1. “Performance Evaluation of the IGCC Process Development Unit System”, HWAHAK KONGHAK, Vol. 37(1), 47-55 (1999)

As an approach to evaluate the performance of the IGCC(Integrated Gasification Combined Cycle) PDU(Process Development Unit) process and to understand the integration conditions between coal gasification plant and gas turbine system, process simulations for 100 ton/day-class IGCC PDU plant have been carried out. Two bituminous and two subbituminous coals were selected for this study. Power output and cycle efficiency have been calculated for two gas turbines, one for M3142(J) and the other for LM1600PA of General Electric company. In addition, the process simulations based on design thermal input of both gas turbines have been conducted to calculate the power output and cycle efficiency. For the 100 ton/day-class PDU plant, simulation results exhibit that about 80 ton/day of oxygen is required while 80 ton/day of saturated steam from the raw gas cooling system and 350-450 ton/day of saturated steam from the flue gas cooling system are produced. The power output and cycle efficiency of gas turbines are 4.5-8.5MW and 22-32 % when coal gas is fried, which are fairly lower than those of natural gas firing cases. On the basis of the design thermal input of the gas turbines, the coal consumption rate is 1.3-1.8 times of the 100 ton/day-class PDU plant and the saturated steam production is increased in this proportion. The power output and efficiency of coal gas firing cycles are similar or slightly higher than those of natural gas firing cases regardless of coal type.

2. "Reaction Characteristics of Zinc Titanate Sorbent for the Design of a Hot Gas Desulfurization Fluidized Reactor", HWAHAK KONGHAK, Vol. 37(1), 81-86 (1999)

A reaction rate of a zinc titanate sorbent with H_2S for scale-up design was obtained from a simplified semi-batch fluidized reaction model and experimental data from a hot gas desulfurization fluidized bed reactor at high pressure condition. The global reaction rate from a fluidized bed reactor of 7.5 cm inside diameter was 1,276 cm^3 gas/gmole H_2S/sec, which is 5 times smaller than that from TGA. The global reaction rate can be used in the design for the scale-up because the reaction rate includes the effects in fluidized bed such as bubble charateristics, mass transfer, entrainments, and solid mixing etc. Sensitivity of parameters on a fluidized reactor performance was analyzed with the simplified model.

3. “Effects of Temperature and Height on the Transition Velocity to Turbulent Flow Regime in a Gas Fluidized Bed”, HWAHAK KONGHAK, Vol. 37(2), 178-185 (1999)

Qualitative effects of temperature and height from the distributor plate on the transition velocity to turbulent flow regime(Uc) have been measured in a gas fluidized bed(0.1 m i.d. and 2.1 m height) using sand as bed material. Bed temperature(15-500 ℃), height from the

distributor plate(0.02-0.10, 0.10-0.15, 0.15-0.24, 0.24-0.29, 0.02-1.97 m), and mean particle size(0.134, 0.256 mm) were considered as experimental variables. The transition velocity to turbulent flow regime increased with increasing bed temperature, however, decreased with increasing height from the distributor plate. The previous correlations on transition velocity to turbulent flow regime compared with the measured values. Most correlations reported in the literature appeared inadequate to determine the effects of temperature and height from the distributor plate on transition velocity to turbulent flow regime.

4. "Pitfalls in Start-up and Shut-down of Pressurized Fluidized Bed Reactors", HWAHAK KONGHAK, Vol. 37(2), 186-190 (1999)

Serious potential problems in pressurized fluidized bed reactors were agglomerations and entrainments, occurred often when the reactors were unsteady-states. Based on theoretical evaluations on minimum fluidization velocity and terminal velocity, optimum loci for the manipulation of temperature and pressure were proposed when the reactors were started-up and shut-down.

5. "Flow Stability of Circulating Fluidized Bed with Polymeric Particles", HWAHAK KONGHAK, Vol. 37(2), 191-197 (1999)

The flow stability of circulating fluidized bed with polymeric particles was investigated from the pressure drop fluctuation. The test facility was 5 cm I.D. x 250cm long and the PE and PVC were employed as the bed materials. The pressure drop fluctuations of the CFB was analysed in terms of standard deviation, probability density function. The effect of addition of coarse particle and relative humidity of fluidized gas on the flow stability was determined from change of pressure drop fluctuations. Axial profiles of pressure drop fluctuation were measured and results showed that at the lower part of the bed the pressure drop fluctuation was more severe. It also showed that the addition of coarse particles and humid fluidized gas prevented the particle agglomeration thus the narrower pressure drop fluctuation was observed.

6. "Water Sorption Behaviors in High Performance Polyimide Thin Films Based on p-Phenylene Diamine(p-PDA)", HWAHAK KONGHAK, Vol. 37(3), 459-464 (1999)

Four different p-PDA based polyimides were prepared from their respective poly(amic acid)s through thermal imidization at 400 ℃ , Poly(p-phenylene pyromellitimide) (PMDA-PDA), poly(p-phenylene biphenyltetracarboximide) (BPDA-PDA), poly(p-phenylene 3,3′′,4,4′′- oxydiphthalimide) (ODPA-PDA) , and poly(p-phenylene 4,4′′-hexafluoroisopropylidenediphthalimide) (6FDA-PDA). Sorption and diffusion of water into films were gravimetrically measured at 100% relative humidity and 25℃ by using home-made Thin Film Diffusion Analyzer. Diffusion behaviors and sorption of water in

thin films were interpretated in terms of chemical affinity to water and morphological structure. The sorption behaviors in thin films were well fitted by Fickian diffusion model regardless of their morphological heterogeneities. The diffusion coefficient of water in films varies in the range of $1.6\times10^{-10}cm^2sec^{-1}$ to $10.5\times10^{-10}cm^2sec^{-1}$, and is in the increasing order :

7. "Preparation of Microporous Separator with Polyethylene/Silica/Mineral Oil", HWAHAK KONGHAK, Vol. 37(3), 465-471 (1999)

A separator was composed of the particle mixtures wish polymer(UHMWPE, HDPE), process oil(mineral oil), silica carbon black and BHT. Two kinds of separators extracted process oil, and process oil and silica with PR(polymer g/process oil g) were prepared, and then their properties were investigated. The specimen which was extracted by nonpolyar organic solvents extracted process oil of nearly 98%. The extracted amount of silica showed slowly the weight loss of specimens with the lapse of 30 min in sodium hydroxide solution. The resistance of specimens against sulfuric acid showed the weight loss of specimens of nearly less than 1 % with the increase of PR(polymer g/process oil g) ratio. As the PR ratio was increased, the tensile strength was increased but the electrical resistance of specimens showed the high resistance value. The isotherm by N2 gas adsorption-desorption method exposed the increase of the surface area with the increment of process oil having hysteresis regions of capillary condensation. In the result of SEM analysis, the micropores within PE layers was well distributed as the amount of process oil was increased.

