New Clues in Sciences 2 (2012) 104-110

Available at woaj

New Clues in Sciences

Journal homepage: www.woaj.org/NCS

Effects of Climatic Conditions on Production and Sales Pattern of Water Packaging Industries in Nigeria

Sadiq, Ibrahim Ogu

Department of Mechanical Engineering, Federal University of Technology, Minna, P.M.B. 65, Minna, Niger State, Nigeria.

ARTICLE INFO

Article history:

Accepted:
Available online: 6 December 2012

Keywords:

Climatic conditions,
Empirical relationship,
Proportional sales,
Forecast sales.

ABSTRACT

The effect of climatic weather on production and sales pattern of water packaging industries was analysed and reported. Sales data, humidity data and temperature data were collected for a period of four years. Graph of proportional sales versus relative temperature and relative humidity are plotted separately to show the effect of climatic weather conditions on the sales of sachet water. Periods of high sales which falls during the dry season (i.e February to May) and low sales at raining season, especially in the months of June to September are also identified using multiple chart for a period of four years. High sales of sachet water are found to occur between February to May when the environmental temperatures are highest accompanied by lowest values of humidity while low sales occur between June to September when the environmental temperatures are lowest and humidity values are highest. Empirical equation given shows the relationship between proportional sales with temperatures and humidity for the four years investigated. There are good agreements between the actual proportional sales and forecast proportional sales.

1. Introduction

Due to many years of neglect by government and inadequate investment in public infrastructure thepublic drinking water supply in Nigeria have been leftin an unreliable state. The society has therefore, taken to severaladaptive measures of alleviating this through the dependence on sachet water, for good supply of drinking water popularlyreferred to as 'pure water'[3].

Water packaging industries are the most common industries that are located in cities, towns and even villages in Nigeria. These industries are also great em-

* Corresponding author.
email address: engr2k4@yahoo.co.uk.

ployers of unskilled or semi-skill workers in Nigeria, in addition to providing Nigerians with clean and safe drinking water. The quality of water supplied by these industries to their consumers is carefully monitored and maintained by the National Agency for Food and Drug Administration and Control (NAFDAC) by examining and certifying through quality water analyses, regular fumigations of factories and its environment, medical tests of factory workers, uses of correct water packaging polythene materials e.g. low density polythene (LDPE).

Water packaging industries consist basically of *water supply* from boreholes or public pipe borne water. Water is the main source of raw material, usually stored in *overhead storage tank*. The *water filtration section* is made of particles/sediment filtration, reverse osmosis membrane filtration systems or cartridge fillers (of varying microns) and ultra-violet (UV) water sterilizer system. *Water sachet production section* is where the water is sealed in sachets using automatic liquid (water) packaging/sealing machine. *Packaging storage section* is where sealed water sachets (containing 50cl of water) are packed in plastic bags. Each plastic bag contains twenty sachets. The plastic bags are then stored temporarily for sale.

It is a common sense that water intake into the human system varies from season to season. Presumably, in a tropical region such as Nigeria, we have two extreme seasons made of the dry and wet seasons.It is therefore clear that the human body's demand for water is higher in the dry season than wet season. Since the goal of any business is to deliver effective and efficient goods and services, it is, therefore, necessary to plan productions and sales bearing in mind the effects of these climatic weather conditions. This will enable the producers to plan carefully for periods of higher and lower demands of water. Basically, effects of two major climatic conditions considered here are environmental temperature and humidity on the productions and sales patterns in the water packaging industries in Nigeria.

Theoretical Analyses

Production Analyses

Average Packs Produced per Kg of Cellophane

This refers to the total sachet water produced comprising of non-defectives and the defectives from total Kg of cellophane used. It is expressed mathematically as:

Average packs produced per kg of cellophane =

$$\frac{Total packs produced\, P_t}{Total material supplied\ (kg)} \quad 2.1$$

Useful Average Packs per Kg of Cellophane

Useful average packs refer to the useful produced sachet water that are free of defects. It is expressed mathematically as:

Useful Average Packs per Kg of Cellophane =

$$\frac{Useful packs produced\, P_u}{Total material supplied\ (kg)} \quad 2.2$$

Material Input-Output Balance

This refers to the balancing of total input and output of material used for production of sachet water. Since the output is made up of non-defective products and the defective products (both on the production floor and returns from sales), their summation should give 100% to ensure effective material balance [1]. It is expressed mathematically as:

Total production (P_t) = Non defective product + Defective on floor + Defective from sales 2.3

