

# **Improving Industrial SBR Treatment with IFAS Technology**

Clifford A. Merritt  
Owens Corning  
Science & Technology Center  
2790 Columbus Road, Granville, Ohio 43023

## **ABSTRACT**

This paper is a case study in the installation, startup and operation of applying Integrated Fixed-Film Activated Sludge (IFAS) technology to an existing sequencing batch reactor (SBR) system treating a complex industrial wastewater. Increased flow and load from process wastewater and landfill leachate; both containing ammonia (NH<sub>3</sub>) and color constituents led to an expansion of the biological treatment system. Due to space constraints and operational considerations, the SBR was outfitted with fifteen IFAS modules. The resultant increase in biomass concentration has allowed greater removal of organics, ammonia and color.

## **KEYWORDS**

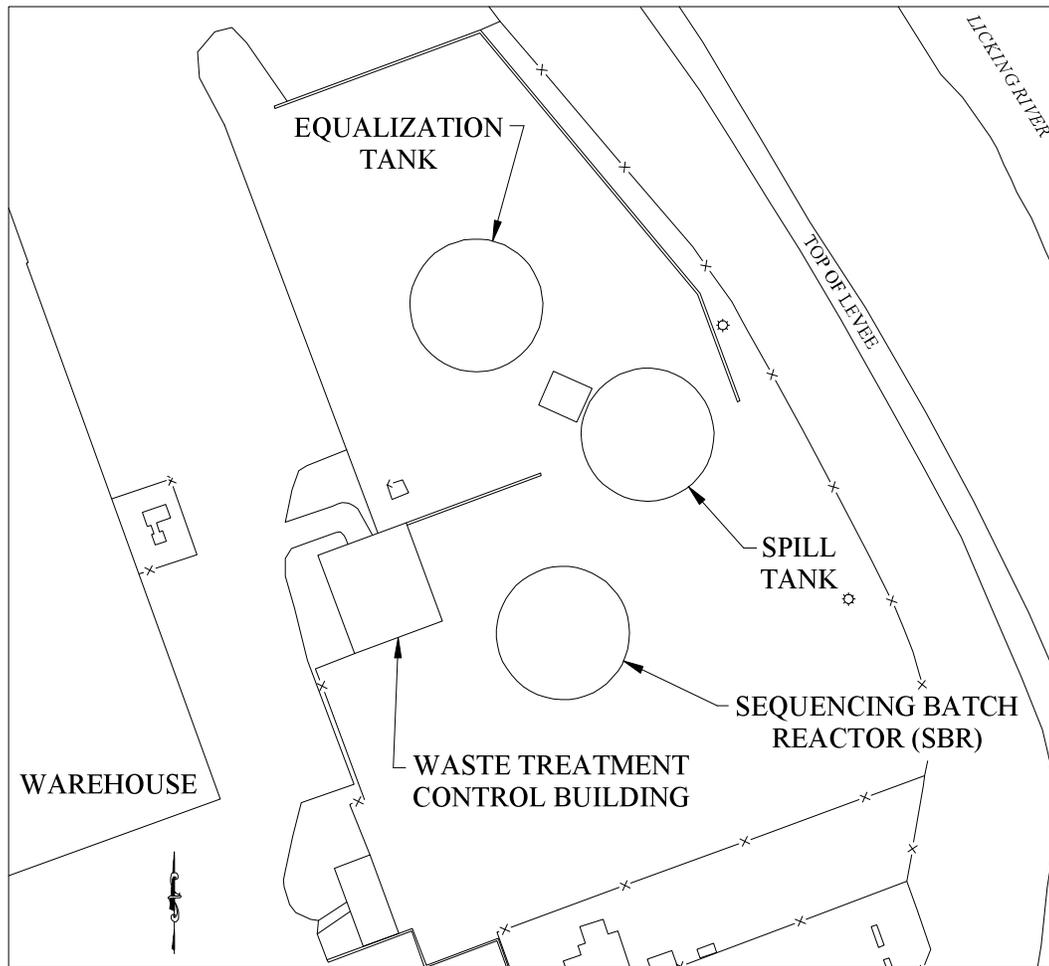
Sequencing batch reactor (SBR), Integrated Fixed-Film Activated Sludge (IFAS), web mesh fabric, industrial wastewater, colored wastewater, azo dye, biological treatment

## **BACKGROUND**

Owens Corning (OC) produces fiberglass insulation at a manufacturing facility in Newark, Ohio. As a discharger to the local Publicly-Owned Treatment Works (POTW), the plant pre-treats a combination of process wastewater, landfill leachate, sanitary sewage as well as first-flush stormwater runoff from the plant property.

