ENGINEERING

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ABSTRACTS

Development of a Robust Routine for Calculating Vapor-Liquid Equilibrium Conditions. WARREN W. BOWDEN, Department of Chemical Engineering, Rose-Hulman Institute of Technology, Terre Haute, Indiana 47803.——Reliable routines for the calculation of vapor-liquid equilibrium conditions are a necessity for the design of equipment for such operations as flash separation, distillation and absorption. This paper describes an efficient and robust algorithm for this type of calculation.

Here 'efficient' means that the number of iterations is not large and 'robust' means that convergence to an unambiguous solution occurs for appropriate starting values.

The algorithm involves calculation of K-factors using the Lee-Kesler equation of state. Composition effects are introduced by the methods of Plöcker, Knapp and Prausnitz (1978). The equation of state is applied twice, once to the liquid phase and again to the vapor phase, to evaluate the fugacity of each component in both phases. This calculation requires an iterative solution of the equation of state to determine the liquid- and vapor- densities. Hence, the calculation involves a double iteration: an outer loop where temperature (for example) is the variable and an inner loop when density is the variable. At moderate conditions the calculation proceeds without difficulty. At more severe conditions, especially as the critical point of the mixture is approached, the calculation quite commonly fails. A robust routine must have provisions for appropriate starting temperature- and density-values and carefully constructed iterative procedures.

This paper describes a) the features of the algorithm which make it robust: choice of initial values, iteration techniques, and b) some results obtained with the program.

Combined Sewer Separation: Case Study. CHRISTOPHER B. BURKE, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.——After Congress enacted the Water Pollution Control Act (PL 72-500), much of the nation has been required to eliminate combined sewer overflows. Different approaches have been proposed and implemented. Three of the approaches are: 1) the upgrading or design of a sewage treatment plant or interceptor to handle the combined sewage during storms 2) temporarily store the combined sewage or 3) physically separate the stormwater from the sanitary wastes. This paper will take a look at the third alternative as it was applied to an urban area.

The project was undertaken for Lansing, Illinois a suburb located southeast of Chicago. The engineer was R. W. Robinson and Associates in South Holland, Illinois. The storm sewer system and detention pond were designed using the Illinois Urban Area Simulator (ILLUDAS). The total drainage area separated was about 460 acres.

Microcomputer Driven Multi-Point Controller. DAVID D. CHESAK, Department of Physics, St. Joseph's College, Rensselaer, Indiana 47978.——There has been a marked increase in the use of microcomputers in industrial and academic settings. While many of these are used as programmable controllers, it is felt that further advances can be made. The interface circuit described in this paper is intended to provide a simple means for digital control of multi-element devices such as pipe organs, incandescent light displays or control valves in a robot.

The interface circuit requires only one eight bit port from the computer to drive hundreds of elements in an on-off, two state mode. The switching operations are accomplished in microseconds. Any computer that provides an eight bit port can be programmed in machine code or any of the more sophisticated languages to drive the interface. Machine code provides the fastest switching speeds while a language such as BASIC provides greater ease of programming.

The circuit described has been used to play a three octave electronic organ. The program in BASIC compiles the note sequencing from a data code taken from sheet music. There is no particular limitation on the number of notes that can be sounded simultaneously. The microcomputer uses the very flexible S-100 bus system with an 8080 CPU. As many as 96 notes can be controlled with the circuit described and, with a minor modification, up to 768 devices can be controlled. The integrated circuits are the TTL type and all are available from a number of manufacturers.

Chemical and Physical Characterization of Wastewater Sludges in Indiana. WAYNE F. ECHELBERGER, JR. and J. C. RANDOLPH, School of Public and Environmental Affairs, Indiana University, Bloomington, Indiana 47405, J. MICHAEL JETER, Indianapolis Water Company, and STEVE W. KIM, Division of Water Pollution Control, Indiana State Board of Health, Indianapolis, Indiana 46206.——This research study was directed at obtaining an accurate and as comprehensive as possible inventory of the quantity and quality of municipal and industrial wastewater treatment sludges being generated throughout the State of Indiana. The specific procedures for data gathering, analysis and computerization were developed and executed through close and continuing coordination with the Indiana State Board of Health (ISBH).

In order to characterize the sludges generated as a result of the treatment of municipal wastewater in the state, sample sites were selected on the basis of population, with the sludges being collected and analyzed for both compatible and incompatible pollutants. The data presented in this survey indicates in detail the chemical concentrations in these residuals from wastewater facilities serving 90 percent of the sewered population in Indiana.

Overall, the results of this investigation indicate that municipal sludge is quite variable in terms of nitrogen, heavy metals and polychlorinated biphenyl (PCB), with the range of concentrations commonly covering three orders of magnitude. Considerations pertaining to these constituents include such things as the industrialization of the surrounding community, efficiency of the treatment processes, solids loading on the treatment plant and sludge handling techniques.

A closer scrutiny of this information indicates that the majority of sites sampled and analyzed were generally found to have relatively low concentrations of incompatible contaminants. A few of the municipalities, receiving heavy industrial loadings from either a single source or a group of manufacturing entities, tend to distort the means and make these values unrealistically high. As such, the overall

mean values are somewhat limited in their use for defining the quality characteristics of Indiana municipal sludges.

For the analysis of the quality characteristics of industrial sludges resulting from the treatment of process wastewater, manufacturing sites were selected primarily on the basis of SIC codes. This was done in an attempt to draw general conclusions aligning manufacturing types with the presence of certain waste constituents. The sampling of these sites posed problems in terms of the variable nature of the wastes treated in each industry and the discretionary respone that was encountered from some of the companies. Ultimately, forty-nine samples were received and analyzed for nitrogen, solids, heavy metal and PCB concentrations.

