. Because the mixers and aerators remain off, this scenario has an energy-savings component. Mixed Fill – Under a mixed-fill scenario, mechanical mixers are active, but the aerators remain off. The mixing action produces a uniform blend of influent Sequencing Batch Reactor Design and Operational Considerations 4 MAJOR PHASES OF THE SBR OPERATIONS CYCLE Source: University of Florida TREEO Center's Sequencing Batch Reactor Operations and Troubleshooting Manual.

Waste water and biomass. Because there is no aeration, an anoxic condition is present, which promotes denitrification. Anaerobic conditions can also be achieved during the mixed-fill phase. Under anaerobic conditions the biomass undergoes a release of phosphorous. This release is reabsorbed by the biomass once aerobic conditions are re-established. This phosphorous release will not happen with anoxic conditions. Aerated Fill – Under an aerated-fill scenario, both the aerators and the mechanical mixing unit are activated. The contents of the basin are aerated to convert the anoxic or anaerobic zone over to an aerobic zone.

No adjustments to the aerated-fill cycle are needed to reduce organics and achieve nitrification. However, to achieve denitrification, it is necessary to switch the oxygen off to promote anoxic conditions for denitrification. By switching the oxygen on and off during this phase with the blowers, oxic and anoxic conditions are created, allowing for nitrification and denitrification. Dissolved oxygen (DO) should be monitored during this phase so it does not go over 0.2 mg/L. This ensures that an anoxic condition will occur during the idle phase.

React:

This phase allows for further reduction or "polishing" of wastewater parameters. During this phase, no wastewater enters the basin and the mechanical mixing and aeration units are on. Because there are no additional volume and organic loadings, the rate of organic removal increases dramatically. Most of the carbonaceous BOD removal occurs in the react phase. Further nitrification occurs by allowing the mixing and aeration to continue—the majority of denitrification takes place in the mixed-fill phase. The phosphorus released during mixed fill, plus some additional phosphorus, is taken up during the react phase.

Settle:

During this phase, activated sludge is allowed to settle under quiescent conditions—no flow enters the basin and no aeration and mixing takes place. The activated sludge tends to settle as a flocculent mass, forming a distinctive interface with the clear supernatant. The sludge mass is called the sludge blanket. This phase is a critical part of the cycle, because if the solids do not settle rapidly, some sludge can be drawn off during the subsequent decant phase and thereby degrade effluent quality.

Decant:

During this phase, a decanter is used to remove the clear supernatant effluent. Once the settle phase is complete, a signal is sent to the decanter to initiate the opening of an effluent-discharge valve. There are floating and fixed-arm decanters. Floating decanters maintain the inlet orifice slightly below the water surface to minimize the removal of solids in the effluent removed during the decant phase. Floating decanters offer the operator flexibility to vary fill and draw volumes. Fixed-arm decanters are less expensive and can be designed to allow the operator to lower or raise the level of the decanter.

It is optimal that the decanted volume is the same as the volume that enters the basin during the fill phase. It is also important that no surface foam or scum is decanted. The vertical distance from the decanter to the bottom of the tank should be maximized to avoid disturbing the settled biomass. Chapter 1: Characteristics of Sequencing Batch Reactors (SBRs) 5 Idle This step occurs between the decant and the fill phases. The time varies, based on the influent flow rate and the operating strategy. During this phase, a small amount of activated sludge at the bottom of the SBR basin is pumped out—a process called wasting.

Sources:

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