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PRESENTATION ON

NOVEL OXIDATION, COAGULATION AND FLOCCULATION SYSTEM

BY

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1. Introduction

J.K. Engineering Ltd. is a civil and environmental engineering consulting company since 1987.

The company operation is throughout Canada and internationally from the head office in Calgary and its subsidiary in Poland.

The company operation is related to water supply, wastewater disposal, storm drainage management, ground water development and land development for municipal and industrial applications.

J.K. Engineering Ltd. provides complete engineering services from preliminary investigations and feasibility studies through detailed design and construction services, and regulatory approvals.

Also, we are engaged in applied research and development related to water and wastewater treatment systems and groundwater well testing and operation monitoring instrumentation.

The research and field experience lead to development and supply of proprietary water and wastewater treatment systems and water well operation monitoring instrumentation.

The topic of this presentation is a water and wastewater super oxidation, coagulation and flocculation system and the system is supplemented with a direct filtration system as a complete treatment package. Both systems are based on proprietary solutions for which patents are pending.

The systems discussed have been tested in pilot plants and in full scale field applications.

2. Water/Wastewater Super Oxidation, Coagulation and Flocculation System Components

The system, as shown on Fig. 4, includes two major components: oxidation, coagulation & flocculation system and filtration system.

The oxidation, coagulation and flocculation system is installed in one vessel and the filtration system is installed in another vessel. The package will provide a complete water treatment in many municipal and industrial applications. This package will also provide a polishing treatment of secondary or tertiary wastewater effluents for the effluent recycling to several municipal, industrial and recreational applications.

The oxidation, coagulation and flocculation system includes three distinct treatment processes: oxidation, coagulation and flocculation which takes place in the same vessel.

The oxidation process can be used as aeration or oxidation with ozone or hydrogen peroxide or superoxidation with ozone and hydrogen peroxide.

The coagulation process has two options which include an independent coagulation, and oxidation and coagulation combined. In both options, oxidation and coagulation processes are installed in one vessel.

The flocculation process is coincidental to the oxidation process.

The filtration system is available also in two options as a one-stage filtration and two-stage filtration system.

The treatment package outlined above offers a wide range of options in regard to oxidation, coagulation and filtration and it can be considered for a wide range of water and wastewater treatment needs in regard to type and level of impurities to be removed and the effluent quality required.

Other treatment processes such as clarification with gravity settling or air/gas flotation system can be included between the oxidation/coagulation system and the filtration system or a membrane filtration can be added at the end of the treatment package presented.

3. Oxidation System

The oxidation system, as shown on Fig. 1, major components include oxidation vessel, circulation pump, air aspirator-mixer, ozone generator, off gas destruction unit and effluent syphon breaker. On-line instrumentation and remote monitoring equipment is added as required by specific applications.

The feed water or wastewater is supplied to the bottom of the oxidation vessel at a designated fixed flow rate or at a varying flow rate, as it may be necessary. The flow rate and total volume are metered to provide inputs to the oxidation system for adjustment of the circulation pump flow rate and the oxidant dosage.

The circulation pump is connected to the feed water supply pipe which allows the pump to draw water from the supply line and from the oxidation vessel at the same time. This arrangement provides a flexibility of operation of the circulation pump at the same, lower or higher flow rates than the feed water flow rate. Usually, higher circulation pump flow rates are used and they can be provided by a single or multiple circulation pumps and the associated oxidation system which includes the air aspirator-mixer and the discharge piping. The multiple oxidation systems are often more efficient than a single oxidation system with the same flow rate and dosage of the oxidant.

The multiple oxidation systems allow for discharges of the oxidized water at different levels in the oxidation vessel and recirculation of the oxidized water to the recirculation system which results in different residence time of the oxidized water in the oxidation vessel.

The air aspirator-mixer (AAM) aspires ozonated air under vacuum conditions and mixes the ozonated air with the feed and recirculated oxidized water. The AAM provides thorough mixing of ozonated air and water which results in a very efficient transfer of ozone and oxygen into water.

The supply of ozonated air to the air aspirator-mixer under vacuum conditions eliminates a potential for leaking ozone into the atmosphere. The discharge piping between the AAM and the oxidation vessel is usually very short, and it operates at a low pressure of 10 psi (69 kPa) maximum. This ensures a very safe ozonation system operation.

