FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

THE IMPACT OF COMPUTER AIDED DESIGN SOFTWARE ON CHEMICAL ENGINEERING PROCESS ANALYSIS, DESIGN AND DEVELOPMENT

By

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B.Sc., PGD., M.Sc., PhD, MNSChE., MNSE, COREN
Professor of Chemical Engineering

INAUGURAL LECTURE SERIES 39

26TH NOVEMBER, 2015

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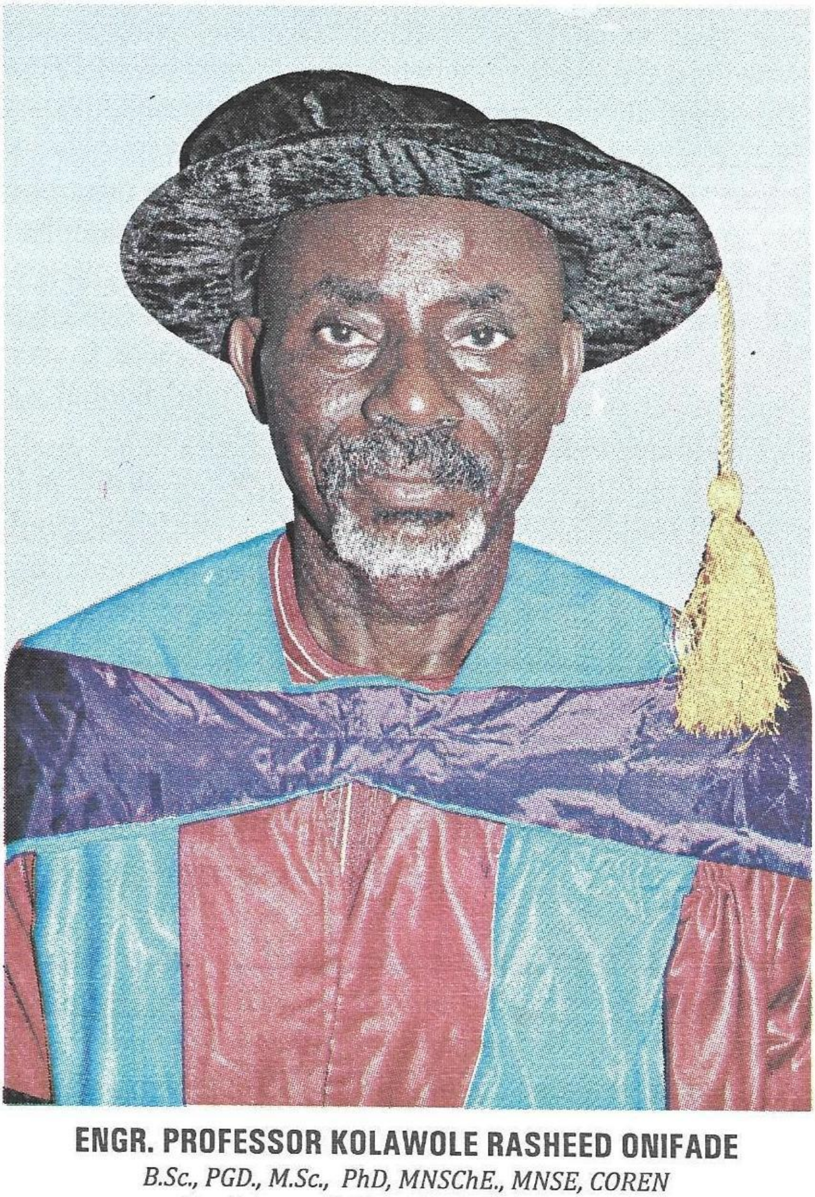

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INTRODUCTION

Materials, whether plant, chemical, nuclear, mineral etc, are produced from a simple process system shown in Figure 1. The input R represents materials used to produce P. The rectangular box represents the black box which aids in transforming R to P. The transformation may be simple, for instance the addition of just one transforming material (e.g. the addition of water remove dirt from R) or complex, where the materials to be added come up from other basic process units within the box, e.g. the production of wax from crude oil. Figure 2 also shows complex system involving many useful inputs into the box and removal of many extraneous outputs that are regarded as "poisons" or inimical to the desired goal of producing product from the activities within the box.

