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ENERGY ENGINEERING (EGY)

EGY 8601 **Figueroa, Arturo Mariano I. (MS Energy Eng'g.)**
Drying characteristic of Ipil-Ipil firewood.
1986.

Drying tests were conducted with small branches of giant ipil-ipil (Leucaena Leucocephala) at two levels of dry-bulb temperatures, 120½F and 140½F. Each test was represented with unbarked and debarked fire wood samples. The diffusion coefficients of each sample were determined using the experimental data and the diffusion model equation for homogeneous infinite cylinder (Crank, 1956). These coefficients were then used to generate theoretical drying curves which were compared to the experimental drying curves. The results showed that the diffusion coefficients of debarked firewood sample can treated as constant whereas the diffusion coefficients of the unbarked firewood sample significantly varies with time. Moreover, the average diffusion coefficients (D_{av}) for the debarked firewood sample indicated a good fit between the theoretical and experimental drying curves. The model equation is found to be not valid to describe the drying progress in the unbarked sample.

EGY 8702 **Gamolo Paulino D. (MS Energy Eng'g.)**
Development of a simulation procedure for evaluating energy use changes due to variations in the operational parameters of the refrigerator
1987.

A computer simulation procedure has been developed for calculating the thermal load and predicting the electricity

use of a refrigerator. Comparative results have shown a good agreement between predicted and measured values of electricity consumption. In addition, the simulation procedure has also been found to predict the same trend of general behavior which is observed in the actual operation of a refrigerator thereby confirming its validity.

The effects of variations in the operational parameters on the electricity consumption of a refrigerator have been evaluated utilizing the simulation procedure. Among the operational parameters considered are room temperature, thermostat setting, door-opening frequency, relative humidity, and food loading at the freezer and fresh-food compartments. Results of evaluation are presented and discussed. Furthermore, a brief discussion on energy-saving opportunities relevant to the operation of the refrigerator is also presented.

EGY 8803 **Bautista, Gino T. (PhD Energy Eng'g.)**
Computer simulation of fuel consumption in driving cycles.
1988.

A computer model for simulating fuel consumption of a road vehicle over any prescribed driving cycle was developed using steady-state performance data from chassis dynamometer tests. This original method is simple and does not require sophisticated chassis dynamometer test facilities used in more advanced countries. The method also eliminates variances due to driving style.

It was determined that the predictions of the computer model agree closely with fuel consumption figures from actual road tests. The use of steady-state performance data from chassis dynamometer tests was found to be suitable in predicting fuel consumption of driving cycles. This study and its conclusions are limited to diesel engine driven road vehicles.

EGY 8804 **Dayco, Rolando P. (PhD Energy Eng'g.)**
Optimal hydrothermal dispatch using Lagrangian decomposition and network flow programming.
1988.

Optimal hydrothermal scheduling is a nonlinear optimization problem constrained by a large number of equality and inequality constraints. The original problem was therefore decomposed into a thermal subproblem and a hydro subproblem through the application of the principle of Lagrangian relaxation.

The resulting thermal subproblem evolved into a set of economic dispatch problems, one for each time period, that can be optimized individually. An efficient linear search technique for solving economic dispatch problems was developed for this thesis.

The hydro subsystem was modeled as a capacitated network flow model with linear and nonlinear arc costs. A unique three-piece linear approximation that explicitly represents the nonlinear hydro generation cost function enabled the use of a computationally efficient network flow programming technique.

For systemwide studies, the algorithm iterates between the thermal and the hydro models until overall optimality is reached. It exhibited efficient and reliable convergence characteristics when tested on hydrothermal systems with different hydro-to-thermal generation capacity ratios.

EGY 8805 **Elepaño, Arnold R. (MS Energy Eng'g.)**
Comparative study of vortex wind machine, Venmar turbine, and a simple chimney for agricultural applications.
1988.

The vortex wind machine, Venmar turbine, and a simple chimney were tested and evaluated in actual field conditions in terms of suction rate, pressure build-up, relative humidity and temperature differences. Available wind tunnel data from the Wind Engineering Center of the University of Moncton were presented and correlated with the actual field

testing data. The wind resource at the International Rice Research Institute in Los BaÊos, Laguna was evaluated as a guide for appropriate design of wind machines.