Sales Analyses

Proportional Sales

The sales data collected for four years are converted to proportional sales by dividing the sales of each month for each year by the total sale for the first year of production (2005) using it as reference for other year's sale to monitor sales growth. It is expressed mathematically [1] as below:

$$\text{Monthly Proportional Sales } (S_p) = \frac{Sm}{St1} \quad 2.4$$

where S_p = Proportional sales
S_m = Monthly sales
S_{t1} = Total sale of the 1st year

Temperature

Temperature is a physical property of matter that quantitatively expresses the common notions of hot and cold. Objects of low temperature are cold, while various degrees of higher temperatures are referred to as warm or hot. Quantitatively, temperature is measured with thermometers, which may be calibrated to a variety of temperature scales. The temperature values are made dimensionless for ease of plotting the graph by dividing the monthly values for each year by the corresponding year average or mean value.

Relative Humidity

Relative humidity is a term used to describe the amount of water vapor in a mixture of air and water vapor. It is defined as the ratio of the partial pressure of water vapor in the air-water mixture to the saturated vapor pressure of water at those conditions. The relative humidity of air depends not only on temperature but also on pressure of the system of interest. Relative humidity is an important metric used in weather forecasts and reports, as it is an indicator of the likelihood of precipitation, dew, or fog. [7].The relative humidity values are made dimensionless for ease of plotting the graph by dividing the monthly values for each year by the corresponding year average or mean value.

Empirical Relationship

Empirical relationship is established to enable the prediction or forecast of future sales taking into account the effects of climatic weather conditions on the sales of sachet water for each month of each year. It will thus enable the producer to know when to have large production based on the forecast sales derived from previous sales data.

For any data consisting of n observations, with a dependent or response variable Y and predictor or explanatory variables X_1, X_2 ...X_p, the relationship between Y and X_1, X_2, ...X_p is formulated as a linear model [2] given by:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \mathcal{E} \qquad 2.5$$

where , $\beta_o, \beta_1, \beta_2, \ldots, \beta_p$ are constants referred to as the model **partial** regressioncoefficients (or simply as the **regression coeficients)** and ε is a random disturbanceor error. It is assumed that for any set of fixed values of X_1, X_2, . . . , Xp, thatfall within the range of the data, the linear equation (2.5) provides an acceptableapproximation of the true relationship between *Y* and the X's *(Y* is approximatelya linear function of the *X's*, and Ɛmeasures the discrepancy in that approximation).In particular, Ɛcontains no systematic information for determining *Y* that is notalready captured by the X's.

The empirical relationship between sales and the climatic weather conditions (temperature and humidity) is obtained with the use of multiple regressions [4]. Thus, in our own case, where two variable factors only are considered, the relationship between sales and the seasonal factors is forecasted with multiple linear regression formula, shown as:

$$F_s = \alpha + \beta T + \gamma H \qquad 2.6$$

where: $\alpha =$ basic proportional sales constant;

$\beta =$ Coefficient of relative temperature term;

$\gamma =$ Coefficient of relative humidity term.

The solution of the above equation can be obtained by analysing data for any particular year or average values taken over a given period.

$$\begin{Bmatrix} n & \Sigma T & \Sigma H \\ \Sigma T & \Sigma T^2 & \Sigma TH \\ \Sigma H & \Sigma TH & \Sigma H^2 \end{Bmatrix} \times \begin{Bmatrix} \alpha \\ \beta \\ \gamma \end{Bmatrix} = \begin{Bmatrix} \Sigma S \\ \Sigma TS \\ \Sigma HS \end{Bmatrix}$$

Hence: $\alpha = \frac{\Delta_1}{\Delta_o}$, $\beta = \frac{\Delta_2}{\Delta_o}$, $\gamma = \frac{\Delta_3}{\Delta_o}$

where $\Delta_o, \Delta_1, \Delta_2, and \Delta_3,$ represent the base determinant, and the determinants corresponding to the constants $\alpha, \beta and \gamma$ respectively.

Materials and Methods

Materials

The main source of raw material is water, usually obtained from boreholes or public pipe-borne water. The low density polyethylene (LPDE) is used for sachet water packaging, as recommended by National Agency for food drug Administration and control (NAFDAC). Each sachet contains 50cl of processed water. Each pack or bag of processed water is made of plastics and contains twenty sachets of water.

3.2 Data Collection

Daily production data, comprising of useful product output and defectives made of production floor defectives and defectives return from sales were collected and recorded for 86days of effective production. In addition, sales data, humidity and temperature data were collected for a period of four years (2005 - 2008).