8. "Minimum Slugging Velocity in a Gas Fluidized Beds", HWAHAK KONGHAK, Vol. 37(3), 472-481 (1999)

Effects of height from the distributor plate and bed height at minimum fluidization on the minimum slugging velocity have been investigated in a gas fluidized bed(0.1 m i.d. and 2.5 m height) using sand(mean diameter : 0.286 mm, apparent density : 2,561 kg/m^3) as bed material. Minimum slugging velocity decreased with increasing height from the distributor plate, however, increased with increasing bed height at minimum fluidization. A model has been proposed to predict the minimum slugging velocity based on bubble size correlation. The proposed model can predict the present and previous experimental results reasonably well.

9. "High-Temperature Characteristics of High Alumina Ceramics Some Additives", HWAHAK KONGHAK, Vol. 37(4), 598-603 (1999)

High temperature characteristics and the corrosion resistance to slag were studied by the specimens of the manufactured according to the addition of clay, zirconia, talc and used the

titanum oxide as a sintering agent in high alumina ceramics. These specimens were fired under the temperature at 1,500℃ and 1,650℃. The specimen fired at 1,500℃ was a better in the properties at room temperature and the mechanical strengh than that fired at 1,650℃. There was no change of phase between the corundum, AT and baddeleyite at the temperatures 1,500℃ and 1,650℃. The existence of liquid phase was observed in the specimens with the composite additives such as clay, zirconia and talc. The specimen with talc and zirconia was good in the thermal bending strength, linear thermal expansion and elasticity at high temperature. The corrosion resistance of TiO_2-added specimen was higher than that of the composite additives specimens.

10. "Pressure Balance Curves in KIER Solid Circulating Fluidized Process with Two Loopseals", HWAHAK KONGHAK, Vol. 37(4), 604-608 (1999)

KIER hot gos desulfurization system consisting of a reactor of a transport mode, a regenerator of a fluidized bed mode, two loopseals, and two gas streams was tested for the stable operation of circulating solids between two reactors. Pressures in a circulation loop at various conditions were measured in a cold mode(a 0.03 m I.D. riser and a 0.075m I.D. fluidized bed) with particles of mean diameter of 87×10^{-6} m and the bulk and particle density of 1,900 and 3,300 kg/m^3 respectively. The voidages and mixture densities of gas-solid at various sections were analyzed from differential pressures data. The continuous circulation of solids was confirmed by the single closed loop of pressure balance curves. The loopseal took a role of preventing the gas of a reactor from flowing to another reactor.

11. "Analysis of Combustion Characteristics of Bituminous and Anthracite Coal Using Pressure fluctuation Properties in a Fludized Bed Combustor(Uniform Particle System)", HWAHAK KONGHAK, Vol. 37(4), 609-614 (1999)

The characteristics of mixed-firing of an anthracite and a bituminous coal were studied in a fluidized bed combustor(0.155m-I.D., 2.2 m-height). The used domestic anthracite coal has heating value of 2,010 kcal/kg and the imported high-calorific bituminous coal has heating value of 6,520 kcal/kg. The physicochemical analysis and the pressure fluctuation properties were measured to interpret the combustion characteristics in a fluidized bed combustor of uniform particles of mixed anthracite and bituminous coal is a function of the particle size ratio and the anthracite mixing fraction. The combustion characteristics of mixed fuels in a fluidized bed combustor could be interpreted by using standard deviation of pressure fluctuations, mean pressure and power spectrum density function. The different burning region of fluidized bed combustor was measured by the pressure fluctuation properties.

12. “Study on Removal of Unburned Carbon From Fly Ash by Column Flotation“, HWAHAK KONGHAK, Vol. 37(5), 719-724 (1999)

In this study, as a removal method of unburned carbon from fly ash for the purpose of recycling, the characteristics of separation and the effect parameters on separate efficiency were investigated by the flotation method, making use of the difference between the surface chemistry of carbon and that of ash. The separation charactieristics were investigated according to fly ash type, and then the flotation experiments were done to increase the separation efficiency by the pH adjustment of pulp, the addition of surfantants and the change of kerosene amount. As a result, the separation efficiency by the pH was highest ar neutral region, pH 7 and the addition of moderate amount of surfactant to kerosene was so effective to increase it. Moreover, the column flotation method produced the refined fly ash containing unburned carbon contents under 2% and yield over 80% at the optimum flotation condition made by a pH adjustment, the addition of moderate amount of surfactant etc. Therefore, it is expected that the recycling of the refined fly ash is possible.

13. “Preparation of Microporous RuO_2-TiO_2 Electrodes by the Sol-Gel Process”, HWAHAK KONGHAK, Vol. 37(5), 725-728 (1999)

Microporous RuO_2-TiO_2 binary metal oxide electrodes with various compositions were prepared by the sol-gel process. Ruthenium chloride hydrate and titanium isopropoxide were used as precursors, and isopropyl alcohol was used as a solvent. Sol solutions were stable and uniform at room temperature. With increasing mole ratio of RuO_2 in the metal oxide electrode, RuO_2 particle grow on the electrode surface and specific surface area was decreased. From Tafel plots and anodic polarization curves, the binary metal oxide electrode with 40% RuO_2 showed the highest exchange current density and the lowest overpotential for oxygen evolution.

