BIO DEGRADABLE

- Biodegradable Waste Water Treatment -

SPR-OX® Process

HABACK(주)그린하백

서울특별시 구로구 구로동 197-22 에이스테크노타워5차 1106

Tel 02) 2103-5940/010-6261-6901 Fax 02) 2685-0353

Manufactured by Hydro Dynamics, Inc.

Harnessing the Power of Cavitation

SPR-OX® Process

Introduction

The SPR-OX® process provides cost-effective destruction of recalcitrant BOD, COD, TOC and color from a wide range of industrial waste streams. By destroying contaminants via renewable oxidative chemistry, SPR-OX® system offer environmentally sustainable water treatment solutions for many applications, including:

- Powerful AOP or O3 and peroxone oxidation
- Renewable process inputs
- No waste residuals
- 50-75% lower OPEX compared to the other AOP
- Up to 99% removal of BOD, COD, & TOC
- Unaffected by color or turbidity or suspended solids
- Very high dosing capabilities
- Efficient, scalable process
- Guaranteed performance
- Biodegradability (BOD/COD≥0.5)

Oxidation Chemistry

In water treatment applications, the term chemical oxidation refers to the reaction of organic contaminants with strong oxidants. Generally speaking, destruction reactions are faster and more complete with strong oxidants such as ozon (O_3) and hydrogen peroxide(H_2O_2). However, when added together, this combination produces the hydroxyl radical($OH\cdot$), the most powerful oxidant available for water treatment, which is up to 40% more powerful than either reagent alone. Once initiated, the multi-oxidant-rich environment promotes a simultaneous range of series and parallel chain reactions that rapidly destroy organic compounds via the most chemically effcient pathway.

Flexible and Sustainable Design

The SPR-OX® process is based on a robust plug-flow design that has been proved at over 105 installations worlwide. Systems can be operated in ozone-only, advanced oxidation process mode, or alternating between the two modes offering the flexibility to meeting changing conditions. With mass transfer efficiencies of up to 100%, systems can be designde to meet even the most challenging very high-dose applications. Green Haback's in-house pilot testing capabilities provide assurance that testing results match actual performance. Process guarantees can be provided to meet the needs of your mission-critical applications.

Key Features

- Unaffected by influent variations
- Treats highly conentrated waste streams with sustainable Hydroxyl chemistry based on O_3 and H_2O_2
- No need for influent additives
- No treatment by-products
- No waste handling or disposal costs
- Very high mass transfer efficiednc y (MTE)
- High efficiency organics destruction
- Unaffected by water turbidity, color, or transmissivity
- Ozone and preozone AOP, or combined operation
- Low maintenance / Fully-automated
- Biodegradability

Advanced Oxidation Process

hydrodynamic cavitation ('Nano-bubbles' at Work)

In the presence of a hydrodynamic cavitation field, Ozone decomposes into two hydroxyl radicals and oxygen gas. The hydroxyl radical will oxidizeall known organic compounds in a matter of nano-seconds.

Nano-sized cavitation bubbles implode, providing a liquid interface in a reaction that instantaneously heats the liquid-gas to as high as 900°F, which in turn oxidizes all known organic compounds in 35-100 picoseconds (a picosecond is one trillionth of a second). This phenomenon, known as sonoluminescence, plays a key role in removal of flowback water by-products, so water can be recycled reused for the hydraulic fracturing process

Applications

Municipal Drinking Water

Wellhead Treatment: Destroy recalcitrant VOCs and/or Color and Taste & Odor contaminants to meet drinking water standards.

Surface Waters: Remove endocrine disruptors and personal care products, remove taste, odor and color contaminants (such as Geosmin/MIB) and perform disinfection.

Aquifer Storage and Recharge: Treat multiple contaminants and perform disinfection while maximizing disinfection by-product formation.

Advantages

- Performs multiple treatment objectives simultaneously (for example: VOCs, Color and Taste & Odor, and Disinfection).
- Minimizes bromate formation to meet strict drinking water standards.
- Does not form THMs, NDMA, or other disinfection byproducts.
- No waste-streams generated.

Industrial Process Water

Process Water Discharges: Remove process chemicals such as 1,4-Dioxane, personal-care products, pesticides and herbicides prior to discharge.

Process Water Recycling: Purify and decolorize process waters that will be reused in an industrial process.

Process Water Reuse & Disinfection: Remove contaminants and perform disinfection of waters for reclamation and reuse.

Advantages

- Enhances the effectiveness of existing biological treatment systems as either intermediate or post-treatment.
- Treats fugitive compounds such as personal-care products and 1,4-dioxane that are not removed by existing biological treatment systems.
- No waste-streams generated.

