

iSBR[®]/iGSR[®]-Process – INVENT's modern interpretation of the Sequencing Batch Reactor Process

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Figure 1: Municipal wastewater treatment plant in Israel with iSBR[®]

Since we have started our business activities in the early nineties we have been in love with the so called Sequencing Batch Reactor process (SBR) for the biological treatment of municipal or industrial wastewater. Batch processes have the great advantage that the reactor behavior is defined, the boundary conditions stay constant and unexpected events are unlikely to occur while running the treatment cycle.

The **INVENT HYPERCLASSIC**[®]-Mixing and Aeration System from the very beginning has been the core of each SBR plant we designed and built. The System can effectively mix without aeration and at a different time efficiently aerate and mix the biomass. This is why it is the ideal basis for SBR and any cyclic or intermittent process.

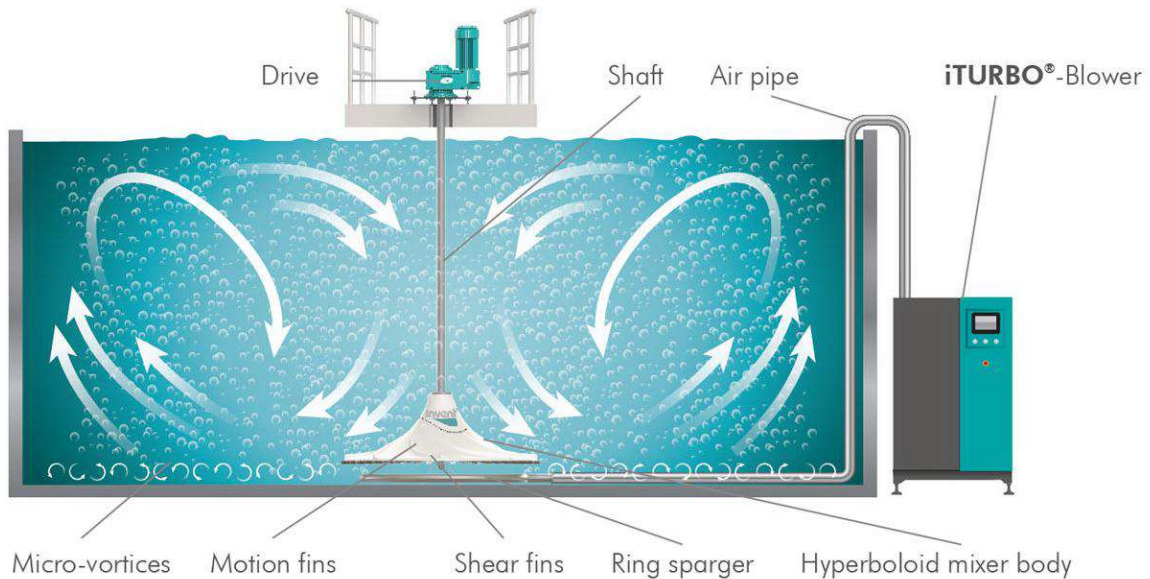


Figure 2: Schematic diagram of the **HYPERCLASSIC**[®]-Mixing and Aeration System

One of our core competencies has always been to deeply understand and analyze fluid mechanical correlations and to use this understanding to design superior products for the water and wastewater industry.

The focus of our activities is on the essential unit processes

- Mixing
- Mass transfer
- Solid/liquid separation

In these areas good fluid mechanical design can make a real difference and improve overall process efficiency and save energy. This is how whole product families of advanced mixing systems, highly efficient aeration systems, high performance decanters and innovative filters developed over time.

A second of our core competencies is to deeply understand the treatment processes and to know how to integrate our products into our client's processes most beneficially. This inevitably led to a deep understanding of the in and outs and specific requirements of SBRs and a dedicated family of products for this special process.

These include:

- Inflow Distribution System
- **HYPERCLASSIC**[®]-Mixing and Aeration System
- **iDEC**[®]-SBR Decanting System
- SBR Surplus Sludge Retrieval Systems
- **iTURBO**[®]-Blower High Speed Turbo Blower
- **iFILT**[®]-Diamond Filter
- SBR Control Systems

Each product can be sized and customized for the individual plant and application to perfectly match each client's needs and specifications.