14. “The Analysis of Combustion Characteristics of Mixed-Firing with Bituminous and Anthracite Coal Using Pressure Fluctuation Properties in a Fluidized Bed Combustor(Multi-Sized Particle System)“, HWAHAK KONGHAK, Vol. 37(6), 910-915 (1999)

The combustion characteristics of mixture of antharcite and bituminous coal were studied in a fluidized bed(0.155m-I.D., 2.2m-height). The pressure fluctuations were measured by a pressure transducer under the various operating conditions. The properties of the pressure fluctuatuons, such as the standard deviation of pressure fluctuations, static pressure, cross-correlation function, dominant frequency and the power spectral density function, were obtained from the statistical analysis. The pressure fluctuation properties, particle size

distribution of ash and composition of flue gas were measured to interpret the combustion characteristics in a fluidized bed combustor uniform of multi-sized particles of mixed anthracite and bituminous coal have been compared with the particle size distribution, antharcite mixing fraction. From this study, the combustion characteristics of mixed fuels in a fluidized bed combustor coulde be intetpreted by using standard deviation of pressure fluctuation and power spectrum distribution.

15. “Phase Holdup Characteristics in Three-Phase Circulating Fluidized Beds“, HWAHAK KONGHAK, Vol. 37(6), 916-920 (1999)

Phase holdup characteristics have been investigated in a gas-liquid-solid circulating fluidized bed(0.102m I.D×3.5 m in height). Effects of velocities of dispersed gas and continuous liquid phases and solid circulation rate on the individual phase holdup and its axial distribution in the bed have been determined. Compressed air and water have been used as a dispersed gas and a continuos liquid phase, respectively, while glass beads with the diameter of 2.1 mm have been used as a fluidized solid phase. It has been found that the gas holdup has increased with increasing dispersed gas velocity, but liquid velocity and solid circulation rate have little effect on the gas holdup. The liquid holdup has increased with increasing liquid velocity, however, it has decreased with increasing gas velocity and solid circulation rate. The solid holdup has increased with increasing solid circulation rate and gas velocity, whereas, it has decreased with increasing liquid velocity. The axial distribution of solid holdup has become uniform with increasing liquid velocity. The gas holdup and bed porosity have been well correlated in terms of operating variables such as gas and liquid velocities and solid circulation rate.

16. “Study of a Non-mechanical Solid Valve(Loop Seal)“, HWAHAK KONGHAK, Vol. 37(6), 925-929 (1999)

The characteristics of loop seal operation and particle flow were investigated by hydrodynamics study in a cold mode riser and loop seal system. The physical dimensiton of 0.2m×0.15m×0.2m cold mode loop seal and riser is serially connected to compose a experimental system. A coal ash was used for the experiment. The flow pattern of particle was investigated by variation of quanity of fluidizing air and location of aeration. The mathematical relationship of the limitation of particle flow rate and system pressure was analyzed. The particle flow rate increased by the increase of air flow of return leg. The pressure difference of down comer section was reduced as the increase of the particle flow rate.

17. "Simulation of the Tonghae Thermal Power Plant CFB by using IEA-CFBC Model -Determination of the CFB Combustor Performance with Cyclone

Modification-", HWAHAK KONGHAK, Vol. 38(1), 53-61 (2000)

The 200 MWe Tonghae thermal power plant CFB(2-units) is the largest boiler to fire a Korean anthracite coal for generation of electric power. The #1-unit CFB boiler has been operated commercially since October 1998, and the #2-unit CFB boiler, of which commercial operation will be achieved at October 1999, is under construction. The optimization and stabilization of the CFB operation have been carried out through the modification of the cyclones for the units of #1 and #2. However the operation data for the large CFB combustor firing the anthracite coal are few, so it is necessary to predict the performance of the CFBC with variation of operation conditions. Therefore, in this study, the development of the simulation scheme has been achieved by using IEA(International Energy Agency)-CFBC model, and the performance of the CFB combustor with variation of the cyclone efficiency has been determined. The improved performance of the modified cyclone, which have been carried out by increase of the vortex finder length and by decrease of the cross sectional area of the cyclone inlet, also has been determined. The cyclone efficiency has been evaluated 98.7%. As the cyclone efficiency increases, the upper differential pressure increases and the freeboard temperature becomes to be low and stable. The modifications of vortex finder and inlet duct of the cyclone have been predicted to improve the performance of the CFB combustor.

18. "Gas-Liquid Reaction Precipitation of Calcium Carbonate in MSMPR and Couette-Taylor Reactors", HWAHAK KONGHAK, Vol. 38(1), 67-74 (2000)

The effect of the operating variables such as mean residence time, agitational speed and surfactant type, on the precipitation of calcium carbonate was experimentally investigated in MSMPR and Couette-Taylor reactors. The precipitates was produced by the gas-liquid reaction of CO2 gas and Ca(OH)2 aqueous solution. Under-fixed temperature and concentration in MSMPR reactor, it was founded that the surfactant type had the greatest influence on the mean particle size and this effect was represented numerically by the zeta potential. With increasing the impeller speed the mean particle size increased due to decrease of the resistance in mass transfer processes. The vortex flow in Couette-Taylor reactor affected the precipitation of calcium carbonate complicatedly. The homogeneous mixing owing to Taylor vortex in Couette-Taylor reactor led to the more uniform particle size distribution than that in MSMPR reactor.

19. "Soybean-Oil Leaching in a Three-Phase Fluidized Bed Extractor", HWAHAK KONGHAK, Vol. 38(2), 225-229 (2000)

Characteristics of soybean oil leaching have been investigated in a three-phase fluidized bed extractor(0.102 ID×1.5 m Height). *n*-Hexane and compressed air have been used as a liquid solvent and a gas phase, respectively. The cracked(cracker) and flaked(flake)

soybeans have been used as a fluidized solid phase. Effects of gas phase velocity, extraction time temperature and fluidized solid types on the extraction efficiency in the extractor have been discussed. As a result of experiments, the extraction efficiency has increased with increasing gas phase velocity and extraction temperature during the same extraction time. The efficiency has exhibited higher value in the flake bed extractor than that in the cracker bed. It has been found that the extraction efficiency has been higher in using the fluidized-bed extractor in the comparison with that of commercial unit. Moreover, the cracker, which needs pretreatment in using the previous process, can be used without modification in the fluidized-bed extractor, thus, the cost can be discarded considerably in using the fluidized-bed extractor.