Environmental Remediation

Industrial Pollution Sites: Remediate groundwater contaminated by difficult-to-treat industrial chemicals such as 1,4-dioxane, TCE, PCE, vinyl chloride, trichloropropane (TCP), dibromochloropropane (DBCP), and more.

Petroleum Remediation Sites: Remove fuel components and additives from groundwater impacted by MTBE, TBA, BTEX, and TPHg.

Other Applications: Destroy explosives, amines, sulfur-based odors, and more.

Advantages

- Destroys recalcitrant chemicals to non-detect levels.
- Flexible design allows adjustments to reagent utilization as contaminant concentrations change over time.
- No waste-streams or air emissions generated.
- No off-spec water discharges.
- Low consumables costs.

Municipal Wastewater

Water Reuse: Remove microcontaminants, VOCs, and more for indirect and direct potable reuse, reclamation or reinjection.

High Intensity Disinfection: Perform on-site disinfection of challenging wastewaters.

Quaternary Treatment: Remove fugitive organic compounds missed by reverse osmosis or microfiltration systems, perform disinfection.

Advantages

- Extremely robust log kill of bacterial and viral pathogens (up to 7 log demonstrated).
- On-site disinfection and contaminant destruction.
- Treates endocrine disruptors, personal-care products, and other compounds that cannot be removed by reverse osmosis or microfiltration.
- No waste streams generated.

Hydro Dynamics, Inc.
Harnessing the Power of Cavitation

WASTE WATER TREATMENT

SPR-OX® Process - Hydrodynamic Cavitation Oxidation for the Treatment of Wastewater and Sludge

Our service ...

SPR-OX® (Hydrodynamic Cavitation Oxidation) process for the treatment of industrial wastewater and sludge.

Typical fields of application include

- Pre-treatment of highly polluted industrial wastewater streams (e.g. before being discharged into a biological treatment plant)
- Sludge treatment (e.g. sewage sludge)

Key element of the process is the homogeneous catalytic oxidation of organic matter with oxygen at elevated temperature and pressure. Characteristics are:

- Reaction in fluid phase (Shock Wave Power Reactor)
- Industrial SPR capacity: max flow from 0.1 to 1,500 gpm
- Pressure range: 3-20 bar
- Temperature range: 120-200°C
- Oxidation with ozone or peroxone
- Catalyst: iron + co-catalyst