Results indicated that the machines should be designed using the Weibull density function and face north-east to south-east (clockwise).

Both tunnel and field testing showed the simple chimney to have performed better than the other two machines in the given configurations. Field testing set-up had the same diameter. The Vortex wind machine and the chimney were of the same height. It is noted that the study was done without any of. applications. Test of the machines coupled with agricultural structures is recommended.

EGY 8806 **Pecson, Ferdinand A. (PhD Energy Eng'g.)**
Coal fragmentation studies in a fluidized bed.
1988.

Coal fragmentation experiments were performed in a 0.3 m internal diameter by 2.1 m high fluidized bed combustor equipped with a solids sampling probe. A 200 g batch of 3.0 to 6.9 mm coal particles was charged into the hot combustor, and after 90 s bed samples were taken at 1 min intervals until burn-off. The samples were immediately quenched with sand, and the burned coal particles were separated from the bed material by screening. Three coals were tested - Texas lignite, Montana sub-bituminous and Colorado bituminous coal. The bed material was 0.4 mm silica sand and the fluidizing velocity was 1.8 m/s. The effect of reducing the fluidizing velocity to 0.9 m/s and the effect of using 0.8 mm aluminum oxide bed material were also investigated. The separated coal particles were sized with a microscope and weighed. changes in burned coal particle size distribution with residence time were determined and for the case of Montana coal, were compared with the predictions of a combined char burning and attrition model. Microphotographs of the particles were taken to study the changes in surface characteristics of the chars.

Results indicate that for all three types of coal there was an immediate shift of the major fraction of the particles from the 5.0-5.9 mm size range to the 0-1.9 mm size range. After 90s there was a 290% increase in number

of particles for the Montana sub-bituminous, 130% increase for Colorado bituminous and 200% increase for Texas lignite. Subsequent fragmentation varied for each coal. Reducing the fluidizing velocity and changing to a coarser sand did not significantly alter the fragmentation patterns. Comparison of the actual and predicted size distribution curves showed the fragmentation during char burn is confined mostly to the larger particles. The sizes of the resulting fragments can be obtained by determining which portions of the actual size distribution curve were above the predicted curve. The measured reactivities of the chars varied from 0.1 to 0.3 $mg/cm^2/s$ depending on coal type. The lignite chars were the most reactive followed by the sub-bituminous and then the bituminous chars. Changing to a coarser bed material significantly increased the measured reactivities if the sub-bituminous and lignite chars. The densities of the char which were also measured did not show any significant changes with burn time. The measured average char densities were 0.8 mg/mm^3 for Colorado bituminous, 0.91 mg/mm^3 for Montana sub-bituminous and 0.71 mg/mm^3 for Texas lignite. Microphotographs of the partially burned coal particles show numerous fracture planes and distinctly different surface features between the three different chars.

EGY 8807 **San Mateo, Jesus Amado A. (MS Energy Eng'g.)**
Validating the testing of solar air collectors under simulated solar radiation.
1988.

This thesis seeks to validate the use of indoor testing of solar air collectors under simulated solar radiation. By conducting performance tests under a solar simulator and comparing the results with those obtained from outdoor testing, the accuracy of indoor testing can be determined. Since most of the established and accepted test procedures are designed for outdoor testing under clear sky conditions in temperature climates, the ability to conduct tests indoors eliminates the variability in weather conditions, a serious problem in conducting tests in the Philippines.

Three existing test procedures were studied, and an original test procedure was developed which simplified data

collection. Outdoor tests were conducted and data gathered on ambient temperatures, air temperatures along the collector length, exit air temperatures and solar radiation. Equations were generated with these data to predict the outlet air temperature as a function of solar radiation and ambient air temperature. These equations were then applied to the data collected under simulated solar radiation to determine the accuracy of the predictor equations.

It was found that by taking a three period moving average of the solar radiation values, a linear equation could predict the air exit temperature.

EGY 8808 **Santos, Arturo Martin B. (MS Energy Eng'g.)**
A one-dimensional model for predicting the temperature distribution in stratified water thermal storage tanks.
1988.

A one-dimensional model for predicting the temperature distribution in an underground stratified water thermal storage tank was developed using fundamental thermodynamic principles. It was determined that a one-dimensional model, with an empirical adjustment to account for diffusion, is sufficient in predicting the temperature distribution in a thermally stratified storage tank if the walls are considerably insulative. It was also ascertained that if the walls of the tank in contact with the water in storage were made of materials that conducted a significant amount of heat, then an additional parameter must be incorporated to account for this.