In cases in which the client wishes to benefit from and make use of our experience and expertise we can offer our design and engineering package along with our hardware package. We can complement this integrated hard- and software package with installation supervision, start-up and training and supply a complete SBR package. We call this in case of a conventional process design **iSBR**[®] and in case of a granular sludge process **iGSR**[®]. These complete systems can be used in all common wastewater treatment applications such as e.g.

- Municipal wastewater treatment
- Industrial wastewater treatment
- De-ammonification process
- Granular Sludge processes

The four main areas in which we have achieved improvements compared to conventional systems in the market are

- the key equipment,
- the overall reactor design,
- the overall process design, and
- the overall fluid mechanical design

Overall Reactor Design

The **iSBR®/iGSR®** reactor design is based on the idea of creating several individual zones in one reactor module, which are positioned in series. This design, which only works thanks to the unique features of the **HYPERCLASSIC®**-Mixing and Aeration System, allows for the realization of an advanced process which has

1. Cascaded reactor design
2. Runs continuously
3. And cyclic

We call this iC^3 -Process.

Cascaded reactor design

Each **HYPERCLASSIC®**-Mixing and Aeration System creates an individual zone which are cascaded over the entire reactor. This allows for a much higher process flexibility since we can run different modes and process parameter in the individual zones during the same cycle. The first zones for example can act as a selector while the last zone is decanting.

The individual steps of the **iSBR®/iGSR®**-Process

We differentiate the five different process phases, which happen at different times and four different spatial zones (Zones 1 - 4). These zones are defined by the 4 different spatial zones of equal size in which we can divide each SBR tank.

Overall Process Design

The continuous inflow and the division of the reactor in individual zones allows for an advanced process design which is explained in this paragraph.

In figure 3 the five basic cycle phases of the **iSBR®/iGSR®**-Process are shown schematically. After phase 5 the cycle repeats itself and jumps back to phase 1. What happens in the individual phases is as follows.

