ABSTRACT

At present the fuel and energy from Biomass is one of key area for the solution to decentralized energy production. The objective of this work concern to give the state and art of several computational modeling methodology process synthesis, and optimization process. In addition to this, risk analysis and optimization were carried out based on changing several techno-economic input variables. The stochastic analysis using Monte Carlo simulation was implemented in a spreadsheet model utilizing @Risk v. 4.5 software for Excel and optimization using genetic algorithms by the Envolver software. The preliminary results of these several projects under developments are reported. The important advantage of computer aided process are the possibility to quickly design, analysis with precision and reliability. The project of charcoal and fuel making process using thermal energy from small cogeneration internal combustion motor has shown to be the more appropriate system.

KEY WORDS: Biofuel, Simulation, Energy, optimization, Sintesy, Analysis.

RESUMO

A energia e combustível derivados da biomassa brasileira constitui hoje uma das áreas de pesquisa de produção de energia mais propícia para desenvolvimento no Brasil. O presente trabalho trata o estado de arte neta área, o desenvolvimento e implementação de ferramentas computacionais voltadas para a produção de biocombustível, com a finalidade de tomar decisões mais precisas em síntese e análise de projetos. Tais ferramentas têm como objetivos principais à análise da viabilidade técnica e econômica para a produção de biocombustíveis e otimização do projeto. O balanço de massa, energia e a avaliação econômica foram obtidos através de simulações, utilizando para isso o software SuperProTM Designer v.3.0. Realizou-se, também, a análise de risco econômico e otimização com entrada de variável tecnoeconômica. Desenvolvemos a simulação estocástica utilizando planilha eletrônica baseada em métodos de distribuição de incerteza e o software @Risk, simulador Monte Carlo e otimização usando software de algoritmo genético, Envolver através da simulação determinística e estocásticos foram desenvolvidos cinco diferente processos. Os resultados preliminares deste sistema em desenvolvimento são apresentados.

PALAVRAS-CHAVE: Biocombustível, Simulação, Energia, Otimização, Síntese, Análise

INTRODUCTION

Great rides have been made in recent years in the use of microcomputers for process simulation (PannirSelvam, 1998). The analysis of economic problems were made easy by using commercial software for process simulator such as software SuperPro designer, rapid development the material, energy and economic report (Petrides, 1995). How ever such system
development for small scale energy systems are in developing stage, even though well applied for large scale systems. The selection of the process based on the economic values to meet the internal and external market demand is an important and critical step in the process development, which needs to be optimized together with economic objectives of the rate of return. For a complex system, modeling and simulation are very useful tools to accelerate this work.

Our research, not influenced by over developed countries but use the intermediate equilibrium technology. This technology development related to rural region with the integration of small scale energy system and waste treatments and natural biomass resources. Our research group mainly focus work on computer aided tool for a Process and Cost analysis. For a long time we are working in these fields from energy projects. Our research also integrate with the ANP/PRH-14/UFRN, of the Petroleum and Gas Agency (ANP) of Brazil. Field of process optimization of energy production, evolutionary optimization of engineering process industrial problem of local industry.

In this work, we outline developments of our research work and the results related to the flow sheeting, design optimization of small scale fuel and energy production from biomass and the liquid and solid waste. The purpose of our study are the economical analysis of these projects to draw conclusion on the manufacturing costs and rate of return of small scale fuel and energy production for Brazilian conditions.

Further more, we address the issue of the risk involved in the small scale energy production from biomass to variation in the price of the product and production capacity with emphasis on stochastic simulation study coupled with process flowsheet simulation.

**PROCESS DESIGN FOR CLEAN TECHNOLOGY DEVELOPMENTS FOR RURAL ENERGY PRODUCTION FROM BIOMASS.**

Process design is the conceptual work done prior to building, expanding or retrofitting a process plant. It consists of two main activities, process synthesis and process analysis. Process synthesis is the selection and arrangement of a set of unit operations (process steps) capable of producing the desired product at an acceptable cost and quality. Process analysis is the evaluation and comparison of different process synthesis solutions. In general, a synthesis step is usually followed by an analysis step, and the results of analysis determine the subsequent synthesis step. Process design and project economic evaluation require integration of knowledge from many different scientific and engineering disciplines and are carried out at various levels of detail. (Petrides, 1989, 1991 and 1994).

Order-of-magnitude estimates are usually practiced by experienced engineers who have worked on similar projects in the past. They take minutes or hours to complete but the error in the estimate can be as high as 50%. Most engineers employed by operating companies usually perform detailed level 2 and 3 studies. Such studies take days or weeks to complete using appropriate computer aids. The main objective of such studies is to evaluate alternatives and pinpoint the most cost-sensitive areas – the economic “hot-spots” – of a complex process. The results of such analyses are used to plan future research and development and to generate project budgets. (Petrides, 1989, 1991 and 1994).