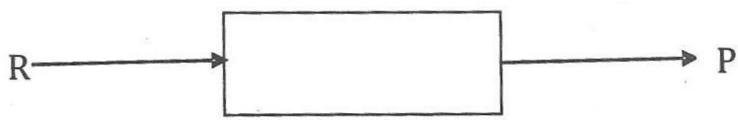

Figure 1: A basic process

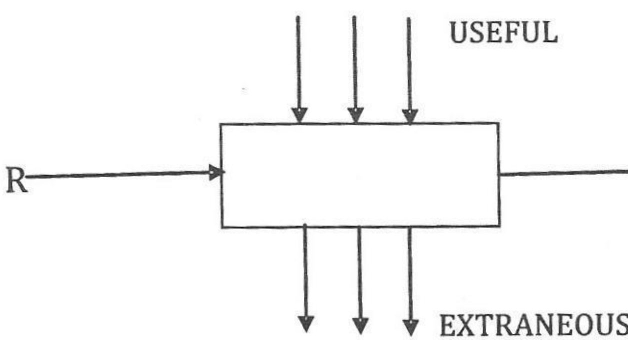

Figure 2: Process Modifications

Computer aids are many and depend on the system being studied, the inputs being added, the unwanted materials being removed and the manner of removing them. Hence Computer Aided Design (CAD) software represents a procedure that helps in resolving difficult activities within the rectangular box especially when it involves, estimation of physicochemical properties, reaction equations, models representing sub-systems within the box etc. It can also be viewed as a utility that exploits the capabilities provided by computers for speedy processing of design procedures. It enables the engineers to solve large and complex design problems much more rapidly and accurately than hitherto. The evolution, types, structure, components and advantages of CAD are well detailed (Oguntoyinbo 1993, Onifade 2000, Pressman 1987, and Westerberg *et al* 1979).

The development of CAD follows the same structure like that of a computer program. The problem must be well researched and understood. An algorithm is then developed for the solution of the problem and transformed into a flowchart for coding of in high level language like C++, Turbo Basic, Q Basic, Fortran, etc.

There are quite a large number of commercial and professional CAD software. Some of these are shown in Table 1. They are usually very expensive because of the huge amount spent in developing them. Some are specific to a particular application while some are of general nature, in the sense that they consist of many applications bandied together in a portfolio. The most common, widely and most powerful used software in our part of the world is the ASPEN suite.

The software has a database of models and properties relevant to the many engineering processes like thermodynamic, fluid and reaction engineering processes. Its sister software, Aspen HYSYS, is also widely and mainly used for refining application, and oil and gas processing, process design and optimization. The other useful CAD software are COSMOL Multiphysics, MATLAB and SIMULINK are other software that also find wide applications in Chemical Engineering.

CAD software offer a lot of versatility for the design of chemical plants. Some of them do this by making use of models for systems contained in the black box, especially for unit operation equipment. Also tested optimization techniques are often used to determine the best values for properties of substances in the box. CAD software are indeed useful tools in the hand of a design expert. However, among the inexperienced, it may turn out to be a time bomb. When results returned by CAD software are displayed, it is always a joyful picture to behold. But it requires experience to know that some results may not have sound fundamental basis or be explainable by reasonable theory. Hence, there is a tendency to fall a victim of the syndrome **REAL IN FICTITIOUS OUT (RIVO).**

TABLE 1: LIST OF CAD SOFTWARE

Software	Developer	Application	Operative system	License	URL
Ariane	ProSim	Utilities management and power plant optimization			[1] (http://www.prosim.net/en/softwareariane10.php)
APMonitor	Data reconciliation, realtime optimization, dynamic simulation and nonlinear predictive control				[2] (http://apmonitor.com/)
Apros	Fortum and VTT Technical Research Centre of Finland	Dynamic process simulation for power plants	Windows	Commercial	[3] (http://www.apros.fi/en/)
Aspen Plus	Aspen Technology	Process simulation and optimization			[4] (https://www.aspentech.com/products/aspenplus.aspx)
Aspen HYSYS	Aspen Technology	Process simulation and optimization			[5] (https://www.aspentech.com/products/aspenhysys.aspx)
ASSETT	Kongsberg Oil & Gas Technologies AS	Dynamic process Simulation			[6] (http://www.kongsberg.com/en/kogt/offerings/software/assett/)
BatchColumn	ProSim	Simulation and Optimization of batch distillation columns			[7] (http://www.prosim.net/en/softwarebatchcolumn9.php)
Batch Reactor	Prose	Simulation of chemical reactors in batch mode			[8] (http://www.prosim.net/en/softwarebatchreactor4.pup)
Spice	Kongsberg Oil & Gas Technologies AS	Dynamic process simulation and multiphase pipeline simulation			[9] (http://www.kongsberg.com/en/kogt/offerings/software/kspice/)
CADSIM Plus	Aural Systems Inc.	Steady state and dynamic process simulation			[10] (http://www.aurelsystems.com/csplus.htm)
ChromWorks	ChromWorks, Inc.	Continuous/Batch chromatography process simulator			[11] (http://chromworks.com)
CHEMCAD	Chem stations	Software suite for process simulation			[12] (http://www.chemstations.com/Products/What_is_CHEMCAD/)

CycleTempo	Asimptote	Thermodynamic analysis and optimization of systems for the production of electricity, heat and refrigeration			[13] (http://www.asimptote.nl/software/cycletempo/)
COCO simulator	AmsterCHEM	Steady state Simulation		free of charge	[14] (http://www.cocosimulator.org/)
Design II for Windows	WinSim Inc.	Process Simulation			[15] (http://www.winsim.com/design.html)
Distillation expert trainer	ATR	simulator for distillation process			[16] (http://smartprocedures.com/distillation_expert)
DWSIM	Daniel Medeiros, Gustavo León and Gregor Reichert	Process simulator	Windows, Linux, Mac	Open source	[17] (http://dwsim.inforside.com.br)
EMSO	ALSOC Project	Modeling, simulation and optimization	Windows, Linux	ALSOC License	[18] (http://www.enq.ufrgs.br/trac/alsoc/wiki/EMSO)
Dymola	CATIA Systems Engineering	Dynamic modeling and simulation software			[19] (http://www.3ds.com/products services/ catia/capabilities/systemsengineering/ modelicasystemssimulation/ dymola)
gPROMS	PSE Ltd	Advanced process simulation and modeling			[20] (http://www.psenterprise.com/)
HSC Sim	Outotec Oyj	Advanced process simulation and modeling, Flowsheet Simulation	Windows		[21] (http://www.outotec.com/en/Productsservices/HSCChemistry/ Calculation modules/ Sim process simulation/)
HYDROFLO	Tahoe Design Software	Piping System Design with Steady State Analysis	Windows	Free Academic Std Commercial	[22] (http://www.tahoesoft.com/)
METSIM	Proware	Generalpurpose dynamic and steady state process simulation system	Windows		[23] (http://www.metsim.com)
ProSim DAC	ProSim	Dynamic Adsorption Column Simulation			[24] (http://www.prosim.net/en/softwareprosimdac12.php)
ProSimPlus	ProSim	Process simulation and optimization			[25] (http://www.prosim.net/en/softwareprosimplus1.php)