20. "Modeling and Coal Gasification in an Internally Circulating Fluidized Bed Reactor, HWAHAK KONGHAK", Vol. 38(2), 259-268 (2000)

Australian coal was gasified in an internally circulating fluidized bed(0.3 m ID×2.7 m high) with a draft tube(0.1 m ID×0.9 m high) and a gas separator over the draft tube at atmospheric pressure. The effects of reaction temperature(780-900℃), oxygen/coal ratio(0.30-0.53), coal feeding rate(5.3-12.1 kg/h) and steam/coal ratio(0.30-0.81) on compositions of the product gas, carbon conversion, cold-gas efficiency, gas yield and calorific value of the product gas have been determined. In the present coal gasifier, low calorific value gas(3.3-5.9 MJ/m^3) in the draft tube region and medium calorific value gas(8.6-13.2 MJ/m^3) in the annulus region can be obtained. A predictive mathematical model is proposed based on the bed hydrodynamics, reaction kinetics and the empirical correlation of pyrolysis yields to predict gasification characteristics in the internally circulating fluidized bed gasifier with a draft tube. The model including the effect of combustion reaction in the freeboard region can explain the reaction behavior more precisely than the model excluding the effect of combustion reaction in the freeboard region in the reactor within the range of variables studied.

21. "A Study on Ammonia Removal Properties using Clinoptilolite Part 2: Ammonia Removal Properties in Recirculating Fluidized Bed Reactor", HWAHAK KONGHAK, Vol. 38(3), 411-415 (2000)

Using Recirculating Fluidized Bed Reactor (RFBR), more than 85% and 70% of ammonia were removed at initial ammonia concentration (C_i) of 3 ppm and SR=8, and (C_i)=1 ppm and SR=10, respectively, where flow rate is 424 ml/min. Simultaneous removal of aluminum ion reached 70% at the second condition. Also continuous regeneration of deactivated zeolite was possible. Continuous removal of ammonia and regeneration processes using clinoptilolite & RFBR will cost below 40 won per ton water for treating 50,000 m^3/day-water having 3 ppm ammonia.

1. “EFFECT OF TEMPERATURE ON PARTICLE SIZE FOR VAPOR-PHASE SYNTHESIS OF ULTRAFINE IRON PARTICLES”, KJChE, Vol. 16(1), 64-68 (1999)

For the vapor-phase synthesis of iron particles from FeCl2 at temperatures ranging from 800 to 950 ℃, the reason is sought why the model based on the classical nucleation theory brought an increase of particle size with temperature increase, in reverse to experimental observation. The nucleation rate according to the classical theory should decrease with a temperature increase, due to the decrease of super-saturation ratio resulting from the increase of vapor pressure. The decrease of nucleation rate ultimately leads to an increase of particle size. Yang and Qiu''s nucleation theory was applied in place of the classical theory. However, the same result as with the classical theory was obtained : the nucleation rate decreased with the temperature increase. Finally, an Arrhenius-type nucleation rate equation was introduced. The preexponential factor and the activation energy for nucleation were determined to be 1348.2 sec-1 and 159.1 KJ/mol, respectively. With these values put into Park et al.''s model, good agreement was obtained in temperature dependence of particle size between model prediction and experimental data.

2. “PREPARATION OF ALUMINA FIBERS FROM ALUMINUM SALTS BY THE SOL-GEL METHOD”, KJChE, Vol. 16(1), 75-81 (1999)

Alumina fibers were synthesized from two different systems, AlCl3-Al powder-H2O and Al(NO3)3-Al powder-H2O, by the sol-gel method. For the former system, gel fibers were obtained from solutions in a composition range of Al powder/AlCl3 molar ratios of 2 to 5. For the latter system, the spinnable range was narrower compared to the aluminum chloride system. The thermogravimetry analysis (TGA) curve of the aluminum chloride system showed a weight loss up to 700℃, while the TGA curve of the aluminum nictate system showed no weight loss above 400℃, which indicates that thermal decomposition of Cl- is more difficult than that of NO3-.

3. “SOLIDS FLOW CHARACTERISTICS IN LOOP-SEAL OF A CIRCULATING FLUIDIZED BED”, KJChE, Vol. 16(1), 82-88 (1999)

The hydrodynamics of solids (FCC) recycle in a loop-seal (0.08 m) at the bottom of the downcomer (0.08 m-I.D.×4.0 m-high) in a circulating fluidized bed (0.1 m-I.D.×5.3 m-high) have been determined. Solid flow rate through the loop-seal increases linearly with increasing aeration rate. At the same aeration rate, the maximum solid flow rate can be obtained at a loop-seal height-to-diameter ratio of 2.5. The effects of solid inventory, solid circulation rate and gas velocity on pressure balance around the CFB have been determined. At a given gas velocity and solid circulation rate, pressure drops across the downcomer and loop-seal increase linearly with increasing solids inventory in the bed. At a constant solid inventory, pressure drops across the riser and the downcomer increase with

increasing solid circulation rate but decrease with increasing gas velocity in the riser. The obtained solid flow rate has been correlated with pressure drop across the loop-seal.

4. "Heat Transfer in a High Temperature Fluidized Bed", KJChE, Vol. 16(2), 260-264 (1999)

The heat transfer characteristics between the bed and immersed tube in a high temperature fluidized bed (7.5 cm 1.D.× 70 cm H) were investigated with sand and iron ore particles. The heat transfer coefficients were measured at operating temperatures of 200-600℃ and gas velocities of 1-10 Umf. The bed emissivity measured by the radiation probe was found to be 0.8-0.9. The experimentally obtained radiative heat transfer coefficient was in the range of 30-80 W/m2K for the operating temperature of 400-800℃ and the contribution of radiation to total heat transfer was about 13% and 18% for the operating temperatures of 400℃ and 600℃, respectively.

