WATER TREATMENT – THE NO-MOVING PARTS METHOD

It has been said that "running water purifies itself." This adage is only true however in the ideal application where suspended particles are large enough in diameter to settle out on their own, or where a nearly infinitesimal amount of purification must be obtained over a nearly infinite length of flow. Unfortunately, in most wastewater applications neither of these ideal situations occur. It is therefore necessary to find the most suitable method to purify water to the degree that must be obtained. Motionless mixers used in conjunction with control instrumentation provide a way in which wastewater can be treated on a continuous basis.

There are a number of effective wastewater treatment processes. For example, zeolites or cation exchange resins are used for the removal of heavy metal cations. Cation exchange resins can deionize wastewater by using a mixed-bed ion exchange process or using a weakly or strongly basis anion exchange subsequent to cation exchange. Activated carbon absorption beds are effective in removing chloride or fluoride ions from wastewater where the concentration is high. Carbon is best utilized in its granular form which facilitates its reuse. Reverse osmosis is also an effective method of wastewater treatment that combines a high pressure pump and a semi-permanent membrane to filter dissolved salts. Each of these various treatment systems has certain strengths and weaknesses which make them suitable for removal of many, but not all, ions and colloidal particles in solution.

For large systems, or systems where ion contamination is in excess of 600-700 rpm, they become economically undesirable and cannot match the flexibility of inline treatment offered by motionless mixers. Colloidal particles, that is particles with a diameter on the order of one to five hundred milli-microns, are too small to settle out of wastewater by gravity.

These small particles develop electrostataic surface charges. It is therefore necessary to add a coagulating agent to the wastewater to bring these particles together and make them heavy enough to settle out of solution. The Schultz-Hardy Rule states that a colloidal particle's precipitation is affected by the ion of an added electrolyte that has a charge opposite to that of the colloidal particles, and also that the effect of the ion increases with the number of charges it carries. It is for this reason that alum (hydrated aluminum sulfate) is such a popular additive for coagulation. Aluminum is trivalent and relatively heavy. As a result negatively charged colloidal particles, as well as excess hydroxyl ions, are attracted to the Al.3 ions, aggregate in the case of colloidal particles, or gel in the case of Al (OH) and settle out of solution. The sulfate ions in alum attract positive ions and some of the resulting salts precipitate out as well. Iron salts, for example, FE2 (SO4) are also used for this same reason, however, overfeeding can result in bad color and foul taste in the water. It is apparent from the above reactions that coagulation is not always a simple case of chemical precipitation.

Controlled addition and mixing of chemicals with the wastewater is paramount. Flocculation is usually dependent on a physical mechanism called "contacting". It is for this reason that polyelectrolytes have been developed by synthetic organic chemistry.

Polyelectrolytes are long-chain macromolecules found in essentially three different types: cationic, anionic and non-ionic. The cationic and anionic types are given positive and negative electrostatic charges respectively, that serve to trap ions and charged particles. The non-ionic type works on the same principle without the aid of electrostatic forces. Therefore when using this type of material, it is essential to achieve good dispersion for contacting without breaking the polyelectrolyte apart.

Motionless mixers are an industry generic term for a special non-motorized type of mixer. Essentially, motionless mixers consist of a pipe containing baffles which aid in giving turbulence or mixing action to liquids or gases as they pass through the pipe. These baffles or elements can either be welded into the housing or set on a retaining ring for removability. There are no moving parts involved in the motionless mixer, therefore, it is basically maintenance free and is installed as easily as any piece of pipe. For wastewater treatment, there are special types of motionless mixers to select from depending upon the specific application. For example, they are commonly used for mixing chemicals for control of pH and oxygen reduction potential (ORP) and coagulation and flocculation, oxygen concentration, flow control, and heat transfer for temperature control.

There are many different styles of motionless mixers available from several manufacturers. Because proper contacting of the wastewater with the treatment chemicals is essential, the correct type of motionless mixer must be selected to achieve optimum results. One style mixer may be ideal for handling the addition of Cl2, O2 or alum (where contacting is a direct function of turbulence and vigorous mixing) whereas a completely different style is needed for polyelectrolyte addition (where contacting is a function of residence time). Overly turbulent flow in this application would break apart the macromolecule and negate its effect. In Figure 1, a cutaway of a motionless mixer is shown having sets of two semi-elliptical baffles. These baffle sets make up one element that is set at a 45-degree angle with respect to the central axis and at 90 degrees to each other. Additional elements are then rotated 90 degrees about the central axis with respect to the previous baffle set. This results in a length to diameter ratio of 1.5 and an extremely vigorous mixing action. Figure 2 shows a motionless mixer that has two baffles set at a 30-degree angle with respect to the central axis and at 120 degrees with respect to each other. This results in a length to diameter ratio of 1.75 and a turbulent, though somewhat less vigorous mixing action than the type shown in Figure 1, while at the same time enhancing residence time. The work done by a motionless mixer is measured as the pressure drop times the volume of the pipeline. Pressure drop is directly related to flow rate as shown in Figure 3. The motionless mixer in Figure 2 provides less turbulence and therefore a lower pressure drop than the type shown in Figure 1 and reduces pressure drop by a factor of 0.46. The number of elements required to ensure adequate mixing is based on the dimensionless Reynold's Number. This can be calculated for motionless mixers by using the following formula: NR = 50.6 Qp/Cd Where NR = Reynold's Number, dimensionless; D = Inside diameter of housing, inches; Q = volumetric flowrate, GPM; p = Density; lb/ft. 3; c = absolute viscosity, centipoise.

The Reynold's Number should only be used as a selection guideline and not as a hard and fast rule. NR must also be evaluated in conjunction with allowanble pressure drop and preferred line size requirements for choosing the appropriate mixer. Motionless mixers provide excellent continuous treatment of wastewater irrespective of flow variations and purification requirements. When used in conjunction with control instrumentation, they provide predictable and acceptable quality control which is essentially maintenance free. Motionless mixers are inexpensive and only require as much pumping power as is necessary to compensate for the calculated pressure drop.