Source: ALSOC Proect ((http://.azprocede.fr//index_usa.html)

One other problem associated with commercial CAD software is cost. There are often very prohibitive. The developers are too anxious to recoup their expenses!

MY CONTRIBUTION

When the School of Engineering was been contemplated before its final birth in 1986, the vision of the founding Vice-Chancellor, Professor J. O. Ndagi, was that the five programmes of Agricultural Engineering, Chemical Engineering, Civil Engineering, Electrical and Electronic; and Mechanical Engineering should be different from the conventional ones running in the old Faculties/Schools. Professor Sanni of University of Ife chaired the Committee that fashioned out the Chemical Engineering Programme. Due to my background in Computer Applications in chemical process, I seized the opportunity to impress that the use of CAD must be introduced when the students take Process Design course. I taught the course for many years. Hence, the first two contributions arose out of the need to familiarize the students with the concept of using CAD procedure for generation Material flow diagram, Mass and Energy balance and equipment design. Later studies were in development of CAD software for unit operation equipment and modeling and simulation of processes and processing units.

Material Flow Diagram

A symbol represents an equipment and utility in a chemical process. Material Flow Diagram is therefore a collection of symbols and flow arrows that represent what happens from the time raw materials enters a process right to the products obtained. The flow diagram speaks volumes for a Chemical

Engineer. It is usually the approved/selected processing route(s) agreed upon by parties involved with the construction and operation of the chemical plant. The flow diagram is tidied up after the plant has been commissioned. Even after the plant has been in operation, any alterations and modifications must be captured by a new flow diagram.

The symbols were created using appropriate drawing software like AUTO CAD Paint, Corel Draw etc. They are then stored in a databank/database, from which they can be retrieved when needed to create a flow diagram. Typical databanks are shown in Figure 3, 4 and 5.