5. "The Effect of Interparticle Forces on Fluidization Regimes in the Magnetized Fluidized Beds", KJChE, Vol. 16(3), 362-370 (1999)

This paper investigated the influence of interparticle forces on the quality of fluidization in a magnetically stabilized fluidized bed (MSFB), where we can "artificially" create interparticle forces (Fattr) of any magnitude by applying an external magnetic field to ferromagnetic particles. A theoretical model was proposed which predicts the transition point from a homogeneous to a heterogeneous fluidization as a function of the magnitude of the interparticle force and other physical characteristics of both particles and fluids that are usually observed in fluidization (ρp, ρf, μ, dp, ε). The concept of the elastic wave velocity, Ue, and the continuity wave velocity, Uε, was introduced. In particular, the interparticle force manipulated by an externally applied magnetic field was taken into account in addition to a general consideration of a conventional fluidized bed. Bubbles from in a bed when the continuity wave velocity becomes faster than the elastic wave velocity. The simulation demonstrated the proposed model could predict the transition point of fluidization regime with reasonable accuracy

6. "Gas Backmixing in the Dense Region of a Circulating Fluidized Bed", KJChE, Vol. 16(4), 456-461 (1999)

The gas backmixing characteristics in a circulating fluidized bed (0.1 m-ID×5.3-m high) have been determined. The gas backmixing coefficient(Dab) from the axial dispersion model in a low velocity fluidzation region increases with increasing gas velocity. The effect of gas velocity on Dab in the bubbling bed is more pronounced compared to that in the Circulating Fluidized Bed (CFB). In the dense region of a CFB, the two-phase model is proposed to calculate Dab from the two-phase model and mass transfer coefficient (k)

between the crowd phase and dispersed phase. The gas backmixing coefficient and the mass transfer coefficient between the two phases increase with increasing the ratio of average particle to gas velocities(Up/U g).

7. "Selective and Complete Catalytic Oxidation of Natural Gas in Turbulent Fluidized Beds", KJChE, Vol. 16(4), 494-500 (1999)

Turbulent Fluidized Bed (TFB) reactors appears to be ideal for exothermic and fast reactions such as catalytic oxidation of methane. In this paper, a use of TFB reactor for two catalytic oxidation of methane: catalytic combustion of methane and catalytic selective oxidation of methane for the ethylene synthesis is described. Catalytic fluidized bed combustion of methane is shown to be an emerging technology capable of meeting all environmental constraints as far as nitrogen oxides and carbon monoxide are concerned. This reaction carried out in both the bubbling and the turbulent regimes at 450-500℃ shows that the turbulent regime is more favourable. A self-sustained combustion with complete conversion and a zero emission of NOx and CO was achieved with a mixture of 4% methane in air at 500℃. The two-phase model of Werther [1990], which phenomenologically introduces the enhancement factor due to chemical reaction, predicts quite well the combustor performance. The same model but without enhancement factor (slower reactions) predicts satisfactorily the experimental data for the oxidative coupling of methane and can be used to quantify the influence of homogeneous and catalytic reactions.

8. "NOχ Removal by Selective Noncatalytic Reduction with Urea Solution in a Fluidized Bed Reactor", KJChE, Vol. 16(5), 614-617 (1999)

A fluidized bed reactor has been developed to overcome the plugging problem of urea injection by employing a sparger rather than nozzles in the SNCR process for simultaneous removal of SO2 and NOx. In a developed fluidized bed reactor, the optimum temperature to remove NOx is shifted to lower values, the reaction temperature window is widened with the presence of CO in flue gas, and NO conversion is higher than that in a flow reactor. The optmum amount of urea injection in the reactor is found to be above 1.2 based on the normalized stoichiometric molar ratio (NSR) with respect to NO conversion. In the simultaneous removal of SO2/NO, conversions of SO2 and NO reach 80~90%, nearly the same values for the individual removal of SO2 and NO above 850℃.

9. "Solid Circulation and Gas Bypassing in an Internally Circulating Fluidied Bed with an Orifice-Type Draft Tube", KJChE, Vol. 16(5), 617-623 (1999)

The effects of orifice diameter in the draft tube, particle size, gas velocities and bed height on the circulation rate of solids and gas bypassing between the draft tube and annulus have been determined in an internally circulating fluidized bed(i.d., 0.3 m ; height,

2.5 m) with an orifice-type draft tube. Aconical shape gas separator has been employed above the draft tube to facilitate the separation of gases from the two beds. The circulation rate of solids and the quantity of gas bypass from the annulus to draft tube show their minimums when the static bed height is around the bottom of the separator. The circulation rate of solids increases with an increase in orifice diameter in the draft tube. At fixed aeration to the annulus, gas bypassing from the draft tube to annulus sections decreases, whereas reverse gas bypassing from the annulus to the draft tube increases with increasing the inlet gas velocity to the draft tube. The obtained solids circulation rate has been correlated by a relationship developed for the cocurrent flow of gas and solid through the orifice

10. "Radial Gas Mixing Characteristics in a Downer Reactor", KJChE, Vol. 16(5), 624-629 (1999)

In a downer reactor (0.1 m-I.D.×3.5 m-high), the effects of gas velocity (1.6-4.5 m/s), solids circulation rate (0-40 kg/m2s) and particle size (84,164 ㎛) on the gas mixing coefficient have been determined. The radial dispersion coefficient (Dɣ) decreases and the radial Peclet number (Peɣ) increases as gas velocity increases. At lower gas velocities, Dr in the bed of particles is lower than that of gas flow only, but the reverse trend is observed at higher gas velocities. Gas mixing in the reactor of smaller particle size varies significantly with gas velocity, whereas gas mixing varies smoothly in the reactor of larger particle size. At lower gas velocities, Dɣ increases with increasing solids circulation rate (Gs), however, Dɣ decreases with increasing Gs at higher gas velocities. Based on the obtained Dɣ values, the downer reactor is found to be a good gas-solids contacting reactor having good radial gas mixing.

