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Design of the first pilot scale plant of China for supercritical water oxidation of sewage sludge

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ABSTRACT

Supercritical water oxidation (SCWO) is a promising technology to deal with organic wastes. Nowadays, we have successfully constructed the first SCWO pilot scale plant of China with a specific reactor configuration and optimized system compositions to treat sewage sludge. In this report, the existing problems and corresponding solutions concerning corrosion, plugging and high running cost in SCWO are introduced systematically. The detailed system components, evident properties, advanced control methods and primary experiment results of the pilot scale plant are described objectively. Moreover, a simple economical comparison with incineration is carried out and subsequently in-depth works are also proposed for further promoting the commercial application of the plant. The information should be helpful for designing and constructing SCWO plant to dispose sewage sludge or other organic wastewaters.

Keywords: Supercritical water oxidation; Sewage sludge; Pilot scale plant; Economical comparison; Reactor; Automatic control

1. Introduction

Compared with normal water, supercritical water ($T > 374.15\,^{\circ}C$, $P > 22.12$ MPa) owns a smaller amount of hydrogen bonds, a lower dielectric constant, a lower viscosity and a higher diffusion coefficient. SCWO that has been the subject of many patents since Modell in MIT in the middle of 1980s (Modell, 1982), is an effective and advanced oxidation technology to destruct organic matters through the unique properties of supercritical water under the typical operation conditions of 450–600 °C, 24–28 MPa (Veriansyah and Kim, 2007). Organic matters and oxidant are dissolved into supercritical water completely to create a single phase environment, which overcomes the interphase mass-transfer resistance and accelerates the whole reaction rate. SCWO rapidly completely decomposes organic matters into small molecular compounds such as CO_2, N_2 and H_2O, and meanwhile heteroatoms are also converted into their mineral acids. It can also deal with organic matters with more than 90 wt% water content without a dry procedure of high energy consumption. A small SCWO plant is able to achieve a large scale treatment capacity owing to its short reaction time, commonly less than 1 min. When mass concentration of organic matter in feedstock is more than 3 wt%, maintaining the whole reaction process usually does not require an extra energy input process (Gidner and Stenmark, 2001).

Nowadays, SCWO plants have been commercialized by several famous companies (Veriansyah and Kim, 2007; Bermejo et al., 2009) such as General Atomics, EcoWaste Technologies, Chematur, and Supercritical Fluids International, etc. Brunner (2009) has summarized SCWO results of real waste materials including textile wastewater, wastewater from terephthalic acids, food wastes, municipal excess sludge and alcohol distillery wastewater. Furthermore, Veriansyah and Kim (2007) also has systematically introduced SCWO experiments of toxic organic wastes such as pesticide DDT, bacteria and dioxins, chlorophenol and chlorobenzene, pharmaceutical and biopharmaceutical wastes, chlorocarbon γ-hexachlorocyclohexane and hexachlorocyclohexane, highly contaminated activated sludge, pond sludge, chemical weapons stockpiles, stockpiled chemical warfare agents, smokes, dyes, and pyrotechnics, VX [O-ethyl

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