EGY 8909 **Vinluan, Felipe D. Jr., (PhD Energy. Eng'g.)**
Design performance analysis and modeling of a combined updraft-stratified downdraft (CUSD) gasifier.
1989.

An experimental CUSD gasifier was designed, fabricated and tested at the Mechanical Engineering (M.E.) Power

Laboratory of the U.P. College of Engineering, Diliman, Quezon City.

A mathematical model was formulated to predict the performance of the CUSD gasifier. The model was developed based on the first law of thermodynamics using the heat of formation and sensible heats of the reactants and products, the equilibrium constants of the participating chemical reactions, Dalton's law and the mass balances of the elements C, H, O and N. The formulation of the model was facilitated by defining a variable L, the hypothetical kmole of fixed carbon that remains in 1 kmole of biomass fuel as it passes through the downdraft stage. The solution of the set of non-linear simultaneous equations was obtained using the combined Newton and Gauss elimination methods. The procedure involved an iterative calculation using the augmented matrix representing the partial differential equations of the original set of simultaneous equations. The model was programmed in BASIC language.

Among others, the model can predict the gasification reaction and oxidation temperatures in the downdraft and the updraft stages, the gas composition in both stages as well as the combined gas, the fuel requirement in kg per SCM product gas, and the volume of gasifying medium required in the downdraft and updraft stages. These values are calculated for a given type of fuel and for a particular composition of the gasifying medium. For each value of L, a nondimensional variable A_R was calculated. A_R is the ratio of downdraft to updraft airflow rates. The A_R values were used as the basis of the airflow adjustments in the CUSD gasifier during the experimental runs.

Although the model was formulated for a CUSD gasifier, it can also be used to simulate a single-stage reactor. In fact, its accuracy was validated by using it as a downdraft gasifier and by comparing the output with published data on the modeling and the actual testing of downdraft gasifiers.

With the use of ipil-ipil wood chips as fuel, the CUSD gasifier was proven to have a favorable performance as evidenced by the heating value of the gas, color of the flame, specific gasification rate and gasification efficiency. The peak efficiency was obtained at L=0.15 which corresponds to $A_R = 7.34$.

A comparison of the theoretical and experimental data showed that the CO, H_2 and gas heating value obtained in the experimental runs were significantly below the equilibrium values calculated by the model. This means that despite the favorable performance of the experimental CUSD gasifier, modifications can still improve its performance.

The CUSD gasifier possesses some desirable features which give it advantages over single-stage forced-draft gasifiers. These features include continuous gas production during fuel feeding, stable reaction zones even without tuyeres and movable grate, clean gas being produced with the proper combination of downdraft and updraft airflow rates, and effective removal of ash even without a movable grate. If translated into the users' benefits, these features could mean lower initial investment cost, easier maintenance and simpler operation than existing.

EGY 8910 **Quiros, Edwin N. (PhD Energy. Eng'g.)**
Control of fresh fuel-fresh air mixing in a toroidal engine combustion chamber.
1989.

The compression ignition (CI) engine is pre-eminent in applications where fuel economy is the most important factor. The CI engine has excellent fuel economy because it operates at higher compression ratios and can burn overall lean mixtures. Burning lean mixtures is made possible by heterogenous combustion due to fuel introduction into the cylinder late in the compression process. However, the short time available for introducing, distributing, mixing (with air), and burning the fuel causes problems. In addition, fuel is typically introduced into partially vitiated air after combustion has started. Numerous combinations of fuel injection pressure, number and size and direction of fuel injector holes, and gas motion prior to and during combustion caused both by the intake process and the combustion chamber configuration have been used to provide the required mixing in the short time available. Invitably this results in compromises in factors such as injector and combustion chamber complexity, heat loss, volumetric efficiency, and fuel consumption.