11. "Powder Coating Efficiency of Small Particles and Their Agglomeration in Circulating Fluidized Bed", KJChE, Vol. 16(5), 630-634 (1999)

The coating efficiency of fluidizing small particles and their agglomeration were investigated to evaluate the possibility of powder coating by the use of a circulating fluidized bed. Glass beads, whose mean diameter was 43㎛, and silica powder of 1㎛ were used as a core and a coating material. Ployvinyl alcohol was used as a binder and its solution was supplied together with silica powder from a spray nozzle equipped in the circulating fluidized bed. Glass beads of 43㎛, which had been impossible to coat in a conventional fluidized bed coater, were successfully coated with silica powder in a circulating fluidized bed, and agglomeration among core particles was prevented. From this result, it was confirmed that a circulating fluidized bed performs excellently as a coater, especially for fine core particles, so a circulating fluidized bed coater has bright prospects for particle coating.

12. “Effect of Satellite bubbles on Dynamics of Gas Absorption from a CO_2 Bubble into a Downward-Flowing Liquid”, KJChE, Vol. 16(5), 635-640 (1999)

The dynamic process of gas absorption from a CO2 bubble into a liquid is examined in the presence of satellite bubbles. The bubble under consideration is held stationary, except its jittering, by the liquid flowing downward. The mass transfer rate is determined by monitoring the rate of reduction in the equivalent bubble diameter during the initial absorption process. It is found that the interaction with the satellite bubbles generally hampers the dissolution of the primary bubble. The extent of reduction in the dissolution rate increases with the net contacting time during the interaction. When the secondary bubbles interact with the primary bubble mainly outside of its wake, however, the disslution tends to be enhanced due to induced trubulence in the surrounding liquid flow. A simple theoretical model is developed to simulate the observed results as well as the basic features prevailing in a recently proposed scheme, called the GLAD system, for shallow injection of CO2 gas into seawater.

13. “Simulation of the 200 MWe Tonghae Thermal Power Plant Circulating Fluidized Bed Combustor by using IEA-CFBC Model”, KJChE, Vol. 16(5), 640-645 (1999)

The 200 MWe Tonghae thermal power plant CFB boiler (2-units) is the largest boiler to fire a Korean anthracite coal for generation of electric power. The #1 unit CFB has been operated commercially since October 1998, and the #2 unit CFB, which will begin commercial operation in October 1999, is currently under construction. However, there is little operational data of the large CFB combustor firing anthracite coal, so it is necessary to predict the performance of the CFB combustor with variation of the operation conditions. Therefore, in this study, the simulation of the Tonghae CFB has been carried out to predict the performance with various nominal rates, coal particle size distribution and operating conditions. The simulation results with various loads could be fitted well to the design values at the given operation conditions. At the various operation conditions, the simulation results could explain the performance of the Tonghae CFBC well.

14. “Classification and Characterization of Hydrodynamic and Transport Behaviors of Three-Phase Reactors”, KJChE, Vol. 16(6), 709-720 (1999)

Abstract–According to axial profile of solid concentration, the cocurrent upward three-phase reactors with liquid as continuous phase can be classified into three types: (a) gas-sparged slurry reactors, (b) three-phase bubble columns, and (c) three-phase fluidized beds. Comparative study shows that the gas hold up, bubble characteristics and mass transfer are significantly dependent on the type of three-phase reactors. Three types of reactors exhibit the different hydrodynamic and transport behaviors with particle size, solid concentration and gas holdup. The structural analysis of the axial solid distribution indicates the bubble and bubble wake dynamics are the key factors to the hydrodynamic and transport behaviors of three-phase reactors.

15. "Functionalization of HDPE Powder by CF_4 Plasma Surface Treatment in a Fluidizaed Bed Reactor", KJChE, Vol. 16(6), 731-736 (1999)

Abstract–The surface of HDPE polymer powder was fluorinated by CF_4 plasma in a fluidized bed reactor. Plasma is generated by an inductively coupled electrode at 13.56 MHz (rf) frequency, connected to an auto matching network and an rf power generator. In plasma surface fluorination, the CF_4 gas is diluted with He gas. The experimental variables are treatment time and rf power. The chemical property of the modified powder has been determined by using ESCA and FTIR. Plasma surface fluorination with the powder in a fluidized bed reactor results from the formation of $CHF\text{-}CH_2$, CHF-CHF and CF_2 groups. These fluorine functionalities and the fluorine atomic ratio on the surface increase with the treatment time and rf power. It has been found that the composite parameter is a good measure for determining the effect of total energy input on the plasma surface treatment of polymer powder in a fluidized bed reactor.

16. Particle Flow Behavior in Three-Phase Fluidized Beds, KJChE, Vol. 16(6), 784-788 (1999)

Abstract–Non-uniform flow behavior of fluidized solid particles in three-phase fluidized beds has been analyzed by adopting the stochastic method. More specifically, pressure fluctuation signals from three-phase fluidized beds (0.152 m ID × 2.5 m in height) have been analyzed by resorting to fractal and spectral analysis. Effects of gas flow rate (0.01-0.07 m/s), liquid flow rate (0.06-0.18 m/s) and particle size (0.001-0.006 m) on the characteristics of the Hurst exponent, spectral exponent and Shannon entropy of pressure fluctuations have been investigated. The Hurst exponent and spectral exponent of pressure fluctuations attained their local maxima with the variation of liquid flow rate. The Shannon entropy of pressure fluctuation data, however, attained its local minima with the variation of liquid flow rate. The flow transition of fluidized solid particles was detected conveniently by means of the variations of the Hurst exponent, spectral exponent and Shannon entropy of pressure fluctuations in the beds. The flow behavior resulting from multiphase contact in three-phase fluidized beds appeared to be persistent and can be characterized as a higher order deterministic chaos.

17. "Effects of Geometrical Parameters of Draft Tubes and Clear Liquid Height on Gas Hold in a Bubble Column for Gas Dispersion into Tubes", KJChE, Vol. 16(6), 789-794
(1999)

Abstract–The effects of the geometrical parameters of draft tubes and the clear liquid height on the average gas holdup E_G in a 0.16 m I.D. bubble column for gas dispersion into the tubes were experimentally studied in an air-tap water system. The gas holdup depended on the superficial gas velocity U_G, the kinds of gas spargers, the diameter and length of the draft tubes, clearance C_b between the lower end of the draft tube and the bottom of the bubble column, and the clear liquid height H_L. E_G increased with decreasing hole diameter of the gas sparger at a small gas velocity U_G, but did not depend on the kinds of gas spargers at a large U_G. E_G decreased with increasing clear liquid height H_L. The effect of H_L on E_G was well expressed by the modified three-region model. The experimental data of E_G were correlated.