Also, the supply of the ozonated air under vacuum conditions allows for use of low pressure or vacuum ozone generators which is a significant factor in the costs of ozone generators and air preparation systems.

The ozone destruction unit, mounted at the top of the oxidation vessel, completes the safety and environmental requirements of the ozonation system.

The effluent from the oxidation vessel is discharged by gravity through a syphon breaker system which eliminates a potential for escape of ozone with the effluent water. The

syphon breaker system can also be used to control a discharge of the effluent by a pumping system.

The oxidation system outlined above has a wide application in water and wastewater treatment processes for aeration, oxidation and super oxidation applications and they include the following:

- Aeration of water for removal of H_2S, CO_2, Ammonia, odour control.
- Ozonation of water as pre-oxidation, for other treatment processes for removal of algae, colour, turbidity, Fe, Mn, H_2S, As, dissolved organics, CN, taste and odour.
- Aeration of wastewater for biological treatment in secondary or tertiary treatment processes.
- Ozonation of municipal wastewater effluents for disinfection.
- Super oxidation for removal of difficult to oxidized industrial pollutants.
- Super oxidation of treated water for reduction of dissolved organic carbon prior to chlorination.

The aeration of water for removal of H_2S, CO_2, Ammonia, and odour control, and aeration of wastewater for biological treatment in secondary and tertiary treatment processes can be accomplished to a high level of oxygen saturation of the water/wastewater due to high efficiency of the air aspirator-mixer and multiple aeration recirculation systems.

The air aspirator-mixer causes a very dynamic, turbulent interaction of water and air which results in a high level of oxygen transfer into water and which is independent of the height of the aeration vessel. The multiple aeration recirculation system will ensure maintenance of a high level of oxygen in the water in the aeration vessel regardless of the vessel water retention capacity.

The specific features of the aeration system will allow for a flexible design to accomplish the required oxygen content and retention time of the water in the oxidation vessel for treatment of water and for treatment of wastewater with biological treatment processes.

The oxidation of water with ozone has a wide application for removal of Fe, Mn, H_2S, CN, As, colour, algae, turbidity and dissolved organics in conjunction with coagulation, flocculation and direct rapid filtration, or with clarification and rapid filtration, or with membrane filtration.

Oxidation of water with Ozone is particularly useful, and often necessary, when Fe, Mn, As & U are complexed by naturally occurring organic matter (NOM).

The ozonation of municipal wastewater effluent disinfection is a valid option to UV light effluent disinfection and for a polishing treatment of wastewater effluent with filtration for the effluent recycling.

The super oxidation with ozone and hydrogen peroxide has two significant applications in water and wastewater treatment.

In water treatment, super oxidation can be used for reduction or complete removal of dissolved organic carbon before or after coagulation, flocculation and direct filtration or clarifications and filtration, and before the final disinfection with chlorine.

Use of superoxidation after coagulation, flocculation and filtration provides an economical solution for removal of high levels of dissolved organic carbon before chlorination and prevention of formation of trihalomethanes, and precipitation of organic matter in distribution systems.

Waters with high levels of dissolved organic carbon and low turbidity, which are typical to most lake water supplies, can be treated with super oxidation, coagulation, flocculation and direct filtration. Also, complete removal of giardia and cryptosporidium can be accomplished with the super oxidation, coagulation, flocculation and direct filtration system.

The use of ozonation or ozone & hydrogen peroxide superoxidation and chlorination ensures a double barrier protection against bacteriological contamination.

Industrial wastewaters which contain difficult to oxidize organic compounds can successfully be treated with super oxidation system along or in conjunction with coagulation, flocculation and direct filtration system depending on the pollutant loading and ease of oxidation. Chemical compounds which are very difficult to oxidize may undergo a molecular structure change in the oxidation process and become easily biodegradable or reactive with coagulants, or susceptible to co-precipitation with other impurities.

They key factor in the aeration, oxidation and superoxidation processes is efficiency of the system which has a profound impact on the system installation and operation costs, and the installation footprint requirements.

4. Oxidation, Coagulation and Flocculation System

The oxidation system outlined above is supplemented with coagulation and flocculation processes which take place in the same vessel with the oxidation process.

The flocculation process is coincidental to the oxidation process, and it is accomplished by the air or ozonated air supply into the oxidation vessel which cause mixing of the water contained in the vessel.