The statistical means, medians, and ranges for the industrial sludge analyses that were determined from this survey, in general, reveal tremendous variations in the quality characteristics for these sludges. This is no doubt due to the selective nature of the wastewater treatment procedures and the specific characteristic of the source for these constituents. The removal of plating wastes, as an example, will be significantly influenced by the chemicals used for the particular electroplating process and the presence of other constituents will generally be a negligible factor. As such, the sludge quality characteristics should be regarded as unique to the industrial source and somewhat representative of the manufacturing process. Comparisons to other types of industrial activities can be done only in a very general sense.

This research was jointly sponsored by the Indiana State Board of Health, U. S. Environmental Protection Agency, and Indiana University.

Particulate Sedimentation in Shallow Lakes. ALDO GIORGINI and MARK SMITH, School of Civil Engineering, Purdue University, West Lafayette, Indiana. 47907. ——Particles are released from the surface of a shallow lake with idealized bathymetry and their motion is followed until they deposit on the lake bottom. Since an exact solution of the wind driven circulation in such lakes was found by the senior author, it has been considered possible to interpret numerically the trajectories of the particles which are usually strongly effected by numerical approximations.

It is found that the bottom distribution of particles, as generated by a uniform distribution of "lighter" particles on the surface, is highly irregular and has regions where particles never fall.

[Particles are defined as being "light" when their free fall velocity in the water is smaller than the largest upward velocity component in the lake].

The Boundary Conditions of Oxygen Transfer in Water with Respect to Temperature. Robert H. L. Howe, West Lafayette, Indiana, 47906.——The three boundary conditions of oxygen transfer in water with respect to temperature are discussed: (1) when oxygen supply is provided by an excess air flow rate in a small volume of water under a back pressure; (2) when the air flow rate in an appreciable volume of water and a steady state is maintained; and (3) when the air flow rate is relatively small and it takes quite a long time to reach the dissolved oxygen saturation level. Mathematically, the three conditions are: (1) $dc/dt = -$; (2) $dc/dt = 0$; and (3) $dc/dt = +$; where C = dissolved oxygen concentration in mg/liter and t = time.

The Determination of the Rising Velocity of a Gas Bubble Through a Liquid Column by Howe's Method. ROBERT H. L. HOWE, West Lafayette, Indiana 47906 and

HAKKI DINGIL, Istanbul Technical University, Turkey.——A mathematical derivation for the determination of the rising velocity of a gas bubble is presented. Examples of the experimentation and some results are discussed in comparison with the calculation by the Newitt-Dombrowski-Knelman Formulation.

The equation derived by Howe can be used also to determine the fluid viscosity when the gas diameter and its rising velocity are known.

Difference Models of River Reaches. P. G. KATZ and G. H. TOEBES, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.——River flow-watershed runoff models of the Green River Basin of Kentucky are required for efficient operation of reservoirs in the basin. Correlative linear models that relate reach outflow to reach inflow and precipitation offer a relatively simple, easy to use method of satisfying the requirements.

The forecasting errors of previously constructed linear models for the Green River basin were examined. This provided a guide to the construction of new models. These models relate the changes in inflows to the changes in the outflow. Such models, called difference models, were constructed for the 9 reaches in the basin. Their construction involved taking the first difference of each of the outflow series and relating them statistically to the first differences of the inflow series. Precipitation was not differenced. The submodels and the basin model made by linking the submodels together were found to be better than the linear models constructed earlier.

Attempts were made to improve the difference models by the addition of an error model and the use of multilevel difference models. None of these variants were found to significantly improve the accuracy of the model.

Premultiplication of the precipitation by the average monthly runoff coefficient was found to improve the forcasting accuracy of a difference model built on that basis. The use of the SCS Direct Runoff Method to estimate effective precipitation for input into the difference model was found to decrease the accuracy of the model.

Analysis of Suspended Particulate Data from Chicago. A. RAMACHANDRA RAO, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.
——The air-suspended particulate data from Chicago are seasonal and nonstationary. The nonstationary in the data is made more pronounced by regulations which banned the use of high sulphur coal in Chicago.

The present study deals with modeling air-suspended particulate data from Chicago. A stochastic modeling technique called the 'Intervention Analysis' is used to develop models for these data. The modeling technique and its implications on policy are discussed in detail.

Performance of the Purdue Hydromechanics Laboratory Closed Circuit Wind Tunnel. GERARD F. SHELDON and DONALD D. GRAY, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.——The Hydromechanics Laboratory of the Purdue University School of Civil Engineering houses a large, single return, closed circuit, subsonic wind tunnel having two test sections in series. The tunnel is powered by a 150 h.p. electric motor which produces continuously variable mean velocities of up to 14 m/s in the large test section (3.05m long x 2.44m wide x 1.83m high) and up to 58 m/s in the small test section (4.57m long x 1.34m wide x 0.95m high). Each test section contains a remote controlled motorized traversing mechanism.

Following structural modifications intended to reduce tunnel wall vibrations, pitot tubes and hot wire probes were used to measure mean velocity and turbulence intensity distributions in seven planes normal to the flow at three airspeeds. In each test section, variations in mean velocity and turbulence levels generally declined in the streamwise direction. At top speed, the mean velocity varied by 12.6% and the maximum turbulence intensity was 1.1% in the farthest downstream plane of the large test section (outside of the wall layers). At top speed in the farthest downstream plane of the small test section, the corresponding values were 2.8% and 0.3%. The superior performance of the small test section is attributable to the greater contraction ratio. The modifications were found to have reduced turbulence intensities by up to 86%.