18. "Desing and Operating Experience for a Fluidized Bed Incinerator to Treat Industrial Hazardous Scum and Waste Oils", KJChE, Vol. 16(6), 795-797 (1999)

Abstract-The production of industrial hazardous wastes increases with population growth and industrial progress. Most industrial hazardous wastes are in the forms of sludge, scum or waste oil and have organic properties. The best way to treat those wastes is to burn them in a fluidized bed type incinerator. Because the properties of scum and waste oils are different from those of industrial sludges, the design and operation of such kinds of incinerators are also different from that for industrial sludges. This paper presents the design method and the operating experience for a fluidized bed incinerator to treat specifically industrial hazardous scum and waste oils.

19. "Coal Combustion Characteristics in a Pressurized Fluidized Bed", KJChE, Vol. 16(6), 804-809 (1999)

Abstract-The characteristics of emission and heat transfer coefficient in a pressurized fluidized bed combustor are investigated. The pressure of the combustor is fixed at 6 atm. and the combustion temperatures are set to 850, 900, and 950 °C. The gas velocities are 0.9, 1.1, and 1.3 m/s and the excess air ratios are 5, 10, and 20%. The desulfurization experiment is performed with limestone and dolomite and Ca/S mole ratios are 1, 2, and 4. The coal used in the experiment is Cumnock coal from Australia. All experiments are executed at 2 m bed height. In this study, the combustion efficiency is higher than 99.8% through the experiments. The heat transfer coefficient affected by gas velocity, bed temperature and coal feed rate is between 550-800 W/m^2 °C, which is higher than those of AFBC and CFBC. CO concentration with increasing freeboard temperature decreases from 100 ppm to 20 ppm. NO_x concentration in flue gas is in the range of 5-130 ppm and increases with increasing excess air ratio. N_2O concentration in flue gas decreases from 90 to 10 ppm when the bed temperature increases from 850 to 950 °C.

20. "Stability Analysis of Perforated Plate type Single Stage Suspension Fluidized Bed Without Downcomer", KJChE, Vol. 16(6), 810-817 (1999)

Abstract-The stability of operation of a perforated plate type suspension bed without downcomer was analyzed experimentally and numerically. The effects of the feed rate, the gas flowrate and the opening ratio and hole diameter of the perforated plates on the operating stability of the fluidized bed were examined. A full three-dimensional discrete particle simulation method proposed by Tsuji [1993] was performed to study the formation of a stable suspension fluidized bed. The course and behavior of particles that formed a dense and stable fluidized bed are discussed. Both the experimental and simulation results of this study show that the process of forming a suspension bed can be categorized into (i) an induced stage, (ii) a growing stage, and (iii) a stable stage. The velocity of gas through the orifice directly controls the formation of the bed while the solid flow rate over a considerable range maintains a balanced hold-up in the suspension bed system without downcomers. The existence of a multiplicity of steady states corresponding to different gas flow rates, for the same feed rate and perforated plate type, was observed. Results show that the design of the plate, the particle feed rate and the gas velocity distribution through the hole affect the stability of the fluidized bed. The simulated results agree qualitatively well with experimental observations.

21. "Operation of Ceramic Candle Filter at High Temperature for PFBC Application", KJChE, Vol. 16(6), 823-828 (1999)

Abstract–In order to develop a reliable system of a ceramic filter for particulate collection at high temperatures like Pressurized Fluidized Bed Combustion (PFBC), an experimental study was carried out to observe the characteristics of the ceramic filter utilizing a simple block weigh-down. One block weigh-down fixes four commercial filter elements coincidentally by pressing down the individual venturi diffuser. Its operational performance was investigated in the temperature range of 600-800 °C in a bench scale unit using oil combustion gas into which fly ash was fed. The transient aspects of the temperature and pressure in the pulse cleaning system were also observed during the pulse cleaning.

22. "Hydrodynamic Behaviour of Soild Transport for a Closed Loop Circulating Fluidized Bed with Secondary Air Injection", KJChE, Vol. 16(6), 840-842 (1999)

Abstract–The aim of this work was to study the mechanism of solid circulation in a Circulating Fluidized Bed pilot as a function of secondary air flow rate. A rectangular column of 7 m height equipped with a U type siphon was used for this purpose. The results obtained showed that the solid circulating phenomenon depends on different limiting steps like feeding step (dense bed), siphon circulating capacity and suspension saturation capacity.

23. "Enhancement of Mass Transfer in the Fluidized Bed Electrode Reactors", KJChE, Vol. 16(6), 843-847 (1999)

Abstract–With the view of developing the fluidized bed electrode system, mass transfer coefficient, overpotential distribution, and copper degradation have been observed in this investigation. Particles whose diameters were one of 327, 388, 510, 548, 750, and 960 μm were fluidized by the 1,000 ppm copper sulfate electrolyte. This study used two types of the experimental reactor. One had 5×5.5 cm bed-dimension with various thickness in a rectangular side-by-side configuration; the other 3.2 cm bed-diameter with various height in a cylindrical flow-through configuration. Mass transfer coefficient increased with increasing particle diameter, and the optimum fluidization was obtained at the condition of bed porosity near 0.65. For processing a large fluidized bed reactor, the expansion of bed height at a distance between electrodes was found to be more effective than the enlargement of bed thickness between electrodes. By replacing a three-dimensional current-feeder with a plane feeder, degradation and residual concentration of copper ion in a batch recycling mode could be achieved to be higher than 99% and less than 5 mg/L, respectively.