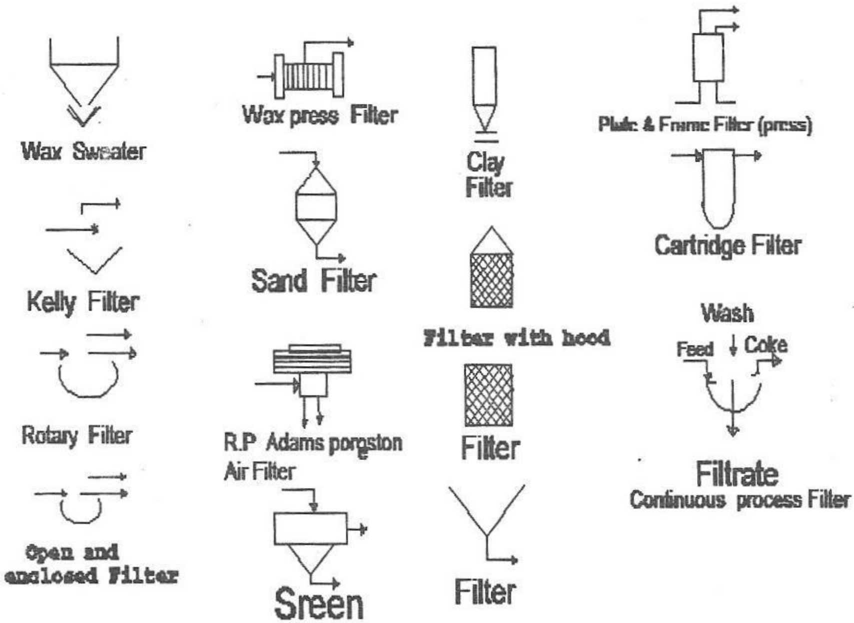

Figure: 3 Filters

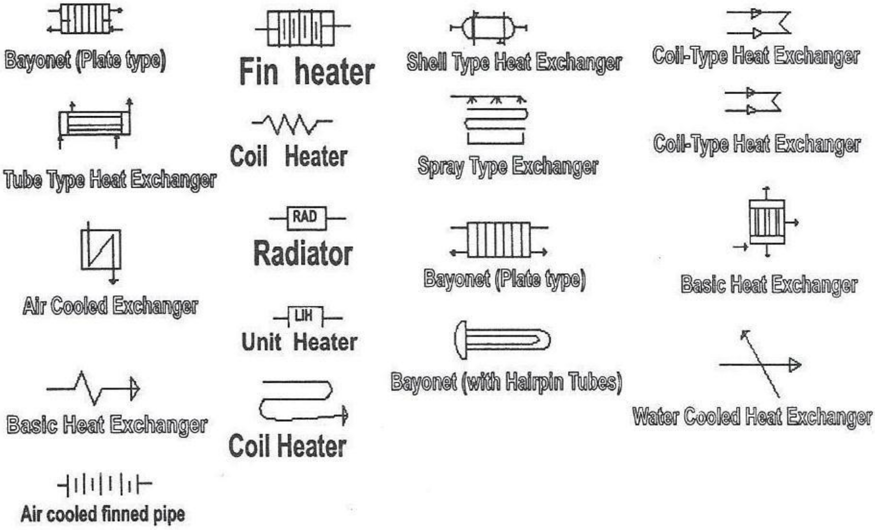

Figure: 4 Heat Exchangers

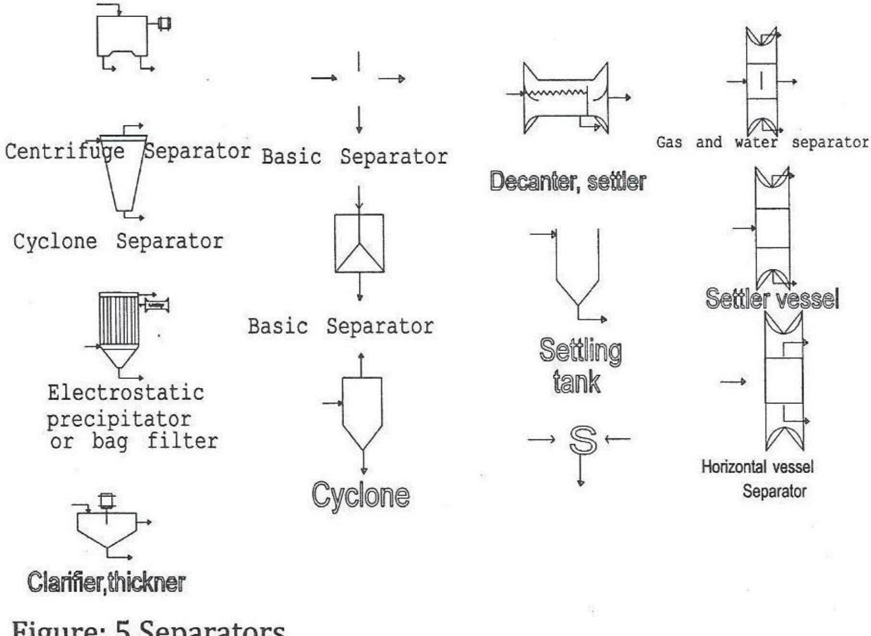

Figure: 5 Separators

Mass and Energy Balance

Mass and Energy represents the foundation upon which the construction of a chemical plant depends. An EXCEL program was developed to carry out the mass/material and energy balance. Usually an assumption based upon 100kg mole/hr of the dominant raw material is used as the starting value of the dominant R. When the final value is obtained, a scale-up factor is obtained. This factor is used to multiply all the other materials flows within the flow diagram. If the actual figures are indicated in the flow diagram, we sometimes refer to the flow diagram as a flowsheet.

Equipment

Many types of equipment like the pumps, valves, heaters, coolers, fans, are used extensively in the operation of a chemical plant. Some of these equipments are also sized by the Civil, Electrical, Electronic and Mechanical engineers. However these components are primarily used by unit operation equipment. The CAD software developed were mainly for the unit operation equipment and some of them are shown below.

Absorption Column

Absorption is a unit operation used in the chemical industry to separate gases by scrubbing a gas mixture with a suitable liquid or solvent. The absorption process may involve physical or chemical phenomenon (Badger 1957, Coulson and Richardson 1993; and Foust 1960). It is used in such processes as by-product recovery, pollutant or contaminant removal and gas separation. The packed columns are commonly used and the feed to the column can be binary or multi-component. These columns are characteristically operated with counter-flow of the liquid and gas.

The mass transfer coefficient is an important design parameter of an absorption column (Jackson 1953 and McCabe *et al* 1993). It depends on physical and thermodynamic properties such as packing type, operating conditions (temperature and pressure), and hydrodynamic properties (density, viscosity, flow rates) of the fluid (Phillip 1979 and Raznjevic 1976).

The following factors are usually taken into consideration for optimum design of an absorption column:

1. The best solvent for the operation.
2. The column diameter to handle the liquid flow and gas flow up to flooding point.
3. The height of the vessel and its internal members e.g. the depth and type of packing.
4. Selection of the type and size of packing.
5. The optimum rate and solvent circulation through the column.
6. The optimum operating conditions (temperature, pressure).
7. The mechanical accessories of the column, e.g. packing, support flow distributors and re-distributors.

Economic design specifications include:

a. The gas flow rate.
b. The gas composition at least with respect to the component to be absorbed.

c. Operating pressure and allowable pressure drop.
d. The minimum degree of recovery of one or more solutes.
e. The solvent to be employed and possibly the type and size of packing.

A comprehensive review of absorption and packed columns can be found in many unit operations books (Perry and Green 1984, Sinnot 1993 and Treybal 1981).