The plant's biological wastewater treatment system consists of three tanks; an equalization tank (EQ, a.k.a. North tank), emergency spill tank and SBR tank. The site plan (Figure 1) shows the layout of the treatment system. All tanks are 15.8m (52 feet) in diameter, 12.2m (40 feet) high with a shell capacity of 2403m<sup>3</sup> (635000 gal) and two of the tanks were former fuel oil storage tanks. The SBR utilizes jet mixing and aeration, a fixed decanter, operates on four 6-hour cycles per day and is designed to treat 1893m<sup>3</sup> (500000 gal) per day. The EQ tank is mixed and aerated with jet mixing also.

When manufacturing curtailment was proposed due to market conditions, the resultant product mix restricted process water recycle and produced more process wastewater, particularly more colored wastewater. The process wastewater contains binders/sizes from washdown water, equipment cleanouts and process upsets. At times highly colored wastewater required dilution



**Figure 1. Site plan showing EQ tank, spill tank and SBR tank locations**

water addition to the EQ tank to allow the biological treatment process to reduce the color concentration. The company's landfill operates with leachate recirculation and with higher rainfall patterns; leachate flow had increased with greater ammonia loads. Stormwater runoff from the first 1.27cm (0.5 inch) rainfall is stored in the EQ/spill tanks and this stormwater does provide dilution water for high concentration parameters when necessary. Overall the wastewater contains organic matter as measured by chemical oxygen demand (COD), ammonia and color constituents from process dyes and landfill leachate exhibiting low percentage transmittance of light. Therefore, additional biological treatment capacity to remove the increased loading from COD, NH<sub>3</sub> and color was necessary for successful implementation of the new manufacturing schedule. As an added benefit, expanding the biological treatment capability would eventually eliminate dilution water addition to the EQ tank to facilitate color removal and subsequent sewer discharge of this unnecessary city water, thereby meeting the plant's sustainability goals.

### **IFAS PROCESS SELECTION**

Options considered to increase biological treatment capacity were either adding another SBR tank or increasing the biomass levels in the existing SBR. Space needed for another SBR tank was not

available as well as being cost prohibitive, so adding more biomass was chosen. Increasing the biomass levels could be achieved by either raising the mixed liquor suspended solids (MLSS) in the SBR or by incorporating IFAS technology. Due to SBR cycle characteristics and decanter configuration the MLSS level reaches equilibrium (what is produced per day is discharged to the POTW within the suspended solids limit of 250 mg/l) and cannot be increased effectively and maintained.

Based upon knowledge of the existing SBR system, a literature review, treatment goals and ease of operation, combining suspended growth (activated sludge) and attached growth (fixed film) treatment processes was determined to be the most cost effective technology for upgrading the SBR process. Hence, this hybrid system is known as the Integrated Fixed-Film Activated Sludge (IFAS) process. Activated sludge exhibits process flexibility and provides a high degree of treatment. Fixed film processes are inherently stable and resistant to organic and hydraulic shock loading. Therefore, packing fixed film media into the activated sludge tank (SBR) combines the advantages of both processes (Flournoy et al., 2008).

Basically two types of synthetic packing materials have been developed for use in activated sludge processes. These packing materials may be suspended in the activated-sludge mixed liquor or fixed in the aeration tank. These processes are intended to enhance the activated sludge process by providing a greater biomass concentration in the aeration tank and thus offer reduced tank size requirements for an expansion project or greater treatment capacity in the same tank for an upgrade project. Because of the complexity of the process and issues related to understanding the biofilm area and activity, the process designs are empirical and based on prior pilot plant or full-scale results (Metcalf & Eddy, Inc., 2003).

The two types of IFAS media configuration, i.e. knitted web mesh fabric media (fixed) or free-floating biofilm carriers (suspended) were evaluated. Both types of fixed-film packing could provide adequate surface area per unit volume and hence a dense population of highly adapted micro-organisms, but a few process goals and potential operational issues favored the web mesh media. Difficulties anticipated with biofilm carriers in a jet mixing application are listed below.