24. "Drying of Water Treatment Process Sludge in a Fluidized Bed Dryer", KJChE, Vol. 17(1), 22-27 (2000)

The drying characteristics of water treatment process (WTP) sludge were investigated with a fluidized bed. The equilibrium moisture ratio WTP sludge increased with relative humidity and decreased with temperature of drying air. However, equilibrium moisture ration of WTP sludge was more sensitively dependent on relative humidity than temperature of drying air. When the sludge was dried in a batch fluidized bed, the drying rate of sludge decreased as the moisture ratio of sludge in the bed decreased. The periods of constant drying rates were apparently not observed on the drying rate curves. In addition, the maximum drying rates were increased with bed temperature and superficial air velocity. As the fluidized bed was operated continuously, the degree of drying of WTP sludge increased with bed temperature but was weakly dependent on superficial air velocity. However, the drying efficiency was decreased with bed temperature and relatively insensitive to superficial air velocity and increased with feed rate of sludge.

25. “Interpretation of Hydrothermal Crystallization of Fine $BaTiO_3$ Powders”, KJChE, Vol. 17(1), 47-51 (2000)

In the preparation of fine BaTiO3 powders under hydrothermal conditions, the reaction mechanism was interpreted through solid-state kinetic analysis of the Johnson-Mehl-Avrami plot. In this experiment reactants were dissolved and consumed to spherical particles of 50 nms from aggregation of several nanometer-sized particles. The particulate formation of BaTiO3 underwent a 1st-order hydrolysis-condensation reaction with phase-boundary transition in the early stage of the reaction regardless of the initial concentration of the feedstock. However, as the concentration of nutrients was reaction, dissolution followed by precipitation became dominant, and a diffusion-controlled reaction proceeded. When the concentration of nutrients was reduced to an extent that was not high enough to sustain supersaturation, the reaction was controlled by solidification for encapsulation of aggregated particles, inside of which the diffusion-controlled reaction slowly proceeded.

26. “The Characteristics of Particle Flow in the Overflow and Underflow Standpipe of Fluidized Beds”, KJChE, Vol. 17(3), 273-299 (2000)

Characteristics of particle flow in standpipes of a 10cm I.D. ×120cm high fluidized bed were investigated. The standpipes used in this experiment were vertical overflow and vertical underflow standpipes. Sand particles and polyethylene powders were employed as the bed materials. The effects of standpipe diameter, gas velocity and particle properties on the solid flow rate were determined. The experimental results showed that the flow behaviors of solids through the overflow and underflow standpipes are different with variations of operating conditions. For both standpipes, the mass flow rate of solids was strongly dependent on the standpipe diameter. For the overflow standpipe, the increase of gas velocity increased the solids flow rate. But for the underflow standpipe it decreased the solids flow rate. From the measured pressure drops, solid fractions in the standpipes were determined by the momentum balance. The obtained experimental data of solids mass flow rate were well correlated with the pertinent dimensionless groups for underflow as well as overflow standpipes. Characteristics of particle flow in standpipes of a 10cm I.D. × 120cm high fluidized bed were investigated. The standpipes used in this experiment were vertical overflow and vertical underflow standpipes. Sand particles and polyethylene powders were employed as the bed materials. The effects of standpipe diameter, gas velocity and particle properties on the solid flow rate were determined. The experimental results showed that the flow behaviors of solids through the overflow and underflow standpipes are different with variations of operating conditions. For both standpipes, the mass flow rate of solids was strongly dependent on the standpipe diameter. For the overflow standpipe, the increase of gas velocity increased the solids flow rate. But for the

underflow standpipe it decreased the solids flow rate. From the measured pressure drops, solid fractions in the standpipes were determined by the momentum balance. The obtained experimental data of solids mass flow rate were well correlated with the pertinent dimensionless groups for underflow as well as overflow standpipes.

27. "Attrition characteristics of Alumina Catalyst for Fluidized Bed Incinerator", KJChE, Vol. 17(3), 284-287 (2000)

Attrition characteristics of alumina catalyst for catalytic incineration have been studied in a fluidized bed cold mode combustor (Φ10cm, 160cm height). The particle size and density of alumina catalyst were 1.4-1.7mm and 1.13g/㎤. As operating variables, excess gas velocity (U-Umf) and bed weight (Wb) were selected. The experimental results show that attrition rate of alumina catalyst increased with excess gas velocity and bed weight due to intensive rubbing and collision caused by bubble coalescence. The size of the entrained particles collected in cyclone ranges over 0.5 to 100㎛, and the mean size for number base increases with an increase of excess gas velocity.

28. "Axial Gas Dispersion in a Fluidized Bed of Polyethylene Particles", KJChE, Vol. 17(3), 292-298 (2000)

Gas mixing behavior was investigated in a residence time distribution experiment in a bubbling fluidized bed of 0.07 m ID and 0.80 m high. Linear low density polyethylene (LLDPE) particles having a mean diameter of 772㎛ and a particle size range of 200-1,500 ㎛ were employed as the bed material. The stimulus-response technique with CO2 as a tracer gas was performed for the RTD study. The effects of gas velocity, aspect ratio (H0/D) and scale-up on the axial gas dispersion were determined from the unsteady-state dispersion model, and the residence time distributions of gas in the fluidized bed were compared with the ideal reactors. It was found that axial dispersion depends on the gas velocity and aspect ratio of the bed. The dimensionless dispersion coefficient was correlated with Reynolds number and aspect ratio.

29. "Preparation of Ultra-fine Alumina Powders by D.C. Plasma Jet", KJChE, Vol. 17(3), 299-303 (2000)

Ultra-fine alumina was prepared by DC thermal plasma. The influence of reactor configuration, input power and cooling conditions was investigated on properties such as particle diameter and phase composition. The powders synthesized without reaction tube were observed to be of two forms. One was metastable nano-sized powder with an average diameter of 30 nm due to rapid quenching of the vapor phase. The other form was larger-sized powder with an average diameter of 200nm, and it was considered to be due to quenching of small liquid droplets, which had not fully vaporized in short residence

time. With a reacting tube, the powder collected at the reaction tube was dominated by α-phase Al2O3, whereas the powder collected at the quenching chamber was mainly composed of intermediate γ- and δ-Al2O3. Input power and injection position of oxygen did not significantly affect the powder characteristics. To increase the conversion, aluminum powder should be vaporized completely. Most of the powders synthesized appeared fluffy spherical white powders with particle diameter of below 150nm.