The developed CAD is thus an assembly of a set of mathematical equations and techniques for solving them. The main program draws relevant information/data from a database of phase equilibra; and physical, chemical and thermodynamic properties.

The program was developed using Turbo-Basic language because of the language's inherent advanced features, which makes it adaptable for modular programming structure (Chimowitz 1983). However, it can also be run using Qbasic compiler.

Design Module Source Code

The effective design of any unit operation equipment depends on certain intrinsic assumptions. The design procedure implemented in the CAD module is based on the following assumptions:

a. The absorption process is assumed to be physical, so any chemical reaction that might have taken place is neglected.

b. The system is assumed to be isothermal; hence the liquid temperature everywhere in the tower is equal to the inlet liquid temperature.
c. The equilibrium curve is assumed to be linear since the process fluids are dilute.
d. The heat of solution is assumed to be insignificant.
e. The solute gas is assumed to be an ideal gas.
f. The molar flow rate of the solute-free gas is assumed to be constant throughout the column.

The flowchart for developing the source code is shown in Figure 6. Finally the CAD software was used to solve an industrial problem. The results generated are shown in Table 2.

Table 2. Results from Test Problem

Parameter Determine	CAD OUTPUT	Manual Output	Result from Text Book
M	37.74	37.75	25.7
N_{OG}	3.96	3.95	5.80
H_{OG}	0.5224	0.539	0.505
$D_V(m^2/s)$	1.323×10^{-5}	1.29×10^{-5}	1.29×10^{-5}
$D_L(m^2/s)$	1.957×10^{-9}	1.964×10^{-9}	1.69×10^{-9}
A_C (m^2)	0.6234	0.621	0.44
D_C (m)	0.887	0.893	0.73
Z_C (m)	2.0667	2.10	2.96

Other Unit Operation Equipment

CAD software were also developed for binary and multi-component distillation columns, condensers (consisting of more than 15 data banks), etc.