Level 4 and 5 detailed studies are usually performed by engineering and construction companies that are hired to build new plants for promising new products that are at an advanced stage of development. It should also be noted that opportunities for creative process design work are usually limited to preliminary studies. By the time detailed engineering work is initiated, a process is more than 80% fixed. Furthermore, the vast majority of important decisions for capital expenditures and product commercialization are based on results of preliminary process design and cost analysis. (Asenjo and Maugeri, 1992; Leser and Asenjo, 1992; Petrides et al., 1989; Petrides, 1994).

The development of a flowsheet for the small scale energy production from biomass is a creative process that draws on the experience and imagination of the engineer.

Environmental impact assessment is an activity closely related to process design and cost estimation. Of energy production plants generate a wide range of liquid, solid, and gaseous waste streams that require treatment prior to discharge. The cost associated with waste treatment and disposal has skyrocketed in recent years due to increasingly stricter environmental regulations. This cost can be reduced through minimization of waste generation at the source. Thus, reducing waste in an industrial process requires intimate knowledge of the process technology, in contrast to waste treatment which essentially is an add-on at the end of the process. In addition,
minimization of waste generation must be considered by process engineers at the early stages of process development.

**COMPUTER AIDED PROCESS ENGINEERING AND OPTIMIZATION USING SOFTWARE**

Process simulation has been successfully used in the chemical and oil industries since the early sixties for optimizing integrated processes and evaluating waste minimization options. SuperPro Designer is a comprehensive process simulator that facilitates modeling, evaluation, and optimization of a wide variety of chemical, pharmaceutical, food, and energy production processes. The expanded version can, in addition, handle water purification, wastewater treatment and air pollution control processes and enables engineers to design and evaluate zero-discharge plants. SuperPro can handle equally well biological as well as physical treatment of wastewater and it is equipped with models for all water purification unit operations. Besides water recycling applications, SuperPro can be used to calculate volatile organic compound (VOC) emissions from manufacturing (batch as well as continuous) facilities and treatment plants (secondary emissions). Further, it can be used to predict the fate of hazardous chemicals (e.g., heavy metals and VOCs) in integrated environmental processes. This is particularly important for industrial wastes because the Brazilian Environmental Protection Agency (IBAMA) regulates the amount and concentration of discharged priority pollutants (various organic chemicals, heavy metals and ions are not well know, or the system design is incomplete (PannirSelvam, 1998).

The preliminary economic evaluation of a project for manufacturing a biological product usually involves the estimation of capital investment, estimation of operating costs, and analysis of profitability.

**GENETIC ALGORITHM APPLIED TO PROCESS DESIGN AND OPTIMIZATION**

Genetic algorithms (GAs) seek to solve optimization problems using the methods of evolution, specifically survival of the fittest. In a typical optimization problem, there are a number of variables which control the process, and a formula or algorithm which combines the variables to fully model the process. The problem is then to find the values of the variables which optimize the model in some way. If the model is a formula, then we will usually be seeking the maximum or minimum value of the formula. There are many mathematical methods which can optimize problems of this nature (and very quickly) for fairly "well-behaved" problems. These traditional methods tend to break down when the problem is not so "well-behaved."

The three most important aspects of using genetic algorithms are: (1) definition of the objective function, (2) definition and implementation of the genetic representation, and (3) definition and implementation of the genetic operators. Once these three have been defined, the generic genetic algorithm should work fairly well. Beyond that you can try many different variations to improve performance, find multiple optima (species - if they exist), or parallelize the algorithms.

Genetic algorithms are general-purpose search algorithms based upon the principles of evolution observed in nature. Genetic algorithms combine selection, crossover, and mutation operators with the goal of finding the best solution to a problem. Genetic algorithms search for this optimal solution until a specified termination criterion is met. Genetic algorithms can be applied to a wide variety of optimization problems such as scheduling, computer games, stock market trading, medical, adaptive control, transportation, the traveling salesmen problem, etc.

All life on earth, including its most intricate and ingenious features is the product of a genetic algorithm, known more commonly as evolution. However, genetic algorithms need not be confined to nature. They can be used to help
solve many design and optimization problems. Computer implementations of genetic algorithms are being used to tackle difficult problems in fields as far ranging as turbine blade design, automatic integrated circuit layout, and even in the training of neural networks. All living things carry a kind of "blue-print" for their construction in the DNA of each living cell. Over a period of time, changes (e.g. mutations) occur to the DNA giving rise to organisms which are more likely to survive, and so have a greater chance of passing their improved characteristics on to future generations. Of course, not all changes will be beneficial, but those which are not tend to die out. This is evolution. It is analogous to engineers making design changes in order to improve their company's product and so gain a competitive advantage or increase profitability. The genetic algorithm is the mechanism invented by nature for trying out alterations to DNA.