1. Biofilm carrier screening: With jet mixing screening is critical to keep biofilm carriers from plugging the high capacity recirculation pump or plugging the jet nozzles from the inside or the pump from destroying the biofilm carriers. Also the jet mixing system is regularly back flushed so exterior screens on each nozzle would be necessary to keep from plugging each nozzle from the outside. In addition the SBR decanter is submerged at a fixed height from the tank floor and would require screens over the discharge slots to keep from plugging each slot or drawing biofilm carriers into the final effluent.
2. Maintenance of screens: Since all of the screens would be submerged in the SBR tank or in the recirculation piping, normal tank agitation would likely scour the screens and keep them cleaned but regular maintenance of the screens would be impossible without taking the SBR tank out of service.
3. Floating biofilm carriers: During the SBR cycles of settle, decant and part of the fill cycle no mixing occurs and the buoyant biofilm carriers would automatically float to the surface

essentially withdrawing that available biomass from the anoxic/anaerobic conditions needed to degrade the color molecule.

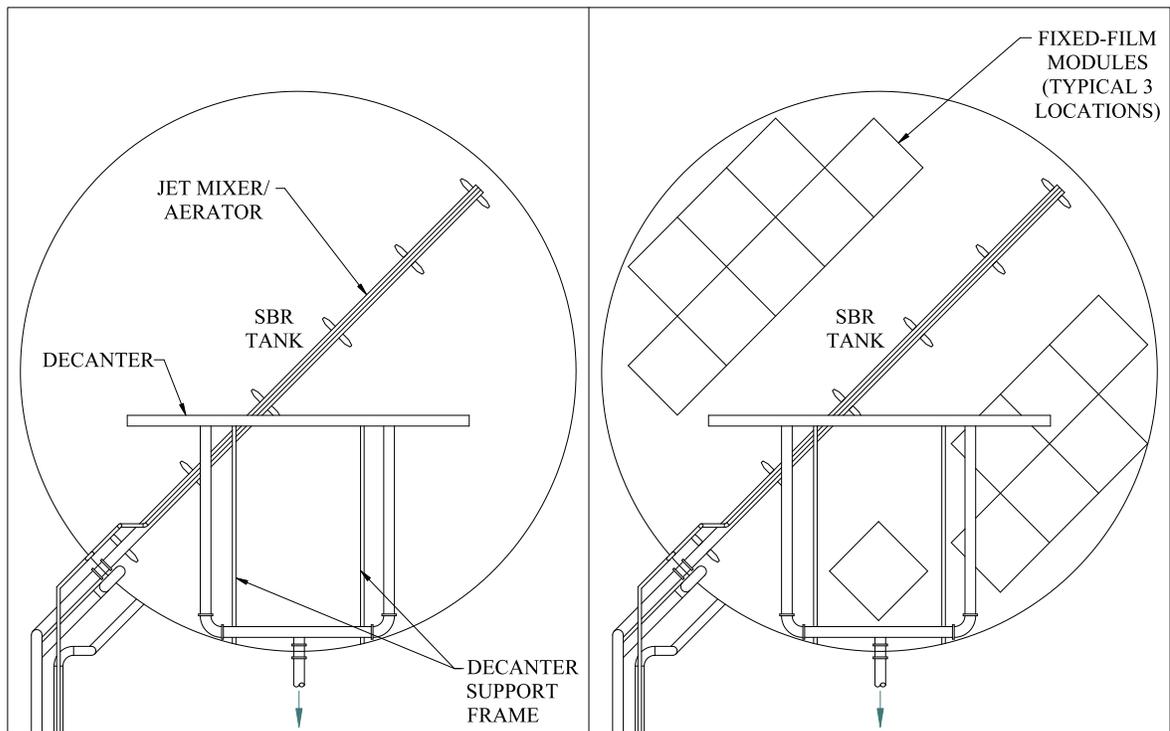
4. Separation of biofilm carriers during SBR tank maintenance: Periodically the SBR tank is drained and cleaned during jet mixer maintenance or other repair work and a relatively simple method to transfer the biofilm carriers to temporary storage or to separate the biofilm carriers from the accumulated debris would need to be devised (Stricker et al., 2007).

#### **DESCRIPTION OF SBR WITH IFAS SYSTEM**

Fifteen (15) IFAS modules [approximately 2.1m (6.5 feet) X 2.1m (6.5 feet) X 6.1m high (20 feet)] were added to the SBR tank. The modules were aligned parallel to the jet mixer and bolted to the tank floor on welded pads. Further, the modules were connected to one another at the tops with stainless steel plates, threaded rod and nuts to maintain stability during jet mixing. The web mesh media addition amounted to approximately 11801m<sup>2</sup> (127000 ft<sup>2</sup>) of surface area for bacterial colonization. This media area is expected to increase biomass concentration in the SBR by approximately 50% in the same tank footprint. The BioWeb™ media and modules were manufactured by Entex Technologies Inc. of Chapel Hill, North Carolina.