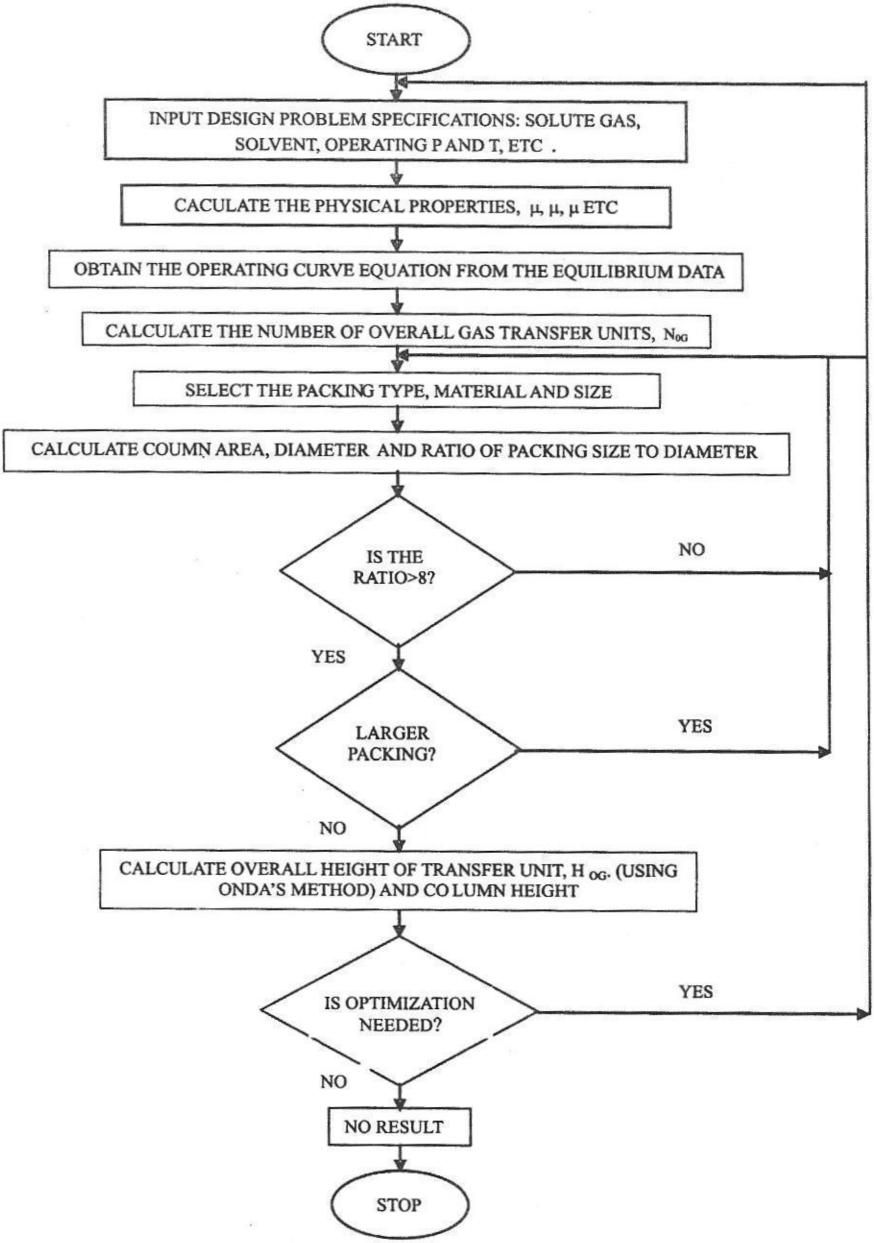

Figure 6: Flowchart for Implementing CAD Module for Absorption Column

Tubular Flow Reactor

The reactor is the 'heart' of most processes and products which are dependent on chemical reactions. It has therefore become an object of intense research over the years (Ari et al. 1980; Levenspiel 1972). Many variables of the system have been studied, but some still continue to attract interest. Notable among these are conversion, energy use and efficiency, simple design procedure and control. For proper analysis, reactors are classified according to certain criteria. Some of these are phase of reaction, mode of operation, mode of heat transfer, mode of flow and mixing of reactants. However, the classification is not sharp as reactor defined using one criterion sometimes subsumes other criteria (Cooper et al 1971).

In a tubular flow reactor, the reactants flow through the tube as "plug". The reactor under investigation was an Armfield Tubular Flow Reactor (Anon 1991). It is a continuous reactor that operates in a steady state. It is also an ideal displacement reactor because the "plug by plug" flow of the reactants occurs without mixing in a laminar flow along the entire reactor length. The reactor consisted of a reactor vessel, the feed supply unit and a Control Panel. The reactor vessel was a glass cylinder fixed with stainless steel plate. It was equipped with a stirrer, a heating unit, temperature sensors and sample and drain points. The feed unit was made up of two feed tanks for the reactants. The reactants were pumped through the flow meters into the inlet feed pipes. The switches for the main power, feed pumps, stirrer motor and system temperatures are incorporated in the Control Panel. The Control Panel also housed the temperature control unit and flow meters. Two figures are relevant to this work. They are presented below.

The model was simulated and the values obtained were compared with those obtained from experiments. The results are shown in Tables 3 and 4. The statistical comparison between the simulated and experimental results is shown in Table 5.

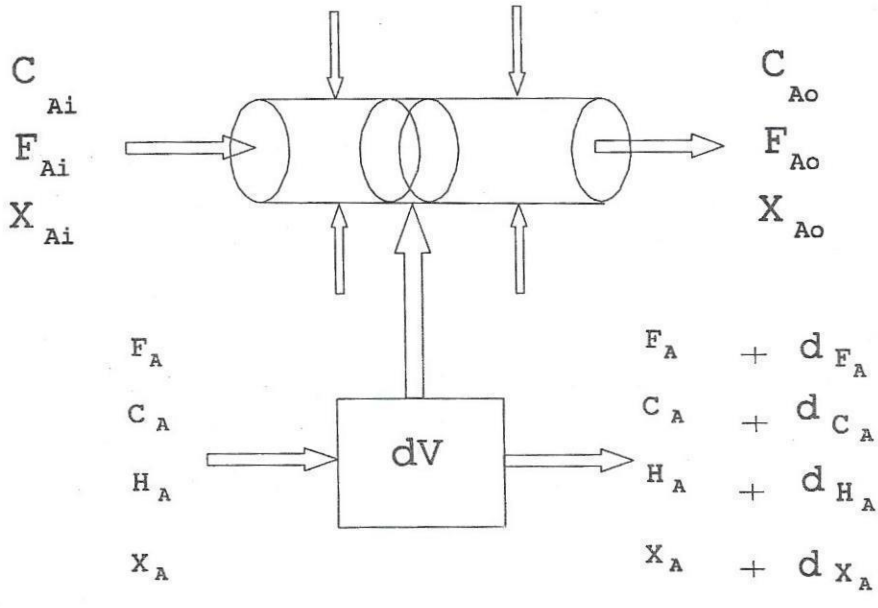

Figure: 7 Tabular Flow Reactor

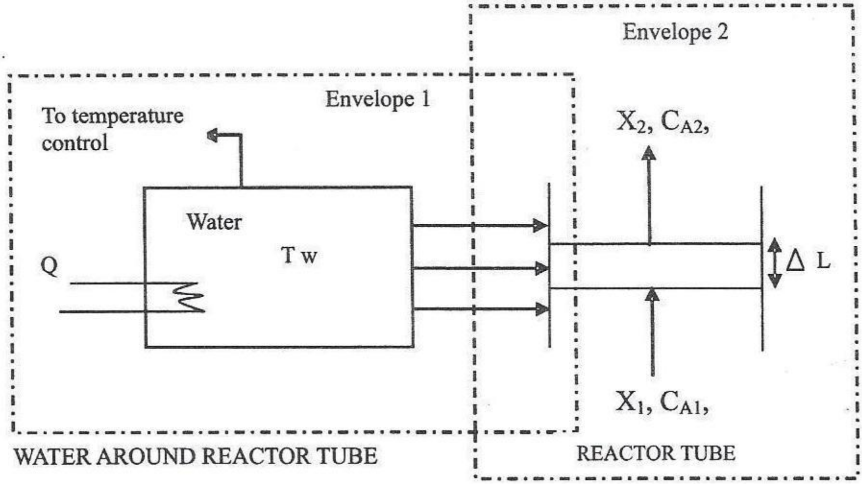

Figure 8: The Reactor and Temperature Control Heating Subsystems

Table 3: Results for EXPTA

	EXP TA1		EXP TA2		EXP TA3	
	Experiment	Simulation	Experiment	Simulation	Experiment	Simulation
Outlet NaOH Concentration (mol/m^3)	4.20	4.46	12.28	12.47	21.90	22.43
Residence Time	34.8	34.8	13.3	13.3	7.34	7.34
Outlet Temperature of products (°K)	308.40	308.21	308.50	307.21	306.20	306.20
Conversion	0.93	0.93	0.80	0.80	0.63	0.62
Correlation coefficient		0.999		0.999		0.999