A toroidal combustion chamber design that attempts to achieve the desired introduction of fuel into non-vitiated air as well as mixing and combustion in the short time available has been investigated. The design objective was to obtain a sufficiently high air circulation rate in the toroid to achieve one rotation of the air at the maximum amount of fuel injected (full load). This chamber design

attempts to utilize initial swirl, injected fuel momentum, energy release from combustion, and geometry modification to effect the required air circulation during injection and combustion so that fresh air is continuously mixed with the new fuel. Experiments were conducted using a constant-volume bomb and high speed photography for flow visualization. Modelling of the gas flow in the chamber was done by solving the unsteady state one-dimensional conservation equations. Results of the study indicate that the rates of circulation in the configurations tested are marginal without initial swirl. Model calculations show that initial swirl (as might be generated in an actual engine) is helpful in obtaining a desired circulation rate.

EGY 9111 **Lacson, Isaias Jr. T. (MS Energy Eng'g.)**
A study on the effects of grate setting and differential pressure on the performance of a downdraft gasifier.
1991.

This study was conducted to determine the effects of varying grate position relative to the throat and varying differential manometer pressure on the performance of a conventional downdraft gasifier, using ipil-ipil wood chips as biomass fuel.

Results showed that grate position and differential pressure have highly significant effect on the gasifier performance, particularly on the gas heating value, conversion efficiency, temperature in the reactor, and on the tar cracking capacity of a downdraft gasifier. Results also indicated that the tar conversion capability of the downdraft gasifier as indicated by the prediction equations for unaccounted carbon, hydrogen and oxygen, is highly dependent on the efficiency, grate setting, and temperature in the reactor specially in the combustion and reduction zones.

EGY 9112 **Rokaya, K.B. (PhD Energy Eng'g.)**
Energy demand and fuel, substitution model for urban domestic sector (for electricity planning): A case of Nepal.
1991.

Nepal imports all of its petroleum product requirements which account for about 72 per cent of her total commercial energy consumption. The urban domestic household sector relies heavily on petroleum products with kerosene which is mainly used for household cooking having the major share. This heavy reliance of the urban household sector on imported kerosene oil for cooking is costing the country too much in terms of foreign currency reserve, trade deficit, fuel dependency and uncertainty in fuel supply. On the other hand, the vast hydropower potential available in the country remains virtually unutilized.

In this study, an analytical model has been developed for energy demand projections and fuel substitution studies for urban domestic sector. The model can be used to update the electric load forecast and consequently the electricity generation expansion plan.

The model has been applied to make energy demand projections and fuel substitution studies for urban household cooking in Nepal. The impact of improving the efficiency of kerosene stove and electric stove on the energy demand for cooking has also been looked into in the model simulation.

The results reveal that the potential for substituting kerosene oil with electricity in urban cooking is very high. The change in the electric load forecast for Integrated Nepal Power System due to kerosene oil substitution very significant. The availability of vast hydropower potential makes this substitution possible.

The total cost of supplying energy for urban household cooking has been calculated for the different scenarios considered. The economic viability of substitution of imported kerosene oil with indigenous hydroelectricity depends on the price of kerosene vis-a-vis the cost of developing hydroelectricity.

EGY 9213 **Bedaño, Jose Ali F. (PhD Energy Eng'g.)**
Parallel high-rate digestion of separated solid-liquid fractions of swine waste.
1992.

A study on the anaerobic digestion of separated solid-liquid fractions of swine waste using tow dissimilar reactors was conducted with the objective of improving biodegradability, methane conversion rate, and energy recovery. The effects of organic loading rate (OLR), hydraulic retention time (HRT) and temperature on reactor performances were also investigated.

The study was divided into two stages: (1) batch digestion and (2) semicontinuous high-rate digestion. Base data obtained from the first provided inputs into the design and operation of reactors/system in the second phase.

Substrates for the entire study were obtained from experimental sows at the swine breeding farm of BAI in Alabang.

In batch digestion, comparisons were made between untreated and pretreated swine wastes. Physical pretreatment consisted of particle size reduction and homogenization through blending, screening and final separation into solid and liquid fractions. The pretreated substrates were as follows: inseparated blended slurry, solid fraction, and liquid fraction.

Erlenmeyer flasks were used as batch digesters. The total organic load was approximately 30 g VS per digester except in the digester receiving the dilute liquid fraction. Start-up was accomplished by step-loading within 20-23 days after which operation shifted to strictly batch. Operating temperature was maintained at 35½C in a water bath, but control was inconsistent due to intermittent power failures. Digestion was terminated only after five successive days of nil gas production.