4.0 Results

4.1 Production Analysis

4.1.1 Average Production Output per kg of Material (Cellophane)

For the 86days of effective production, the following categories of output were obtained. Total quantity of cellophane material supplied in kg, is 1801.92kg.

Non defective p =	34566.00
Defective on floor =	1280.00
Defective from sales =	1095.00
Total production P_t =	36941.00

Average packs produced per kg of cellophane are given by:

$$\frac{Total packs produced P_t}{Total material supplied\ (kg)} = \frac{36941.00}{1801.92} = 20.50 \text{ packs}$$

From the collected production data and the analysis above it shows that about 21 packs of bagged sachet water comprising both of non-defective and defective sachet water can be produced from a kilogram of cellophane.

4.1.2 Useful Production Output per kg of Material (Cellophane)

Useful average packs produced in kg is:

$$\frac{Useful packs produced P_u}{Total material supplied\ (kg)} = \frac{34566.00}{1801.92} = 19.18 \text{ packs}$$

From the above analysis, considering useful packaged sachet water, only 19 packs of packaged water can be produced from one kilogram of cellophane.

The total quantity of material input must be balanced with the sum of non-defectives products i.e useful output products, defectives on production floor and defectives returns from sales. From the above table on production, it can be seen that non-defective products account for 34566 packs of sachet water which gives93.57% of the total production for the period of investigation, while the defective products a mounting to 2375 gives6.43%. See figure 1 below.

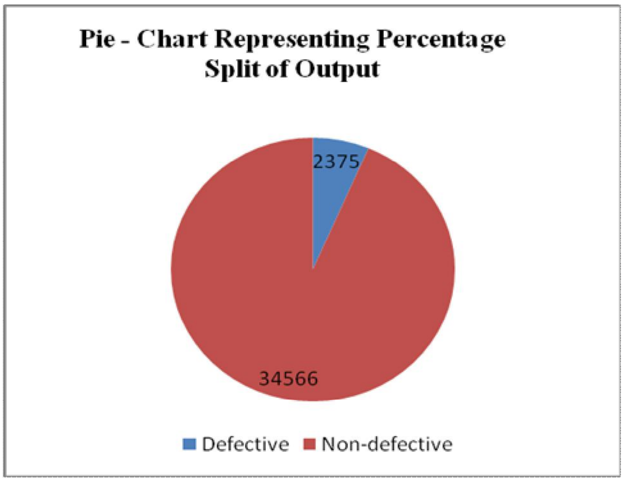

Figure 1: Pie-chart Representation of Production Split

4.2 Sales analyses

4.2.1 Proportional Sales Ratio

Proportional sales density zone is used to indicate the sales pattern over a period of time. In the case of this study, sales data was collected for 4years preceding the year of research. From the histogram of figure 2, the sales density zone can be seen at a glance.

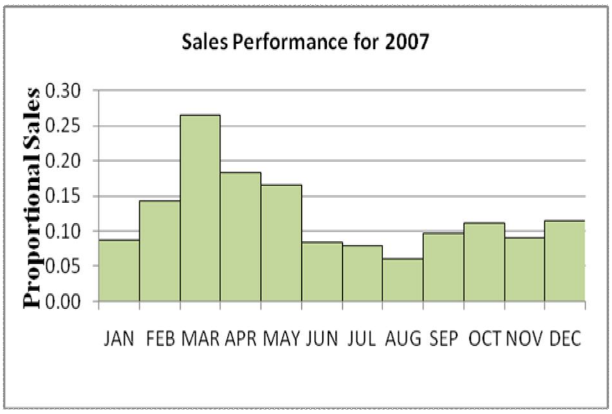

Figure 2: Histogram of Proportional Sales indicating Sales density.

From the 2007 proportional sales histogram of figure 2, high sales density period falls between February and May, with peak value in March. This period tends to represent the hottest period of the year in the dry season accompanied by lowest values of humidity. Low proportional sales occur between June to September during the wet season when the temperature are lowest and humidity values highest