Increasing biomass concentration in response to increased loadings of COD, NH<sub>3</sub> and color necessitated an evaluation of the capacity of the aeration/mixing equipment. The jet mixer had been previously upgraded from a center pod configuration to the current longitudinal configuration which places the 12 jet nozzles across the tank floor. At over 68.1m<sup>3</sup>/hr (300 gpm) per nozzle the tank is well mixed with the IFAS modules in place. One blower normally supplies air to the jet mixer with a second blower brought into service when the dissolved oxygen (DO) goes below 2.0 mg/l during the aeration cycle. Normally the DO is greater than 4.0 mg/l during aeration and no additional blower capacity was necessary.

The BioWeb™ fabric is comprised of high-strength polyester filaments in an interlocking “honeycomb” design which has high break strength. The filaments form loops that stand out from the fabric, thus providing countless growth sites for attached biomass. The BioWeb™ fabric is affixed to the support pipe rods of the module frame with sufficient spacing as to prevent significant in-service contact of adjacent sheets of web mesh while permitting a continuous flexing action and oscillation of individual panels of mesh fabric as the tank is being mixed. The BioWeb™ panels of each module are oriented parallel to the jet mixer discharge plumes with the nearest module located 2.3m (7.5 feet) from the centerline of the jet mixer. The SBR tank plan (Figure 2) shows the tank before and after IFAS modules.



**Figure 2. SBR tank plan before and after IFAS modules**

### **COLOR REMOVAL**

Azo dyes are used by a wide number of industries. While textile mills predominantly use them, azo dyes can also be found in the food, pharmaceutical, paper and printing, leather and cosmetics industries. An azo dye is used to impart the characteristic pink color to Owens Corning's fiberglass insulation. Because these compounds retain their color and structural integrity under exposure to sunlight, soil, bacteria and sweat, they also exhibit a high resistance to complete microbial degradation in conventional wastewater treatment systems.

The color concentration of the wastewater is measured in Platinum-Cobalt (Pt-Co) color units. The local POTW pretreatment limit is 350 Pt-Co color units. One of the primary objectives of this wastewater upgrade project was to determine the best way to increase the color reducing efficiency of the SBR while substantially reducing dilution water addition to the EQ tank without materially affecting short and long-term operating costs.

Research on biological treatment of azo dye compounds indicates that aerobic treatment alone can lower color constituents up to 25-30 percent. Of course, aerobic treatment can greatly reduce carbon content, oxygen demand and nitrogen concentrations. On the other hand, anaerobic treatment alone is capable of color removals of approximately 60-75 percent of the initial color values. But carbon and nitrogen removals are typically low for anaerobic treatment systems. The anaerobic reduction of azo dyes to simpler compounds has been well researched. These studies have all demonstrated the ability of anaerobic microbes to effectively reduce azo dyes to their intermediate structures, thus destroying the apparent color. Further findings in the literature suggest that ANA/AER (anaerobic/aerobic) sequential-step treatment provides the greatest overall

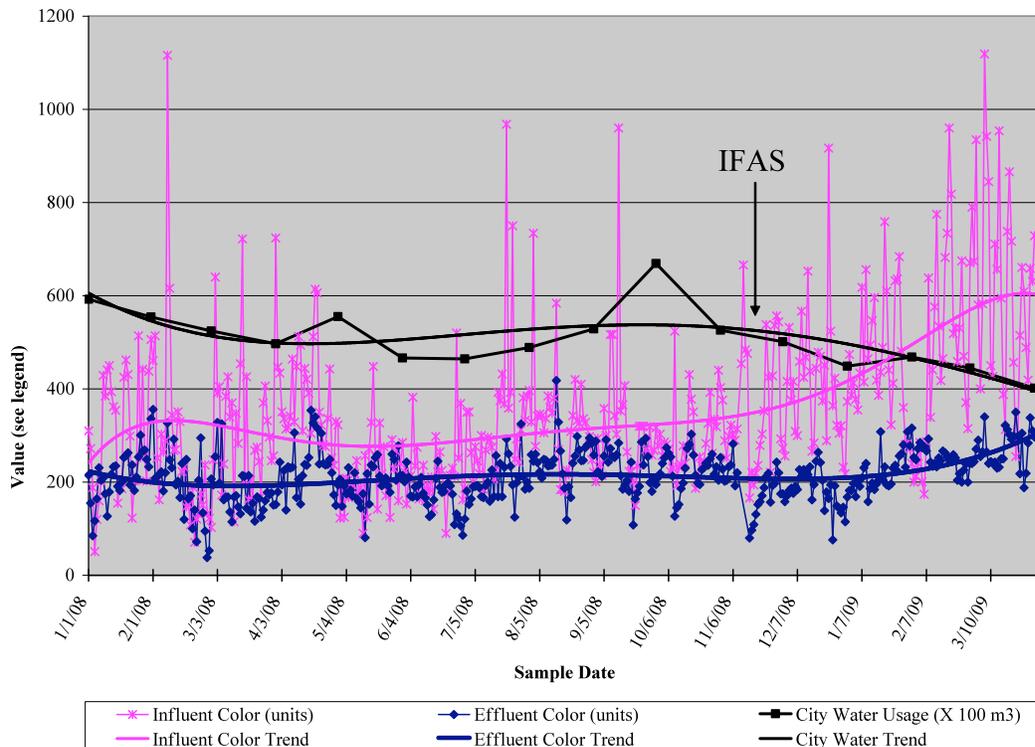
reductions in color, carbon and nitrogen (Wallace, 2001). Sequential treatment consisting of anaerobic conditions followed by aerobic conditions is certainly obtainable with an SBR system.