Table 4: Results for EXPTB

	EXP TB1		EXP TB2		EXP TB3	
	Experiment	Simulation	Experiment	Simulation	Experiment	Simulation
Outlet NaOH Concentration (mol/m^3)	15.00	14.91	7.70	7.74	4.00	4.01
Residence Time	6.28	6.28	6.59	6.59	6.50	6.50
Outlet Temperature of products (°K)	316.20	305.21	325.20	325.23	335.20	336.23
Conversion	0.75	0.75	0.89	0.88	0.94	0.94
Correlation coefficient		0.999		1.000		0.999

Table 5: Statistical Analysis of experiment and simulation results

	Correlation Coefficient	
	EXPTA	EXPTB
Outlet NaOH Concentration (mol/m^3)	0.999	1.000
Residence Time	1.000	1.000
Outlet Temperature of products (°K)	0.848	0.981
Conversion	0.999	1.000

Other modelling and simulation studies

CAD software were also developed for Liquid Phase Reactor and many other processing units.

CONCLUSIONS

A lecture of this nature is too short to provide a broad picture of the influence that Computer Aided Design software have had on Chemical Engineering Process Analysis and Development. Nonetheless, the following conclusions can be drawn from the paper.

1. CAD has played important role in the analysis and solution of problems in the various areas of chemical engineering operations.
2. CAD software are very expensive and still the preserve of the advanced countries.
3. Developers of CAD software are becoming more modular. This is a deliberate ploy to extract a lot of proceeds from the sale of their software. Hence there is a need for more research by indigenous personnel in development of CAD software, so that foreign stipend in this regard can be minimized.
4. Students and staff need to be more grounded in the fundamentals of Process Design. Presently, **Real In Fictitious Out (RIVO)** is prevalent. This is a situation where students get 'beautiful' results which are not in consonance with reason and theory.

RECOMMENDATIONS

It is apparent from the growth and influence of CAD softwares that they will continue to be used in the design of process design for some time to come. It is therefore necessary for the Chemical Engineering Departments to come together, through the Nigerian Society of Chemical Engineers to review the existing course contents of Process Design to incorporate the teaching of CAD procedures.

The lecturers who teach the Process Design that has CAD components should be well versed in the application to eliminate **RIVO** common in the interpretation of CAD results. The Institution of Chemical Engineers, (U.K.) did this by commissioning a book from time to time to take a design process problem and solve it using all the prevailing procedures outlined for the solution of a chemical engineering process. This book /write up should also incorporate the normal traditional way of handling process design problem.

Chemical Engineers who work in the industry should also be encouraged to attend workshops and training media to upgrade their knowledge in the use and application of CAD software relevant to their areas of operations.

Joint research should be encouraged between Chemical Engineers for development of CAD software.

APPRECIATION

The appreciation that is given in this type of presentation is based on looking back over the years and reflecting on factors which have helped in shaping one's life the way it is and perhaps the way it will be in the Allah's spared future. A sensible man should therefore take stock of what has and has not been and know that as Shakespeare says: "There is a fate that shapes our ends, rough hew them how we will." My life has always revolved around a philosophy that I have enshrined in my psyche right from youth. And this is that, good or bad, I will always accept whatever Allah has given me with happiness. My short bio-data has therefore elicited three major areas of appreciation.

The first is that I appreciate ALMIGHTY ALLAH who has been my sustainer through the thick and thin of my life. Considering the various bashings and hammerings of life (the crucible) I have gone through, I would have been nobody today but for HIS GRACE, the good brain and the sparkling 'Never Say Die' attitude HE imbued in me. So ALHAMD-LILAHI, RABIL-ALAMIN. Perhaps I should squeeze in my teachers here. My appreciation goes to Professor Mesubi, my project supervisor at Obafemi Awolowo University, Ile Ife, Professor Jeffreys (M.Sc. and PhD) at Aston University and my primary and secondary modern schools teachers.

Secondly, I will like to appreciate my parents and their kin and kith. Although my parents (Pa Oladejo Salawu Onifade and Madam Olalonpe Anike Onifade) have passed on, I cherish their sterling contribution to my life. They will always continue to live within me. Many a times they had to give up the last 'epinni' on them whenever I came home from the university looking for sustenance money. My mentor, Late Chief Muritala Olanrenwa Shittu, played major roles in my development. He was the first brilliant academic beacon of my family compound, ILE LABOO, in Ibadan. My brother, late Prince Ariyibi Aderibigbe Adeniran (UK), the disciplinarian. I also like to appreciate other members of my big family, Eng Chief Alahaj Kaoliq Shittu, the Mogaji of Ile Laboo Compound, Mr. Abiola Adebisi, Mr. Kunle Adebisi, Mrs. Fatima Kareem and others cousins too many to mention. I do also appreciate my father-in-Law (Late Chief, L. A. Folarin), mother-in-Law (Mrs. Olabisi Folarin), both dead. And the numerous in-Laws. I have been lucky in marrying into a wonderful family.