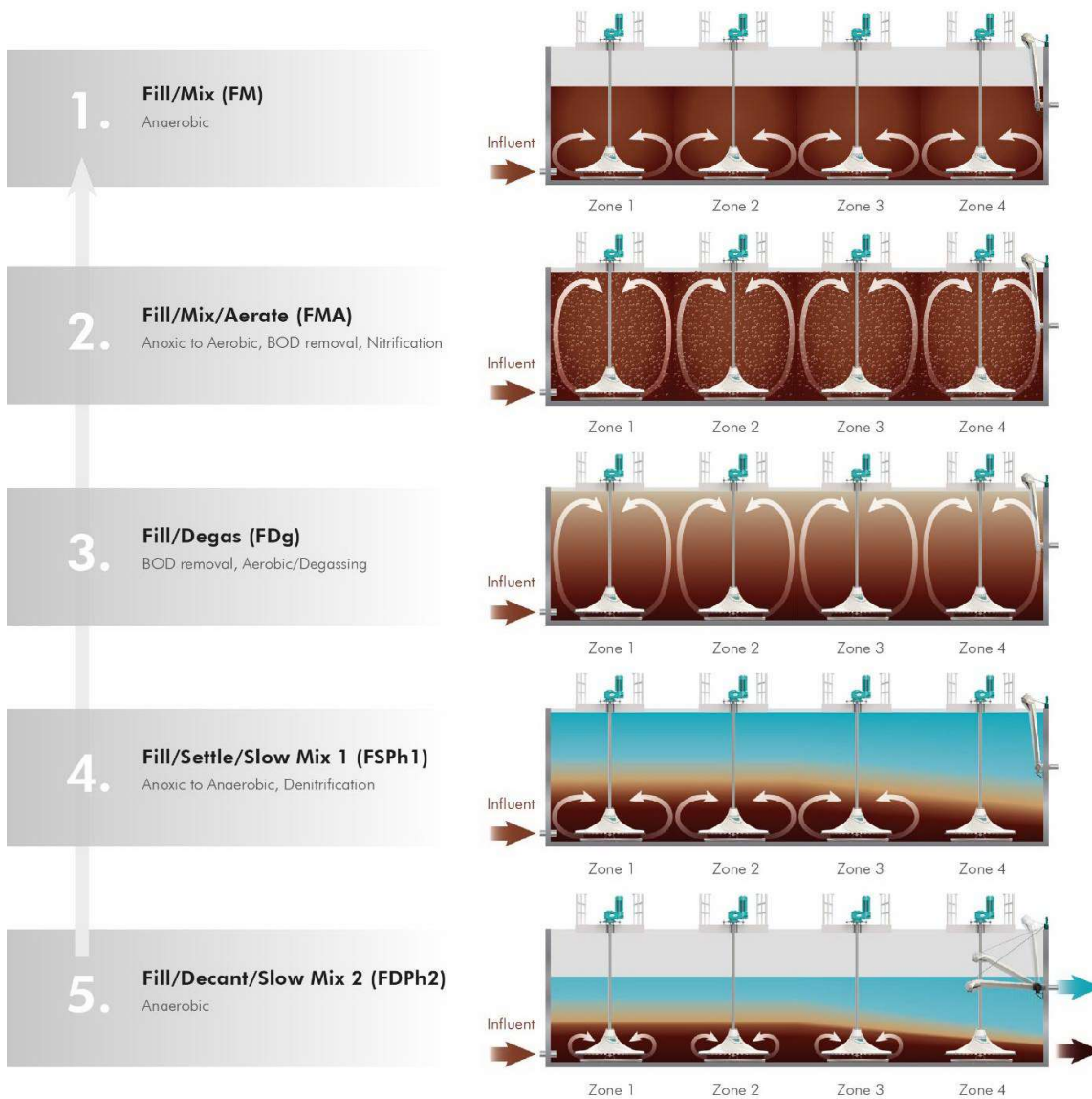


Figure 3: The five main cycle phases of the **iSBR®/iGSR®**-Process

1 Fill/Mix (FM)

In this phase the **HYPERCLASSIC®**-Mixing and Aeration System operates at reduced speed and provides mixing without aeration. Anaerobic conditions due to the continuous filling of wastewater are generated in zones 1 and 2; whereas there are mainly anoxic conditions in zones 3 and 4. In zones 3 and 4 the necessary anaerobic conditions are generated for a

partial degradation of organic compounds, which may not be degraded under solely aerobic conditions, and also for biological phosphorus removal.

2 Fill/Mix/Aerate (FMA)

During the aeration cycle filling continues and the **HYPERCLASSIC**®-Mixing and Aeration System operates at high speed in strong mixing and aeration mode. It efficiently supplies the necessary oxygen for the BOD and COD removal and the nitrification process. Effective mechanical mixing during aeration is very important to maintain and ensure high α -values, to maintain high oxygen transfer rates and to apply the necessary minimum shear stress on the granular biomass.

The **HYPERCLASSIC**®-Mixing and Aeration System is a proven technology for aeration in bioreactors with granular sludge. Mechanical mixing during aeration is also desirable to avoid foaming and scum on the water surface. The strong mixing furthermore ensures aerobic conditions and a minimized anaerobic core in the sludge flocs.

Due to the high oxygen demand resulting from the feed of fresh wastewater to Zone 1 of the **iSBR**®, Zone 1 stays during this phase mainly anoxic.

3 Fill/Degas (FDg)

After the aeration cycle has been completed and the blowers have been turned off a short period of strong mixing at increased speed of the **HYPERCLASSIC**®-Mixing and Aeration System takes place. By this an effective degassing of the sludge flocs is achieved. This improves the sludge settling properties and avoids collection of foam on the water surface.

4 Fill/Settle/Slow Mix 1 (FSPH1)

Due to the anoxic conditions during the settling phase, denitrification processes take place in the first zones of the **iSBR**® and the **HYPERCLASSIC**®-Mixing and Aeration System at the inlet of the **iSBR**®/**iGSR**® operates at low speed and gently mixes the fresh wastewater with the increasing sludge blanket at the bottom. At this low speed the sludge blanket is maintained at the desired depth. The feed of raw wastewater into the sludge blanket creates, after a short anoxic phase, anaerobic conditions with Bio-P release. Additionally these anaerobic conditions promote the conversion of bCOD1 to rbCOD2 in the inlet zone (Zone 1) of the **iSBR**®/**iGSR**® with anaerobic uptake of rbCOD and/or anoxic depletion of the same. This minimizes aerobic uptake of rbCOD, and creates the optimum biochemistry for aerobic granular sludge growth.

