Supercritical Water Oxidation for Complete Mineralization of Environmental Toxins (PFAS, pesticides, pharmaceuticals etc.)

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Theme 3A: Effective and Efficient Wastewater Management (treatment)

SUMMARY

The Aquarden SuperOx™ uses the working principle of Supercritical water oxidation for complete mineralization of hard-to-treat wastes, including the 'Forever chemicals' known as PFAS. At operating conditions above the thermodynamic critical point of water (374°C and 221 bar), the extremely rapid oxidation reaction occurs under the addition of an oxidant, ripping the organic compounds apart within seconds. The SCWO system is solely powered by electricity, with no co-fuel added aside from the organic matter in the wastewater which, if concentrated enough, allows for the reactor to become autothermal. Aquarden Technologies, has by using the SuperOx system proven a degree of destruction of concentrated PFAS waste above 99.999%.

INTRODUCTION

While more technologies enter the market of water and soil remediation – e.g., to remove PFAS, pesticides etc. – a need for proper destruction of highly concentrated toxic wastes is still required.
The Aquarden SuperOx™ technology operates on Supercritical Water Oxidation and can ensure complete mineralization of persistent toxins like PFAS and pesticides without generating toxic byproducts. SCWO can be applied to a variety of different waste types, such as particulate slurries (containing adsorbents from water remediation, explosives etc.), sludges, membrane concentrates, foamate from foam fractionation, firefighting foam, process water etc. with the result of >99.99% destruction of complex problematic compounds.

KEYWORDS

Destruction, environmental toxins, mineralization, PFAS, pesticides, remediation, Super Critical Water Oxidation, SCWO, Wastewater treatment.

TECHNOLOGICAL CONCEPT

Supercritical water is a state of water found above the thermodynamic critical point of water at 374 °C and 221 bar. Under these conditions, the density of water approaches that of gas and transforms into supercritical fluid.

Figure 1 shows a simplified drawing of the SuperOx reactor, with the subcritical water being identified as the phase found below the critical point in the reactor, but at pressures higher than the vapour pressure of water at that given temperature.

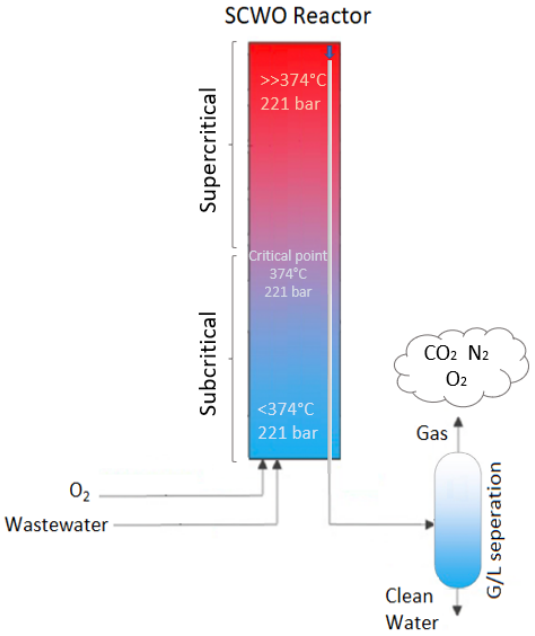

Figure 1.1 *- Simplified concept drawing of the Aquarden SuperOx technology.*

In supercritical water you change the interactions between the water molecules, as their ability to form hydrogen bonds is significantly reduced, changing the very nature of water as a solvent. Supercritical fluid acts more like a non-polar solvent and is great for dissolving organics and gasses in a homogenous phase. Adding an oxidant under these conditions allows for an oxidation reaction that can rip organic compounds apart within seconds to their most fundamental components. With the almost non-polar nature of supercritical water comes a significantly decreased solubility for inorganics, causing salts, heavy metals etc. to precipitate and concentrate in the subcritical water.

When oxidized in SCWO, compounds organically bound to minerals like sulphur, fluoride, phosphorous and chloride will generate their corresponding mineral acids. Neutralization of these acids and detailed knowledge on the composition of the waste to be treated by SCWO therefore becomes a key factor to maintaining an optimal environment in the reactor.

Generated from this process is a hot water stream that, depending on the nature of the treated waste, contains low concentrations of benign salts as well as a gaseous effluent consisting mainly of excess oxygen, nitrogen, and carbon dioxide. Heat exchangers are used to recover heat from the effluent stream, to increase the energy efficiency of the system.

APPLICATIONS

With SCWO being a very versatile technology, it can be applied to a variety of different industries, including but not limited to defense, petrochemical, chemical, oil & gas, pharma, and waste handling.

PFAS

The global PFAS pollution is a topic of great concern. SCWO can provide a complete destruction of wastes generated from PFAS remediation as mentioned in the introduction. Common to wastes containing PFAS, whether it is adsorbents or liquid concentrates, is that they need very specified thermal treatment to ensure that the PFAS compounds are completely broken down and not left in the form of ashes, sludge fractions or as volatile C-F degradation compounds.

Aquarden Technologies has proven that SCWO completely mineralizes PFAS in high concentrations both found in liquious wastes and bound to adsorbents. By analyzing the SCWO effluents from multiple tests for both known PFAS' (22 compounds) as well as inorganic and organically bound fluoride, it was found that PFAS is completely broken down with an efficiency above 99.999%.

For wastes containing either extremely high concentrations of PFAS or salts, subcritical oxidation can be used for the oxidation as well as this allows for a higher solubility of the salts and a higher capacity for acid neutralization. Comparing subcritical oxidation to supercritical oxidation, the reaction runs slower, increasing the reaction time from seconds to minutes. However, it was proven through a series of tests that it is possible to efficiently mineralize PFAS by reducing the organically bound fluoride by more than 95%, leaving only trace amounts for post-polishing steps.

CONCLUSIONS AND UPCOMING WORK

While SCWO has proven efficient in the complete destruction of multiple problematic compounds, Aquarden strives to continuously prove and improve the efficiency and versatility of the SuperOx™ technology. In the time before the conference, multiple tests involving a series of industries and novel applications will take place, generating new information and data on destruction efficiencies for new toxic compounds.
SCWO is part of the solution to an increasing problem where conventional technologies are insufficient and can only offer partial destruction of environmental toxins.