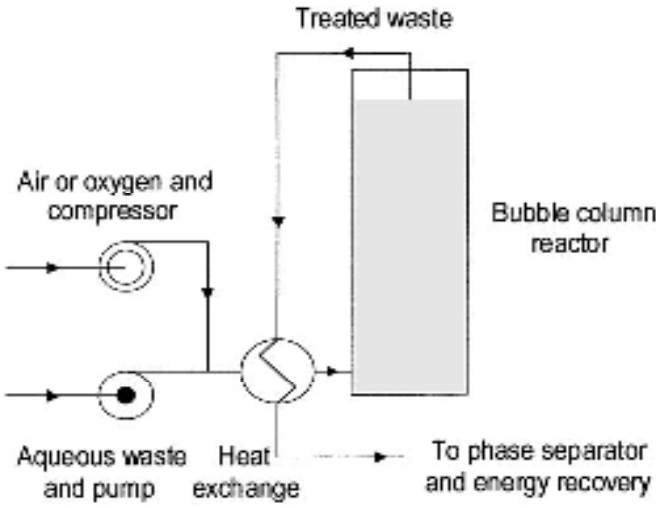
Superheated water-Wet Air Oxidation

Extraction of hazardous waste by superheated water using wet air oxidation.

1. Introduction-----



Wet air oxidation treatment unit. Basic flow diagram.

The term superheated water refers to liquid water under pressure between 100^{O}C and its critical temperature, 374^{O}C. It is much less polar than water at ambient temperatures and can dissolve organic compounds, particularly if they are polarisable or slightly polar.

superheated water can be a good solvent for larger organic compounds, particularly if they have some polar groups or are polarisable like aromatic compounds. The solubility of an organic compound in superheated water is often many orders of magnitude higher than its solubility in water at ambient temperature for two reasons.

1. dielectric constant is decreased.

2. solubilities typically increase with temperature.

1. Pollution prevention:

Some industrial wastewater contain lots of harmful or even toxic organic compounds.

They will remain in the environment for years.

Wet air oxidation can help relieve these pollutions in the following ways:

1.oxidise these compounds by air and convert them to CO_2 and H_2O,

without the emissions of nitrogen oxides (NO_x), sulphur dioxide (SO_2),

hydrogenchloride (HCl), dioxins, furans and fly ash etc.,an thus

prevents air pollution.

2.used in pretreatment of high strength wastewater to

produce biodegradable residual organics, in order to minimize water pollution.

3.used in destruction of specific compounds.(e.g.Sulphides,phenol)

4.eliminate toxicity and reactivity of organic compounds

to prevent polluting the food chain.

2. Atom Economy

The aim of this process is to convert toxic organic waste into non-toxic compounds.

The products of this process are CO2,H2O,HNO3,H2SO4,HCl,HBr,HI.

CO2 and H2O are non-toxic.

HNO3,H2SO4,HCl,HBr and HI are all acids, which can be neutralized by NaOH easily to produce non-toxic salts.

As a result, all products are non-toxic.

Hence, as all products complies to the aim, the atom economy of this process is 100%.

http://www.iwaponline.com/wpt/005/0003/0050003.pdf

3. Energy Efficiency:

Water at high temperature shows a higher diffusion rate than at normal temperature. That means less time is required for the process to take place and hence reduces heat loss which increases with time and thus increases energy efficiency.

As the water does not vaporize, the absorption and recovery of latent heat is excluded in the process, thus the heat loss on the absorption and recovery process is reduced.

By using special materials , the heat loss to the surroundings during the treatment is reduced. The process of oxidation release lots of energy. The energy released is then used to maintain the temperature of existing superheated water . In addition , fresh water keep on coming in and absorb the heat given out and become superheated water and thus maintaining the volume of water inside.

Second , the treated waste will also be passed into heat exchangers and the heat is absorbed before the sludge is being discharged. The recovered heat is transmitted to the incoming sludge by means of a superheated water loop circulating between the two exchangers in a closed loop. Energy is reserved and more efficient use is achieved.