I appreciate OLAMIDE RASHEEDAT ONIFADE, my beautiful wife, mother and grandmother of the nuclear family, and jewel too rare to describe. We had a short romance (less than a year before we departed for UK). As two individuals with strong minds, it is always tough between us. But thanks to Almighty Allah again, we have survived the worst Tsunamis of life and remain happily married together for over 38 years. I like to thank our children, Dr. Ayokola Afiz Onifade, and Messrs Bolaji Teslim Onifade, Oladapo Muhammad Onifade and Olabisi Abdullahi Onifade. They have been wonderful source of joy to us. I also appreciate our grandchildren, Miss Latifah (Tifah) Onifade, Miss Zara Onifade and latest addition, Miss Jadesola Onifade. We appreciate our children in-laws as well.

The third aspect of my appreciation encompasses all others who have contributed to my academic and social life.

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My special appreciation goes to all my colleagues and students in the Department of Chemical Engineering and

School of Engineering and Engineering Technology. I looked back with pride and satisfaction that many of the students are now professors and staff of the Department and School. Allah has blessed our seeds to produce useful fruits indeed. I thank them for the value they always place on my "elder" role in the Department and School.

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Finally, I will also like to thank the students and audience for your patience, Prof. Eng. (Mrs.) Osunde, the Chairperson University Seminar and Colloquium Committee for her constant encouragement to see that I prepare this lecture and her team for the eventual organization of the lecture.

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SHORT PROFILE OF THE INAUGURAL LECTUERER

I came to life on 1st October, 1949 into a middle class polygamous family (my father was a successful businessman in cattle, kola-nuts and kerosine). I was the only surviving male child of the family.

I started school early and was always on top of the class up to my primary six. Then disaster struck. My father's business went into distress and with it went the dreams of going to the best secondary school in town and even travelling abroad for my post-secondary education. But before then, thanks to my parents, who made sure I attended "ile kewu" (koranic school), I have established a good reliance on Almighty Allah. While other children in similar circumstance may become sad and despondent, this early financial challenge bolstered my resolve to become "something" in life. With some loan from my father's female cousin, I attended a Secondary Commercial Modern School, where thanks to Almighty Allah; I was always the best student in my set.

This was followed by what I could call "the crucible years", because it marked the era where I was engaged in all sorts of life strata, which ranged from working as a messenger, typist, account clerk to being a lawyer's clerk and a veterinary assistant-in-training. While this was going on, I continued to get inspiration from Allah that I must continue in my struggle to make a mark in life and serve as a beacon (I suppose according to my Moslem name, Rasheed) to other less privileged children. So, I started to read at home by borrowing books from friends, cousins and library.

Initially, I wanted to be an accountant because Allah has always made easy for me anything that has to do with numbers. I gave up the idea when I was told that dressing formally (especially always in ties!) is a must for the accountants.

Naturally, I don't like anything too formal. Just six months before I registered for LONDON GCE O' Level, I abandoned Economics and Government, which are pre-requisites for accountancy profession and started reading Chemistry, Physics, Biology and Additional Mathematics. Thanks to Almighty Allah again, I passed all the six subjects I registered for at the first sitting in 1970.

I was admitted to read Chemistry at Obafemi Awolowo University OAU, Ile Ife as a "Prelim" student the following year - a science student who has never seen the inside of a laboratory! My bewilderment and curiosity was at red alert, but so also was my determination to succeed in the midst of course mates who were much grounded in science subjects. It is sufficient to capture my stay at Ife by saying that I belonged to the esteemed (?) club of "Indigo." It has left me with a virtue: It is easy for me to fast and survive on little food. But then Allah again sustained my stay and I graduated from Ife in 1975. This educational pursuit was capped with HIS sanctioning my postgraduate studies (Postgraduate Diploma (Chemical Engineering), M.Sc. (Process Analysis and Development) and PhD (Chemical Engineering) at Aston University, Birmingham U.K.

My public career started with being employed as a Research

Officer in training by Public Service Commission and posted to Cocoa Research Institute of Nigeria (CRIN), Ibadan in 1976. I returned to CRIN in 1983 after my postgraduate training and rose to the rank of a Senior Research Officer before joining Federal University of Technology, Minna on 1st October1985. I was No. 1 documented citizen of School of Engineering and Engineering Technology, which took off in January 1986 and Department of Chemical Engineering that admitted its first students a session later.

My position has enabled me to garner more than three decades of academic and administrative experience and looking back I have been lucky in this regard. I have been a Head of department, Coordinator/Dean of a School, Director of Units, Chairman and member of University Committees, Member of Federal University of Technology Governing Council, etc. It is needless to say that I have supervised tens of B.Eng, M.Eng. and PhD students across three Nigerian universities. I have also served as external examiner of many M.Eng. and PhD candidates and external assessor of academic staff for professorial positions.

I have been awarded a fellowship by Association of Commonwealth Universities (ACU). My research interests are in the areas of Process Analysis and Development, Process Design and Process Modelling and Simulation.

I am married with four children.