

# Refining applications

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describe why refineries  
and petrochemical plants  
have turned to RBC and  
SBC applications to meet  
biological treatment  
requirements.**



**Figure 1. After installing the two air headers, the media shaft is fitted into the tanks in one pick/placement. Each unit is put into service less than 50 hours after the tanks are set.**

**P**etroleum refineries and petrochemical facilities commonly consider a number of key factors when evaluating which biological treatment technologies to install in a plant expansion or new construction. Ease of operation, ability to respond to shock loads, mechanical reliability, small footprint, low operating cost and high quality effluent are just a few considerations taken into account.

While several biological treatment processes are used in hydrocarbon processing industry applications, rotating and submerged biological contactors (RBCs and SBCs) are two of the most popular technologies used to meet the tough requirements. Refinery and petrochemical plants worldwide are using the technology for BOD, COD,  $\text{NH}_3\text{-N}$  and phenol reduction.

## **Rotating biological contactors**

RBCs consist of vertically arranged plastic media on a horizontal, rotating shaft. As the shaft slowly rotates at 1 - 1.5 rpm, it submerges approximately 40 - 45% of the media. The high surface area, coupled with the alternating exposure to wastewater and atmospheric oxygen, allows organisms to multiply and form a thin layer of biomass on the media. This large, biochemically active population causes the degradation of organic pollutants. Excess growth is continuously and automatically shed and separated in a downstream clarifier.

RBCs were conceptualised from trickling filters, which are also sometimes known as 'biotowers'. However, unlike biotowers that allow wastewater to pass over the biological support media, the fixed film biological treatment process's media rotate through the wastewater. This hydraulic action, used in conjunction with air scouring systems, helps maintain complete biomass accumulation control over the total media treatment surface. The ability to control the biomass is one of the key advantages of RBC technology over biotowers.

The hydrocarbon processing industry has long recognised the resistance of RBCs to hydraulic and organic shock loads, low energy usage and simple operation. Compared to other biological treatment technologies such as suspended growth systems, RBCs can react quicker to and recover from the high COD loads or toxic conditions that occur in wastewater treatment.

Today's equipment also offers a very robust mechanical equipment design that requires little labour for operation and maintenance. RBCs are extremely efficient, producing consistent process results. Modular construction and reduced excavation make them more cost effective to expand and retrofit than conventional biological treatment processes in a petrochemical plant environment. The technology's low profile, shallow tankage and small footprint offer further cost savings.

## **Submerged biological contactors**

Sometimes known as the 'big brother' of the RBC, the SBC is a newer, rotating fixed film technology. SBCs operate at 75 - 85% submergence, and offer nearly double the surface area of conventional RBCs on a single 7.6 m shaft. Bearings at each end of the rotating shaft are the only mechanical items on the SBC, and they are designed specifically for submerged duty, only needing periodic lubrication.

Air is blown into the tank under the media, which provides oxygen for the biofilm and the torque that rotates the shaft. The air scouring action created by the depth of immersion and the use of process and drive air headers at varied speeds help ensure effective biofilm control on the media. Aerobic biofilm growth develops, which converts soluble organic pollutants into harmless cell mass for settling in the secondary clarifier. Radial passages throughout the media pack's layers provide proper air wastewater distribution. An electronic mechanism continually measures biological growth and monitors process operations.

The SBC is particularly well suited to high strength industrial wastewater applications with limited available space, and offers operational benefits that are similar to those of the RBC. However, as the SBC is almost submerged, the shaft operates almost buoyantly, greatly reducing the load on the shaft and bearings. The high submergence, combined with air drive (versus gear motor) rotation, reduces lifecycle, operating and maintenance costs. The SBC technology requires approximately half the manpower of typical plants, and produces high quality effluent that meets low BOD and nitrogen standards.

As it is a fixed film process, the SBC does not generate return activated sludge, thus alleviating the need for return



Figure 2. Section view of the RBC unit.

sludge pumps and the associated capital and operating costs of pumping. The large fixed film sludge particles settle much better than sludge from conventional suspended growth systems, causing fewer sludge settling issues in the final clarifiers. Unlike lagoons or other mechanically aerated systems, SBCs do not have remote aeration devices to be accessed or maintained. Compared to activated sludge diffused aeration systems that require periodic cleaning, maintenance and eventual replacement, the SBC uses coarse bubble diffused aeration and requires infrequent cleaning and maintenance, no basin dewatering and little associated downtime.