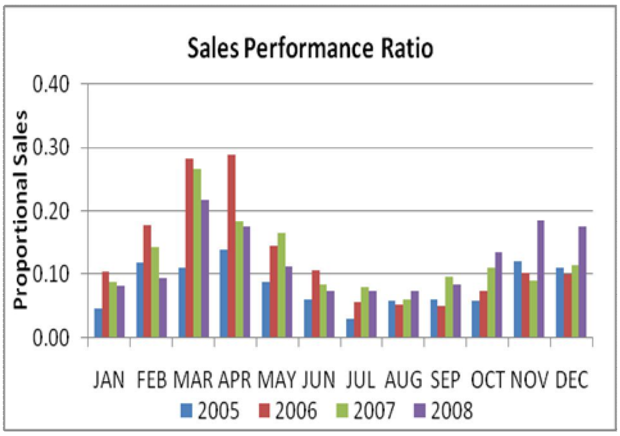

Figure 3: Monthly Proportional Sales for each Year

Figure 3 shows the monthly proportional sales for each year from 2005 to 2008. High and low proportional sales occur at the months as stated above for each year. Using the first year of production (2005) sales as reference, it shows that there have been growth in sales for years 2006, 2007 and 2008 over the reference year with the exception of months of August and September in 2006; and November in 2007 where decrease in sales are recorded in reference to year 2005. This decrease in the case of August and September of year 2006 results from the climatic weather condition as the periods is in the wet season. The decrease in the month of November of year 2007 could result from either insufficient production materials, especially water or shutdown of factory due to maintenance of equipment.

4.2.2 Effect of Climatic Condition on Sales

Climatic weather conditions i.e humidity and temperature have great impact on the production and sales of sachet water. Due to the nature of Nigerian weather conditions, we have wet season and dry season. Both seasons have these factors present in them but, degree of severity varies. While high environmental temperature and low humidity is associated with dry season, the reverse is the case in the wet season.

Humidity is a term for the amount of water vapour in the air, and can refer to any one of several measurements of humidity. In everyday usage, it commonly refers to as *relative humidity*, expressed as a percent in weather forecasts. In meteorology, humidity indicates the likelihood of precipitation, dew, or fog. High relative humidity reduces the effectiveness of sweating in cooling the body by reducing the rate of evaporation of moisture from the skin[5]. Under humid conditions, the *rate* at which perspiration evaporates on the skin is lower than it would be under dry conditions. This clearly shows that perspiration from human body is low during wet season due to the prevailing high humidity.

Temperature is a physical property of matter that quantitatively expresses the common notions of hot and cold. Objects of low temperature are cold, while various degrees of higher temperatures are referred to as warm or hot[6].

Below are graphical plots of sales versus temperature and sales versus humidity for two reference years of 2005 and 2007 respectively to show the impact of these weather conditions on the sales of sachet water.

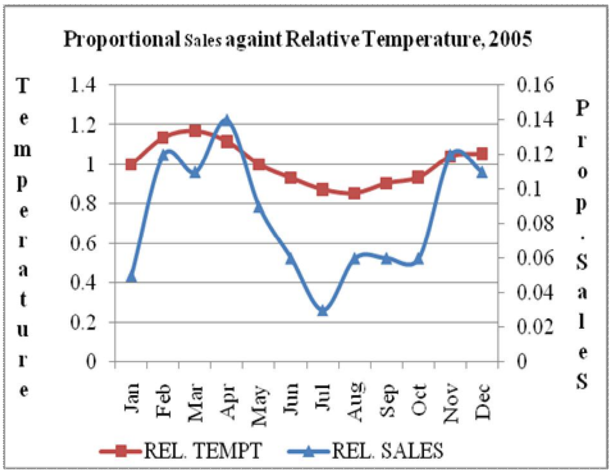

Figure 3: Variations of Proportional Sales with Temperature in 2005

At the beginning of the year (January), there was sharp increase in sales relative to temperature. The sales dropped slightly in March and rose back to peak in April after which, it descends approximately linearly to a minimum value in July. It improves in August and remained almost flat or constant till October, before it finally resume the trend with a slight drop in December.

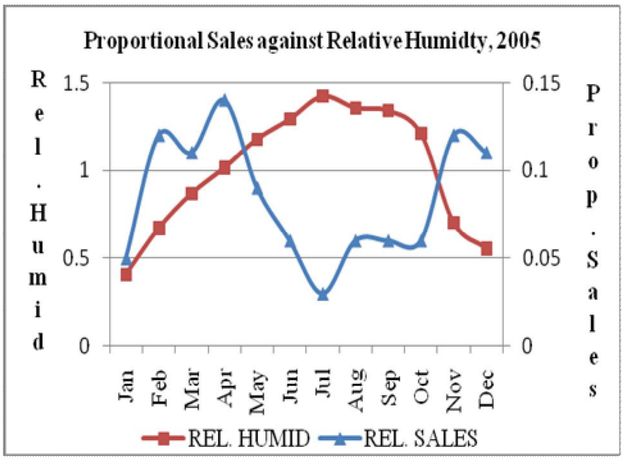

Figure 4: Variations of Proportional Sales with Humidity in 2005

The graph above shows an inverse relationship between humidity and sales. From January to May, before the commencement of rain fall, sales were on the high side with relatively lower humidity. As humidity increases, the values of sales drop to a minimum in July - corresponding to the highest value of humidity in the same month.