In engineering, computer simulations of genetic algorithms can be used to evolve better designs for a variety of systems. The reason is that existing methods are fine so long as the problem is not too complex. A genetic algorithm allows extremely difficult functions to be solved efficiently - even the design of a living organism.

In engineering terms, the strengths of genetic algorithms can be summarized by their abilities to cope with a variety of very difficult problems, to work without prior knowledge about the function being optimized, to optimize "noisy" functions, and to do without secondary information such as gradients. In plain language they can cope with the difficulties represented by real-life problems which are generally insoluble by other methods. A recent and most impressive testament to the fact that genetic algorithms are now coming of age has been provided by General Electric in the USA who used the technique to design an improved gas turbine blade. Their computer model indicates efficiency improvements of 2% for the design, a significant saving in this field, and they are currently spending around $1m verifying the prediction. If this succeeds they will spend $70m re-tooling their production line to produce the new type of blade.

The following are the projects under developments using computer aid.

1. Fuel ethanol from Sugar Cane and Lignocelulosic Biomass
2. Fuel from Municipal Solid and Sewage Waste.
3. Small scale production of solid, liquid and gas fuel from wood with rapid pyrolysis.
4. Small scale biodiesel production from vegetable oil seeds
5. Cogeneration of Energy production using natural and fuel gas from Biomass

METHODS

PROCESS DEVELOPMENT.

Based on the available stochiometric coefficient of these reactions and kinetic constants, as well as several process parameter illustrated in the figure 2 a dynamic modeling of the bioconversion process was made possible using the information (figure 1) as in put to energy conversions.

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![Figure 1. Information flow diagram for process the simulator](image)

PRELIMINARY PROJECT DEVELOPMENT

There are many manufacturing process steps involved for the flowsheet generation of the project. The entire flowsheet generated is using Process simulators. Several auxiliary equipments are omitted, but were included in the economic evaluation study.

THE PROCESS SIMULATION ENVIRONMENT

There are many manufacturing process steps involved for the flowsheet generation of the project. The entire flowsheet generated is using Process simulators. Several auxiliary equipments are omitted, but were included in the economic evaluation study.
The process analysis and economic evaluation of large-scale algae production was done using IBM PC AT SuperPro Designer from Intelligen, Inc as this computer aid is cost effective in relation to other specialized computer aid for cogeneration which are of high cost of the order of 50000 US$.

**PROCESS ECONOMIC SIMULATION ENVIRONMENT**

Project investment, fixed cost, variable cost such as raw material, energy, direct and indirect labor cost are estimated using software developed by our group for windows 95 operation system (PannirSelvam, 1998). The user interface with easy to use menus of this program allow to make investment, cost and project analysis with graphic outputs, offering rapid and better understanding of the output results. This graphical results are shown in the figure 2, 3 and 4

**MONTE CARLO STOCHASTIC SIMULATION**

The stochastic variation of selling price, variable and fixed cost are modeled using statistical distribution from available data and detailed information on this features can be found in our previous work (PannirSelvam, 1998).

These method are implemented using electronic spreadsheet program, Sim.xla developed by Sam.L.Savage using IBM PC AT under Windows 95 operating system environment.

This program simulates the stochastic process variable using random number and requires the observed or available statistical data about the process yield of each conversion step. Monte Carlo methods of random number generator are implemented to obtain a probabilistic of the final economical result, based on the probability of available observed experimental results.

**RESULTS**

**SMALL SCALE BIODIESEL PRODUCTION FROM VEGETABLE OIL.**

In the present work are outlined some of the production process route for biodiesel production based on Brazilian raw materials with focus on economics improvement through co product valorization from glycerin. The general view of Brazilian biodiesel program and the other perspective process innovations are also reported. Project synthesis with case studies was made for two different routes. In the first route, soya bean oil and castor oil are selected. In the second route we selected simultaneous extraction and transferification process and oil cake as feed stock for biodiesel production with co production of glicerated starch for emulsion from glycerin and fertilizer. The processes that have been used for different process synthesis are: Esterification, Extraction, and Separation process using evaporation and distillation, purification. The
preliminary project case study has shown that biodiesel production cost are very high and not have economical viability, but the use of Soya bean, oil cake as feed stock, simultaneous transfericication, has been observed to be economically viable for production of biodiesel

**SMALL SCALE PRODUCTION OF SOLID, LIQUID AND GAS FUEL FROM WOOD WITH RAPID PYROLYSIS**

The charcoal making industry and the other industries which use wood as fuel produce larger quantity of wastes leading to serious pollution needing end pipe tecnology. Among the solution to reduce this toxic effect of this pollution, we need to understand pyrolysis, which results in decomposition and transformation of biomass into residues. In this present work, the charcoal production system is studied and developed to produce liquid and gas bio combustivel. In addition to this, the modeling and simulation of energy production based on pyrolysis of wood was also made. The present study involve innovative methods of process analysis and synthesis which were carried out for the small scale cogeneration of energy production as well as the energy integration of charcoal production with co production bio combustivel. Using the modern process simalater of Super pro design, three different process route with flowsheet have been developed. Comparative results of economic parameters of their routes are obtained including environment impact. In this study, the key feature of our work is related with the optimization the production of biocombustivel with lower pollution technology accessible to rural community.

