Continuous Flow Integrated Clarifier Sequencing Reactor (ICSR) System – An Operation Friendly Alternative To Continuous Flow/Cyclic Sequencing Batch Reactors (SBR)

Sequencing Batch Reactors have a hundred year history – from initial fill-and-draw design of 1914 to very large scale STPs today. In its simplest form, SBR is a basin wherein the activated sludge process takes place in distinct sequential steps – Fill, React, Settle & Draw. The batch process of a single basin can be converted into pseudo-continuous form by proper configuration of number of basins and cycle time. SBRs offer better economics than conventional ASPs and their unsteady state operations help to sustain favourable microbial fauna. However, continuous flow SBRs require multiple basins and are automation-dependent. Varying quality of feed calls for expert monitoring of cycle times while usual short term occurrences of heavy foaming and poor settlement of biomass causes performance issues.

Continuous flow Integrated Clarifier Sequencing Reactor (ICSR) System provides the same economic benefits of lower capital and life cycle cost, without any automation dependency. Its performance is not affected during heavy foam conditions or when biomass does not settle well. It operates without any constant supervision and does not have any moving parts in contact with wastewater that need maintenance. ICSR is a fitting alternative to SBRs.

From the first Fill-and-Draw design of 1914 to the real commercialization in Australia and Europe in late 70's, followed later by major revival and global populism in the last two decades, Sequencing Batch Reactors (or SBRs as they are conveniently called) have a 100-year history to tell. What started as simple batch treatment for house hold sewerage is now market leader in very large scale municipal STPs, and trying to get foothold in more difficult industrial effluent treatment.

For the benefit of those who are not acquainted with SBRs, the SBR, in its simplest form, is a single tank equipped with an aeration system and moving outlet weir.

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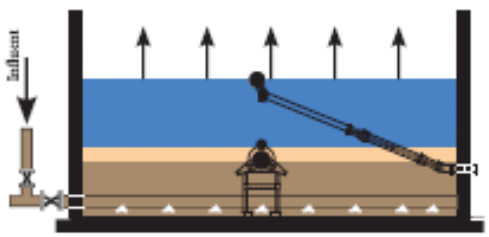
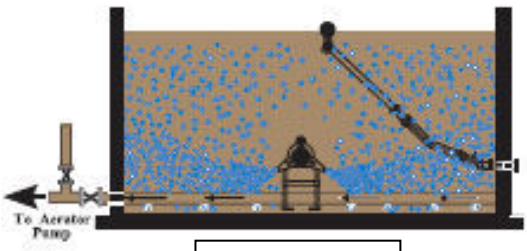
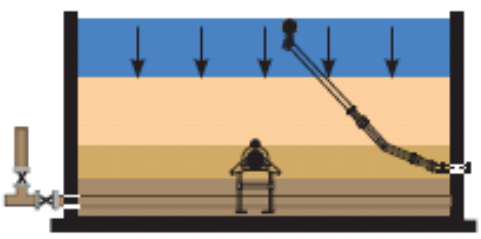


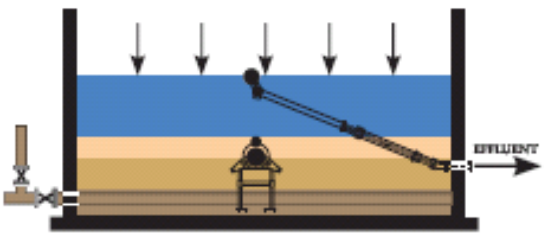
ANOXIC FILL STAGE



REACT STAGE



SETTLE STAGE



DECANT STAGE

Feed wastewater is treated in a series of steps or processes in the same tank. In the basic from – these are four steps in sequence: (a) Fill (wherein the wastewater is fed in a half-empty basin), (b) React (whereby air is introduced in the basin for a fixed duration), (c) Settle (whereby the MLSS in the tanks are allowed to settle by not allowing any feed or aeration) and (d) Draw (whereby the clear supernatant is withdrawn by a moving weir)

All these steps, as a whole, constitute the "cycle time" of a SBR, which typically varies from 3-6 hours in case of domestic sewage to 6-12 hours for industrial effluents. By proving multiple SBR basins corresponding to the cycle time, the plant can be made continuous flow, wherein feed is staggered between tanks in a cyclical fashion.

Apparent advantages of SBR-based continuous flow systems are:

a) Compact common-wall construction with low foot-print
b) Elimination of secondary clarifier
c) Optimization of available resources by changing cycle time and oxygenation based on feed quantity and quality
d) Modular Construction
e) Lower capital and operating cost