5 Fill/Decant/Slow Mix 2 (FDPH2)

During this last step of the **iSBR**[®]/**iGSR**[®]-Process the wastewater inflow into the sludge blanket and the operation of the **HYPERCLASSIC**[®]-Mixing and Aeration System at low speed continues. Anaerobic conditions necessary for Bio-P. are created within the sludge blanket. In this final phase the **iDEC**[®] begins to withdraw the treated effluent (decant) without disturbing the sludge blanket by our waste sludge retrieval system and thus preventing a contamination of the effluent with sludge. During this phase the excess sludge is removed from the settled blanket to maintain the required food to mass ratio for the process design. As soon as the decanting cycle has been completed and the desired discharge volume has been withdrawn from the **iSBR**[®]/**iGSR**[®], the decanter raises to its idle position above the water level and the cycle repeats itself.

¹ bCOD: biodegradable chemical oxygen demand

² rbCOD: readily biodegradable chemical oxygen demand

iSBR[®]/**iGSR**[®] Benefits

Continuous Flow Operation

The **INVENT SBR**[®]/**GSR**[®]-Process uniquely combines the advantages of a batch wise operation with conventional continuous flow across the entire plant. This unique achievement makes large equalization basins in front of the biological reactors unnecessary and further reduces the overall footprint of the plant.

Modular Design

Our **INVENT SBR**[®]/**GSR**[®] are based on a modular design. The individual modules consist of either a single or a double train of **HYPERCLASSIC**[®]-Mixing and Aeration Systems and 3, 4, 5, 6 or i of them in series. The size of the base modules selected depends on the overall plant capacity which is required, the local conditions and the overall design approach. We prefer plant designs with several individual modules because they offer a higher flexibility and operational safety.

Unique Equipment Package

INVENT's unique equipment package used in the **iSBR**[®]/**iGSR**[®]-Process sets us apart from all other approaches on the market. The flow conditions we can create with the **INVENT**

HYPERCLASSIC®-Mixing and Aeration System are unparalleled and make this process possible. The virtual wall effect ensures the desired reactor behavior. The versatile mixing conditions allow for the safe granular sludge growth. The high aeration performance and quick response times facilitate reliable process control. And if you compare the **HYPERCLASSIC**®-Mixing and Aeration System with standard membrane aeration systems which are still commonly used, it has a significantly higher performance under process conditions (α -value) and most importantly it does not age and does not lose aeration performance over time.

Our **iDEC**®-SBR Decanter allows for short decanting times. Our high efficiency **iTURBO**® High-Speed Blower further reduces the energy consumption and our **iFILT**®-Diamond Filter can further reduce the amount of suspended solids in the effluent if locally required or if the water shall be re-used e.g. for irrigation purposes. But the star is the team. Having developed all this products in house means that we could optimally design them for the purpose and the use in **INVENT SBR**®s and **GSR**®s and they optimally work with each other to supply the highest performance in each **INVENT** project.

Reactor Design

Our **iSBR**®/**iGSR**®-Design is optimized for this special process and for the equipment used. It allows for maximum mass transfer optimal reactor behavior, small overall footprint and high operational safety and performance. For the reactor design Typical Flow Diagram of an **iSBR**®/**iGSR**® plant we use the most modern fluid mechanical simulation tools as well as dynamic simulation for the optimization of the overall process performance and specific load conditions.

Process Design

The unique **iSBR**®/**iGSR**®-Process allows for aerobic granular sludge production under continuous flow conditions. This is only possible using a cascade of complete mixed stirred tank reactors we create with **HYPERCLASSIC**®-Mixing and Aeration System and the cyclic process conditions.

Summary

INVENT over the years has been improving the Sequencing Batch Reactor process and is now offering the advanced proprietary **iC**³-Process in its **SBR**®/**GSR**® packages to selected clients.