**COGENERATION OF ENERGY PRODUCTION USING NATURAL AND FUEL GAS FROM BIOMASS**

In view of the present day proven importance of the cogeneration and its benefits in large-scale, this work deals with the application of the Monte Carlo method to the analysis of risk of systems of cogeneration in small scale. The cogeneration systems foresee the simultaneous use of the mechanical and thermal energy proceeding from an only primary energy fonts. Using an engine of internal combustion running with the natural gas and pyrolytic fuel gas the produced thermal energy will be used to advantage to generate steam, this can used in diverse aplications. Initially, the synthesis of the project was realized, the mass and energy balance was carried out and, with aid of computer programs that they make regressions and simulations, the equipments size were specified, being certain, also, the function profit for the process. Later, the analysis economical risk was accomplished; being varied the conditions of operation of the motor-generator that for consequence alters the matter consumption it excels and of products. The stochastic simulation was developed being used electronic spreadsheet based on methods of uncertainty distribution and the software @Risk, simulator Monte Carlo. The results of this work show that the probability of obtaining profit in that process is me I turn of 30%.

**FUEL ETHANOL FROM SUGAR CANE AND LIGNOCELULOSIC BIOMASS**

At the present the fuel ethanol from Brazilian biomass is one of the most favorable energetic project in development to the Brazil mainly with respect to the rural employment, environment and energetic safety. In this context, a technological and economical study was developed applied to fuel ethanol production from sugar cane based on dynamic modeling, simulations and economical risk analysis. The objective of this work concern to develop an stochastic methodology and as well as the implementation of the economic risk analysis inherent to the ethanol process production by the changing of the process variables and parameters based on Monte Carlo simulation method. The mass balance and economic evaluation was obtained from simulations were carried out using the SuperPro Designe™ v. 3.0 software. In addition to this, the economic risk analysis was carried out based on changing in the distribution of the selling price, yield of fermentation and feed flow rate the process stochastic variables. The stochastic analysis using Monte Carlo simulation was implemented in a spreadsheet model utilizing @Risk v. 4.5 software for Excel. Based on deterministic and stochastic simulations of the fuel ethanol production the results several techn economical parameters have been obtained and analyzed. The important advantage of the proposed method is the possibility to predict the economical risk involved in the ethanol production take in to account the aleatory and complex nature inherent to the process, with precision, reliability and very rapidly.
FUEL FROM MUNICIPAL SOLID AND SEWAGE WASTE

The complex theme of the energy crysis and uncontrolled disposal of the organic waste and of the urban sewers, which lead to environmental problem, make it necessary to have increased search forwards alternatives of use of such residues. As the raw material for production of energy. This work proposes a project synthesis using the composting process and it is biological oxidation race ponds for the treatment of the residues producing bio gas for generation of energy, organic and liquid fertilizer. The composting plant of Guaratinguetá-SP was taken as reference for this work development. In the work, with the help of software SuperPro Designer process simulator three scenarios of treatment plants sewage treatment, organic solid residues, and combined treatment are compared, where as all these include anaerobic fermentation. In this work, also were carried investment and cost analysis for the energy production system, from residual biomass.

CONCLUSION

In this work, we have synthesized and analyzed a flow sheet for the production of fuel and energy production based on the information and our previous research work on process development and engineering design work. The work was facilitated using computer aided bioprocess design tool that helped to successfully solve complex process synthesis and analysis, dynamic modeling and project development. The analysis has clearly shown that most of the production cost is associated with raw material cost. The larger number of steps used for the production also need greater general expenses and higher investments. However only few process studied based on cash flow analysis indicated the lower risk involved in fuel, energy and charcoal making in decentralized distributed rural energy production in Brasil. Based on the analysis of variation of several stochastic process parameters using Monte Carlo simulation method, the reliability of the profitability of the higher probability level of several Project is made possible. The important advantage of computer aided process are the possibility to quickly design, analysis with precision and reliability. The project of charcoal and fuel making process using thermal energy from small cogeneration internal combustion motor has shown to be the more appropriate energy producing system for rural areas.

REFERENCE


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