4. **Catalysis**

In order to accelerate the oxidation rate, tests with copper sulphate can act as the catalyst . The experimental results showed that wet air oxidation was effective in degrading the surfactant. More than 70% of total organic carbon (TOC) removal can be achieved even without the addition of catalyst. However , the addition of copper sulphate will further improve the performance of wet air oxidation significantly. Nearly **100%** removal of surfactant could be achieved after **two hours** reaction.

The concentration of the copper ion of **200mg/L** is sufficient.

In addition , further increase of catalyst dosage shows insignificant improvement.

- **5. Less Hazardous Chemical Syntheses**

Most of the water treatment process , including the use of organic solution to react with chemical waste , will always produce extra chemical , though non-toxic they seem , chemicals are still discharged.Sometime , incineration may also be used when waste is extracted out in the form of solid. Having said that, it is handicapped by its bad ecological image of a process which can disseminate products of incomplete combustion and dust in the atmosphere.

Among the various types of processes which can be used for treating aqueous wastes polluted with organic matter, wet air oxidation (WAO) is very attractive. WAO is one of the few processes that does not turn pollution from one form to another, but really make it disappear.
Carbon dioxide and water will always be the final products.
Unlike incineration, oxidation will not give out carbon monoxide & nitrogen oxide(s).
what's more , the reactants are only air and water , which are natural.
WAO use and produce exactly non-toxic substances , even acid will also be produced ,
(about 5-10%) , they are easily be treated , with use of neutralization , and easy to handle.
(where acidic gas in incineration cannot be easily be treated as liquid.)

http://www.bvsde.paho.org/bvsacd/cd43/jean.pdf

http://greenchem.uoregon.edu/Pages/GreenChemGlossary.php

http://www.water.siemens.com/SiteCollectionDocuments/Product_Lines/Zimpro/Brochures/IT3%202002%20WAO%20history%20paper.pdf

6. Use Renewable Feedstocks

The raw material utilized in the process of WAO are

1. distilled water
2. Pure oxygen (or air , for cost effective)

For oxygen , they are recycle in photosynthesis , where they are renewable if carbon dioxide are given for plants.

For distilled water , they are renewable resources that freely found in the earth .

After special treatment(s) from filtration and distillation , pure distilled water can be obtained. In addition , water are only acts as the solvent , providing a platform form oxidation to occur , where the mainly reactant is only oxygen in air.

The only non-renewable resources in the whole WAO process is the large sum of fuels required for maintaining the super-critical / sub-critical temperature , the use of non-renewable resources are minimized.

7. Minimize the Potential for Accidents

Water will not burn , i.e.) it will not explode and catch fire. So accidents related to strong heating can be prevented.

Since the process is conducted in a closed system, workers will not expose to the toxic organic solvent directly, which prevents the workers inhaling the toxic gases and cause accident.

Also, as no acidic gas is evolved , they will dissolve into the treated waste, so that the gas will not cause irritation on eyes / respiratory system .

8. Design for Degradation

As the industrial wastes are oxidized, the effluent are usually biodegradable, as suggested in most real-life cases using the process to handle spent caustic. Apart from the effluent, all other materials returns to the oxidation system.

http://www.water.siemens.com/en/products/physical_chemical_treatment/hydrothermal_oxidation_wao/Pages/Zimpro_Wet_Air_Oxidation.aspx

9. Avoid Chemical Derivatives
Since only a single oxidation reaction is included in the process, the generation of derivatives is avoided. This increases the efficiency of the process.

10. Use Safer Solvents/Reaction Conditions

The solvent used is water, it is a solvent with almost negligible toxicity and does not cause pollution to the environment, so it is a suitable solvent.

The two conditions required in the process are high temperature ($374^{o}C$) and presence of a large amount of oxygen, explosion may occur if both these two conditions are met in a sealed system. But as water is present constantly in the system, the chance of having an explosion is negligible.