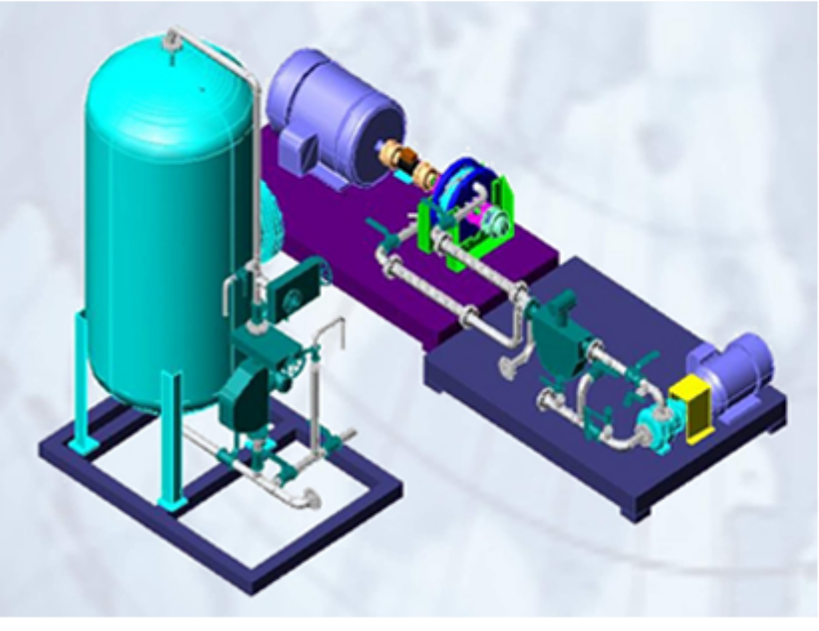


Fig. Plot Plan of SPR-OX®

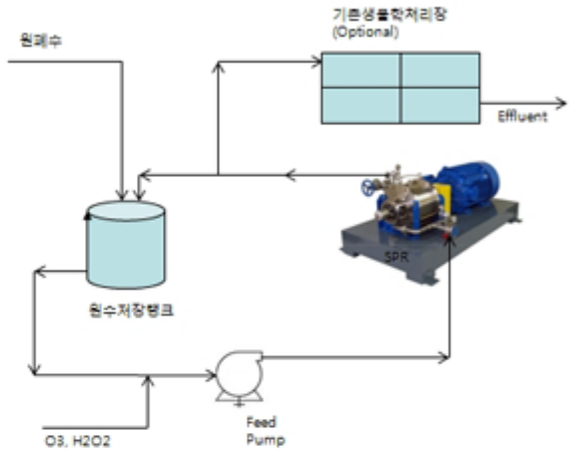
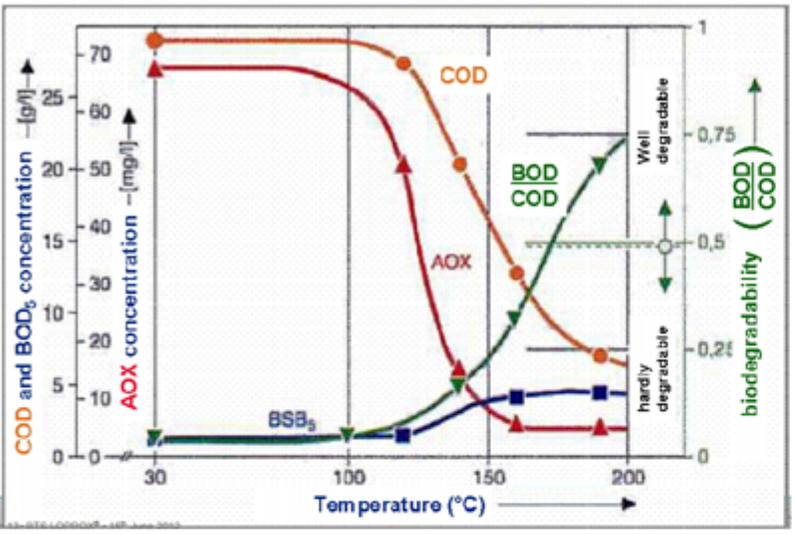


Fig. SPR-OX® Process Flow Diagram

...Is your gain.

- Cost-efficient and custom-designed treatment process for moderately to highly polluted wastewater streams (2-100 g/l COD)
  - Strong improvement of wastewater biodegradability (increasing BOD/COD-ratio from<0.2 to around 0.5)
- Innovative process for sewage sludge disintegration and volume reduction:
  - 85% reduction of organic dry matter
  - Significant improvement of dewatering properties
  - Cost-efficient alternative to thermal evaporation, incineration or wet air oxidation(WAO)
  - Destruction of persistent organic compounds (e.g. pharma-ceuticals, pesticides, PAH, phenols, ...) and wastewater detoxification
- Autothermal operation possible for most applications
- Cheap and environmentally friendly catalyst
- No related with salt concentration
- Proven reliability and mastery of materials and corrosion questions (reactor with up to 18 years running time without replacement)

Biodegradability



Typical course of reaction within the SPR-OX® process

This diagram illustrates the typical course of reaction within the SPR-OX® process applied to poorly biodegradable wastewater containing chlorinated aromatic compounds. Chemical oxygen demand(COD) and adsorbable organic halogens (AOX) are used as parameters indicating the degree of pollution. With increasing reaction temperature, both parameters are greatly decreased, AOX even more so than COD.

Simultaneously, biological oxygen demand (BOD) rises and thus the BOD/COD ratio increases drastically from its initial value of < 0.2 to values noticeably higher than 0.5.

The BOD/COD ratio gives an indication of the biodegradability of wastewater. Wastewater with a BOC/COD ratio > 0.5 can usually be cleaned well in biological treatment plants.

Our approach

Based on our own process developments and more than 15 years of experience, we offer you a custom designed, innovative and effective solution for your wastewater and sludge, based on the patented hydrodynamics cavitation oxidation (SPR-OX®) process.

The first step will be an assessment of the applicability of the SPR-OX® process for the stream in question. This will be done based on a first analysis of the treatment task by our engineers and wastewater experts.

In a second step, batch experiments in titanium autoclaves will be performed, from which suitable reaction conditions and removal rates can be derived for the parameters in question.

Thanks to our experience, these tests already allow a conceptual pre-basic design, including an estimation of investment and operating costs.

The last step of process development will be continuous experiments in our pilot plant to validate th batch experiments and to derive

- Optimum process conditions
- Degradation rates, including certified analysis of the effluent (e.g. AOX, ecotoxicity values, biodegradability, ...)
- Minimization of chemicals and auxiliaries consumption
- Materials testing (to achieve an optimum of corrosion resistance and costs)

Our experienced engineering staff guarantees efficient and professional project management over the entire project cycle, including basic engineering, detail engineering, planning for the operating license, procurement, installation and commissioning, up to turnkey delivery to meet the most stringent requirements. You can also rely on us for plant personnel training and assistance with any future questions that might arise.