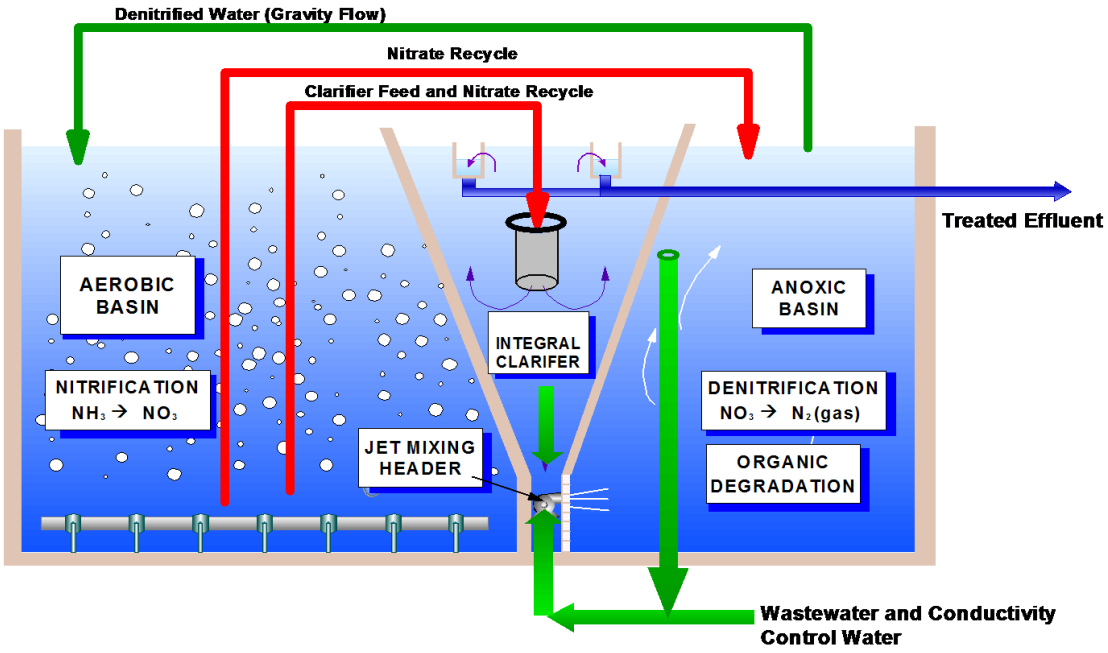
From the process design standpoint, the SBR process offers following distinct advantages:

a) Un-steady state Operations with varying growth rate and oxygenation regime, providing an ideal reactor configuration of completely mixed and plug flow reactors in series
b) Filamentous bacteria control using a selector zone/step
c) Efficiently and convenient nutrient removal achieved by cyclical anoxic and aerobic conditions.

Even with all the apparent advantages, Continuous Flow or Cyclic SBRs still lag behind continuous flow conventional activated sludge systems in terms of number of installations and quantities handled. The practical and operational difficulties with SBRs are:

a) Operations are automation-dependent. Failure of automation system or auto-operated components results into process upset.
b) Variations in feed quality and quantity require expert intervention in changing cycle times and sequencing. If the variations are too frequent on a daily basis, it becomes impossible to adapt to the variations.
c) If the DO-based automation fails, which is often the case esp. with industrial effluents, excessive power is consumed since aeration system is designed for peak consumption during the fill cycle.
d) Foaming and poor settling sludge, which are common occurrences in any activated sludge plant, results into loss of biomass across the moving weir, leading to loss of performance.
e) For industrial effluents with higher TDS, biomass setting is poor and requires addition of polymers. SBRs do not have provisions to add polymers effectively.

A novel approach, with all the advantages of SBR process minus its operational complexity and automation, is the Continuous Flow Integrated Clarifier Sequencing Reactor System. ICSR is constituted by an aeration tank, a secondary clarifier and a sludge recycle system just like as in conventional process, but all within a single basin and without any maintenance-prone moving parts such as sludge scrapper, recycle pumps or moving weirs.



The ICSR can be operated in an un-steady state condition with varying DO levels in different sections. The Static Fill condition of a SBR is obtained in the anoxic zone, the React condition is obtained in the completely mixed aerobic zone (which may further divided into two sections of varying DO levels) and the Settle & Draw operations are replaced by more efficient Integral Clarifier that operates on induced sludge velocity that provides additional force over the gravity to recycle the biomass back to the aeration basin. All of these functions are done in a single basin having thin-walled partitions and without using any rotating component within.

This configuration has all advantages of SBR, viz.:

a) Un-steady state operations
b) Nutrient (nitrogen) removal with anoxic zone
c) Compact construction with low foot-print
d) No separate clarifier or sludge scrapper
e) Modular design
f) Low Capital as well as, low O & M cost

Apart from these, the CFICASS offers additional advantages beyond what SBRs provide:

a) Forced recycling of biomass, resulting in higher operating MLSS and lower effluent TSS
b) No submersible or centrifugal recycle pumps
c) No automation, except optional automation for DO-control to optimize power consumption

d) No operational manpower requirement
e) No need to change cycle times or loading rates
f) No need to have multiple tanks; multiple basins recommended only for very large flows in excess of 20 MLD
g) No need to change operating parameters frequently
h) No interference of foam in clarifier
i) Provision to add and mix polymer before clarifier

To summarize, while SBRs do have district process and capital cost advantage over conventional plants, their dependency on automation, expert monitoring and difficulties in handling foam and poor settling biomass, fail to make SBRs the obvious choice. Continuous Flow Integrated Clarifier Sequencing Reactor, on the other hand, offers advantages of SBRs as well as conventional plants, without any internal moving parts or compulsory automation. It offers same capital and operating cost advantages as SBR and can operate without any continuous supervision. It offers reliability and consistency of performance even with poor settling biomass or foaming effluents. ICSR is an approach worth a serious attention while considering SBRs.