### OPERATING RESULTS

The decanter discharge was in conformance with POTW discharge limits within two days after start-up. Since start-up of the system in 2008, the SBR with IFAS performance has exceeded expectations. The effluent discharge is low in COD, NH<sub>3</sub> and color. The SBR with IFAS has reduced the need for dilution water (city water) in the EQ tank to facilitate color treatment thus addressing the plant's sustainability goals.

The graph of influent vs. effluent color (Figure 3) shows the results before and after IFAS addition and as city water input to the EQ tank was diminished. Before converting to IFAS the SBR achieved about 25-30 percent color reduction. After IFAS conversion and maximizing anoxic/anaerobic conditions in the EQ tank and during settle, decant and fill stages the SBR achieves 50 percent or greater color removal. Continual adjusting of the operating parameters should further enhance color removal efficiency.

Typical EQ tank water has a COD of about 1127 mg/l with the SBR effluent averaging about 733 mg/l. Nitrogen data shows an influent average of 72 mg/l NH<sub>3</sub> with a treated discharge of about 4.2 mg/l. With the additional ammonia loading the amount of soda ash added during the react stage for pH and alkalinity control has tripled to maintain a pH of about 7.2 standard units.



**Figure 3. Influent vs. effluent color and water use**

## CONCLUSIONS

The IFAS upgrade to an existing SBR system used to clean-up process wastewater and landfill leachate has allowed OC to vary production levels at a manufacturing plant site. The ease of operation i.e. no additional manpower, reduced electrical power, some added chemicals and no infrastructure changes were major reasons the IFAS approach was chosen. The operating results demonstrate that an IFAS upgrade to an SBR provides a robust treatment solution for wastewater containing color, COD and NH<sub>3</sub>. The IFAS system maintains a high density of biomass population capable of nitrification at lower solids retention time than conventional suspended growth systems. This novel application of combining two biological processes appears efficient, economical and a flexible method to achieve additional biological treatment capacity and has a bright future in treating various industrial wastewaters.

## REFERENCES

- Flournoy, W. J.; Grillo, R.; Hubbell, S. B.; Kalluri, R.; Mueller, C. (2008) Enhancing Nitrification in an Oil Refinery WWTP with IFAS. *Proceedings of the Water Environment Federation (WEFTEC 2008)*; Session 2, pp 142-150; Water Environment Federation, Alexandria, Virginia.
- Metcalf & Eddy, Inc. (2003) *Wastewater Engineering, Treatment and Reuse, 4<sup>th</sup> Edition*; McGraw-Hill, New York, NY.
- Stricker, A. E.; Barrie, A.; Maas, C. L.; Fernandes, W.; Lishman, L. (2007) Side-by Side Comparison of IFAS and CAS Processes at Demonstration Scale at the Lakeview WWTP. *Proceedings of the Water Environment Federation (WEFTEC 2007)*; Session 3, pp 155-183; Water Environment Federation, Alexandria, Virginia.
- Wallace, T. H. (2001) Biological Treatment of a Synthetic Dye Water and an Industrial Textile Wastewater Containing Azo Dye Compounds, *Masters Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 70 pp.*

## PRESENTED:

WEF Microconstituents Conference, July 2009