The coagulation system can be provided in two alternative arrangements as an independent system as shown on Fig. 2 or in combination with the oxidation system as shown on Fig. 3.

The independent coagulation system, as shown on Fig. 2, includes a circulation pump, a coagulant dosing system, and in-line static pre-mixer and a high gradient static mixer, and inlet and outlet piping connected to the oxidation vessel.

The circulation pump circulates the oxidized water through the coagulation system at approximately the same flow rate as the feed water supply to the oxidation vessel; although, the flow rates may vary to some degree.

The coagulation process takes place in the upper part of the oxidation vessel and it is followed by the flocculation process.

The coagulation process retention time is very short, in range of seconds, and the flocculation process retention time can be several minutes or longer and as required to develop a visible pin floc.

The coagulation system offers a good control of the coagulation recirculation flow rate and dosage of a coagulant in regard to the feed water flow rate and quality which ensures an efficient coagulation process.

The independent coagulation process allows for flexibility in use of single and multiple oxidation processes and a complete independent control of each process.

The combined oxidation and coagulation process, as shown on Fig. 3, uses the same circulation pump for the oxidation and coagulation processes.

This system is suitable for applications with constant feed water flow rates and quality, and single oxidation recirculation systems.

Both systems outlined above offer compact and economical package plant design.

5. Oxidation, Coagulation, Flocculation and Filtration System

The oxidation, coagulation, flocculation and filtration system as shown on Fig. 4 and Fig. 5 provides a complete package for a wide range of water and wastewater treatment applications in municipal and industrial fields.

The filtration system can be provided as a one-stage, as shown on Fig. 4, or two-stage filtration process assembled in one vertical vessel as shown on Fig. 5.

The one-stage filtration system, as shown on Fig. 4, is a rapid type, gravity, downward flow filter with a single or multi granular filtration media.

The filter employs a novel syphon type discharge piping which extends the available filtration head and the filter operation cycle time which result in reduction of the filter backwash water volume requirements.

Also, the syphon piping system design prevents exposure of the filter media during the filter operation and after the filter operation is stopped.

The syphon discharge piping allows for a lower filter vessel without reduction of the filter operation cycle time. The filter application is primarily for removal of turbidity with sand or sand and anthracite filtration media and for removal of dissolved impurities with suitable adsorption media such as granular activated carbon or other proprietary media.

The two-stage filtration system, as shown on Fig. 5, also employs the novel syphon discharge piping.

The filter design offers a number of advantages in the filtration process application as follows:

- The syphon discharge piping design provides the same advantages as outlined in the one-stage filtration process.
- Additional backwash water savings result from the ability of backwashing both filtration stages at the same time, although, independent backwashing can be performed of each filter stage as well.
- Wide range of applications including:
  - Roughing filtration and polishing filtration for removal of suspended matter.
  - Suspended matter removal in the upper stage and dissolved matter adsorption removal in the lower stage with Granular Activated Carbon or other proprietary adsorption media.
  - Adsorption filtration in both stages with the same or different adsorption media for removal of one or two different dissolved pollutants.
  - Flexible, compact and economical system for a wide range of filtration of suspended and dissolved pollutants.

- Small foot print design allows for installation in limited spaces of existing installations and new installations such as offshore oil and gas production platforms.
- Municipal and industrial applications.

6. Conclusions

The systems outlined above have been developed from years of experience and knowledge obtained from applied research, pilot plant studies and full scale field applications.

The systems offer a wide range of applications in water and wastewater treatment for municipal and industrial uses.

Novel designs provide economical and practical systems with small footprint requirements and reduced wastewater production.

Specific applications are of particular interest and they include the following:

- Removal of dissolved organic carbon in water treatment with super oxidation will result in reduction in use of coagulants and formation of trihalomethanes with chlorination and precipitation of organic matter in distribution systems.
- Inactivation of giardia and cryptosporidium may also be accomplished with super oxidation.
- Removal of difficult to oxidize industrial pollutants with super oxidation alone or with direct filtration for industrial wastewater treatment and for groundwater remediation, and soil remediation with steam or water washing process.
- Municipal wastewater effluent disinfection with ozone.
- Municipal wastewater effluent ozonation and direct filtration for recycling.