Dissociation of water and release of oxidation radicals

Exposure to hydrodynamic wave can drive many chemical reaction through the generation growth and subsequent collapse of cavitation bubbles.
It is universally accepted that this cavitation with its accompanying local high pressure and temperature drive these reaction rather than the hydrodynamic drive themselves. The hydrodynamic waves provide means for transferring the energy of the hydrodynamic driver to cavitation neulei whose subsequent behavior converts this energy to pressure, heat, erosion, chemical reaction etc.

When subjected to cavitation, water undergoes dissolution according to the following chemical reaction (1)

$$H_2O \longrightarrow H + OH\cdot \qquad (1)$$

The free hydroxyl radical OH• is one of the most powerful oxidizing agents and is an excellent initiator of chain reaction. Oxidation of organic compound. These include water vapor, carbon dioxide, inorganic ions and short chain inorganic acid. Often the intermediate products also undergo subsequent oxidation.

CASE STUDY

More Efficient and Cost Effective

The self-catalyzing peroxone chemistey of the SPR-OX® process is largely immune to water quality parameters such as color or turbidity. The result is wider applicability and more effcient treatment than many other AOP oxidation systems. SPR-OX® systems eliminate the need for extensive bulb cleaning and replacement, offer much lower maintenance, and up to 50-75% more cost effective treatment than competing oxidation technologies.

TOC and Color Removal

Industry: Water Treatment Residuals
Application: Recalcitrant TOC and Color Removal
Summary: An waste stream from a large-scale wter treatment process was impairing effluent quality from a downstream treatment step. SPR-OX® advanced oxidation process was applied to destroy exessive color and TOC. The project eliminated color problems in treated effluent and significantly improved final effluent quality.
Results:

- 97-99% destruction of 7,800 mg/L TOC
- 99% removal of color
- Oxidant dose of up to 1,150 mg/L

Waste Pharmaceuticals Destruction

Industry: Pharmaceuticals
Application: Destruction of challenging waste products
Summary: Discharge to a pharmaceutical wastewater treatment plant contained very high concentrations of a difficult-to-treat compound. Other AOP treatment could provide only partial oxidation of the target compound which significantly impaired process efficiency. SPR-OX® advanced oxidation process completely destroyed the target compound, which in turn, produced a dramatic improvement tn effluent quality
Results:

- >97-99% destruction of 5,250 mg/L BOD and 8,600 mg/L COD
- Color destruction only possible via AOP
- Effluent COD polishing

COD Polishing

Industry: Food Manufacturing
Application: COD polishing
Summary: An existing biological wastewater treatment process was unable to provide sufficient removal COD and color. A hydrodynamic cavitation SPR-OX® process was developed to destoty recalcitrant COD and color to achieve target effuent quality.
Results:

- >85% destruction of 700 mg/L COD
- >99% color remaval
- Oxidant dose of up to 2,600 mg/L

Biodegradability Index(BI)

1. L사(석유화학폐수)

항목	원수	SPR-OX처리수
pH	12.3	12.86
BOD_5 (mg/L)	75750.5	100590.1
COD_{cr} (mg/L)	172500	176000
COD_{Mn} (mg/L)	34000	34500
BOD_5/COD_{cr}	0.43	0.57

2. S사(정밀화학폐수)

항목	원수	SPR-OX처리수
pH	6.77	7.1
BOD_5 (mg/L)	57652	96039.2
COD_{cr} (mg/L)	153237	124800
COD_{Mn} (mg/L)	47500	48000
BOD_5/COD_{cr}	0.37	0.76

3. M사(P&P폐수)

항목	원수	SPR-OX처리수
pH	6.64	6.8
BOD_5 (mg/L)	497	820
COD_{cr} (mg/L)	1750	1688
COD_{Mn} (mg/L)	646	640
SS (mg/L)	377	450
BOD_5/COD_{cr}	0.28	0.48

4. K사(F&B폐수)

항목	원수	SPR-OX처리수
pH	7.3	7.4
BOD_5 (mg/L)	2577.1	3183.8
COD_{cr} (mg/L)	1870	1230
COD_{Mn} (mg/L)	740	440
SS (mg/L)	420	1990
T-N (mg/L)	105.24	107.55
T-P (mg/L)	11.28	12.24
BOD_5/COD_{cr}	1.37	2.58

BOD_5/COD_{cr} is :

> 0.5 than easily biodegradable

0.4 - 0.5 average biodegradable

0.2 - 0.4 slowly biodegradable

< 0.2 not biodegradable

COD_{cr}/BOD_5 is :

<2.0 - easily biodegradable

>2.0 - not easily biodegradable