Another advantage that sets SBCs and RBCs apart from other biological treatment processes is that they are both compact, covered installations that are safe to use for offgas recovery, collection and treatment of VOCs. The systems can also be provided with warning devices to signal upset conditions upstream of the installation.

### Case studies

Envirex Products, part of USFilter, a Siemens company, has provided more than 15 refinery and petrochemical plants worldwide, with over 60 RBC/SBC systems. Plants in South America, the Middle East and USA, are just a few to use the technology for BOD, COD,  $\text{NH}_3\text{-N}$  and phenol reduction.

#### South America

Three years ago one of the largest South American companies in the oil and gas industries installed 19 RBCs at its 189 000 bpd refinery. Divided into four treatment systems, the RBC system from USFilter Envirex Products treats an average flow of 480  $\text{m}^3/\text{hr}$ . The biological treatment systems provide phenol removal, nitrification, denitrification and polishing.

The RBC system upgraded an existing lagoon treatment system for enhanced performance, which included meeting new nitrogen removal standards. The system's footprint is much smaller than that of the lagoon system.

Results from an eight month pilot study influenced the company's decision to use biological fixed film processes at the refinery. The refinery also cites the RBC's low lifecycle costs, low volume of solids production and higher nitrification efficiency as reasons for choosing the technology over other available biological treatment systems. The system's flexible modular layouts can also be configured to better match treatment conditions.

#### Middle East

A leading Middle Eastern crude oil refiner upgraded the

existing biological treatment system at its Haifa refinery with 12 SBCs from USFilter Envirex Products.

One of the largest refining complexes in the West, the refinery treats 500  $\text{m}^3/\text{hr}$  of wastewater, with the majority of the flow used for cooling tower makeup water. To reduce influent BOD and  $\text{NH}_3\text{-N}$  from 70 and 12 mg/l to 5 and 1 mg/l respectively, the plant required a total media surface area of approximately 334 400  $\text{m}^2$ .

Refinery engineers selected the SBC over other fixed film biological treatment processes because of the technology's cost efficient, shock resistant process that requires little operator attention. Its low maintenance and energy costs also made the SBC an attractive option for the refinery's wastewater treatment needs.

#### North America

A 49 000 bpd refinery in Western USA upgraded its biological treatment system in 1994, with 10 SBCs and eight RBCs from USFilter Envirex Products. The fixed film technologies enabled the refinery to reduce operational costs associated with activated sludge systems and meet new effluent toxicity limits. The plant is designed to handle a maximum flow of 480  $\text{m}^3/\text{hr}$ .

The SBCs started up in June 1995, using biomass from the existing RBCs to 'seed' the SBCs. In four days, COD removal of more than 70%, and effluent  $\text{NH}_3$  concentrations of less than 5 mg/l, were observed. In addition, sulfide, phenol and benzene effluent concentrations were negligible or below the detection limit. Five months later, COD and  $\text{NH}_3$  effluent concentrations remained well below permit requirements, and plant removal rates for phenol, sulfides and benzene were consistently higher than 99%.

Before selecting the SBCs and RBCs, the refinery compared the technologies to several conventional activated sludge systems. Results indicated that the fixed film biological technologies would cost less and be easier to operate and maintain than their conventional counterparts. In fact, annual operation and maintenance costs for the SBCs were estimated to be US\$ 500 000 less. After initial startup in 1995, the annual operating costs for the SBCs were US\$ 35 000. At a cost of US\$ 11 million, the plant was also 7% under budget<sup>1</sup>.

### Conclusion

RBCs and SBCs have proven their effectiveness in the hydrocarbon processing industry. They can effectively reduce BOD, COD,  $\text{NH}_3\text{-N}$  and phenol, while producing high quality effluent that meets strict industry regulations. Both fixed film biological treatment technologies boast of long term operational stability, shock loading neutralisation, complete biofilm control and simple operation.

The systems' small footprint allows them to be installed in areas with limited space, and their cover enables them to be used for offgas recovery, collection and treatment of VOCs. Both fixed film systems offer low maintenance, power usage, replacement parts and other equipment lifecycle costs, and require minimal manpower to operate. SBCs and RBCs can easily be modified for upgrades and retrofits.

### References

1. REYNOLDS, S.L., KALLURI, R. and SCHULTZ, T.E., 'Down Under Submerged Biological Contactors', *Industrial Wastewater Magazine*, September/October 1997. ■