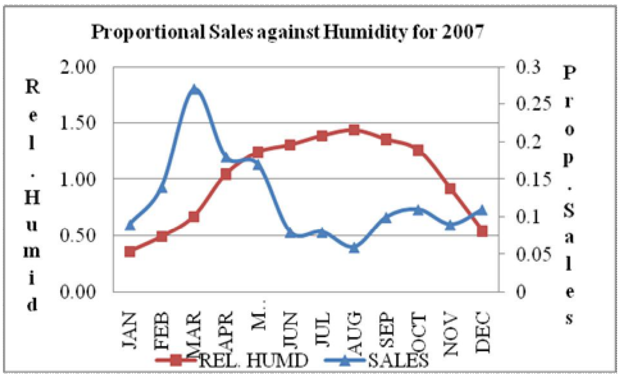

Figure 6: Variations of Proportional Sales with Humidity in 2007

From the graph of figure 4.8, it can be seen that there was an increase in sales from January to March with corresponding low humidity. As the humidity rises, the sales drop drastically and fluctuated through the year.

4.3 Empirical Relationship

Thus, the empirical relationship between the sales and the climatic conditions (temperature and humidity) is obtained with the use of multiple regression analysis. Applying equation(2.6) to the year by year sales, temperature and humidity data generates the regression constant shown below.
Forecasting the future sales based on the 2005, 2006 and 2008 humidity, sales and temperature data collected and substituting the regression constant in table 4.25 and the corresponding humidity, sales and temperature into equation 2.6 [4] yields the following results:

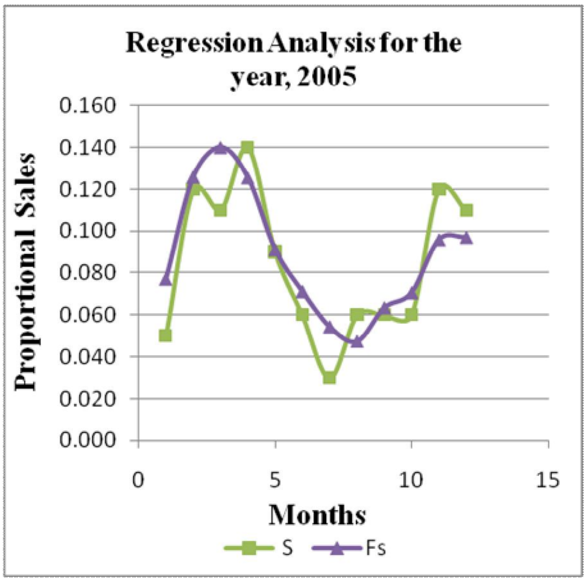

Figure 7: Comparison of actual proportional sales with forecast values for year 2005

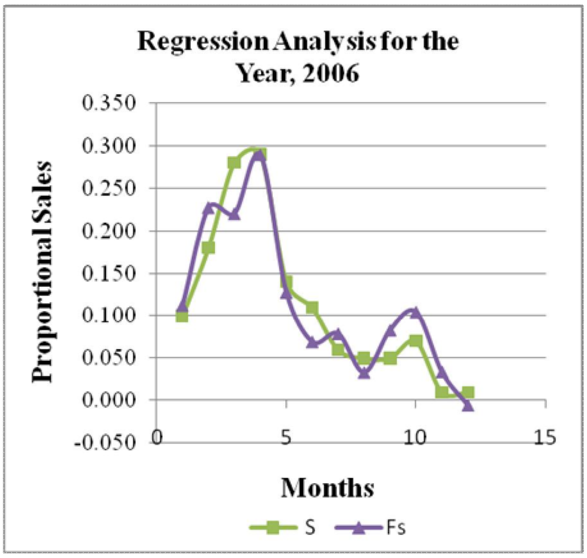

Figure 8: Comparison of actual proportional sales with forecast values for year 2006

Table 4.25 Regression constants from 2005 to 2008

Constants	2005	2006	2007	2008	Average
□	-0.26328	-1.4477	-0.7690	-0.5804	-0.6921
Β	0.00975	0.03904	0.0237	0.0194	0.0215
Γ	0.00029	0.00414	0.00176	0.00090	0.0014

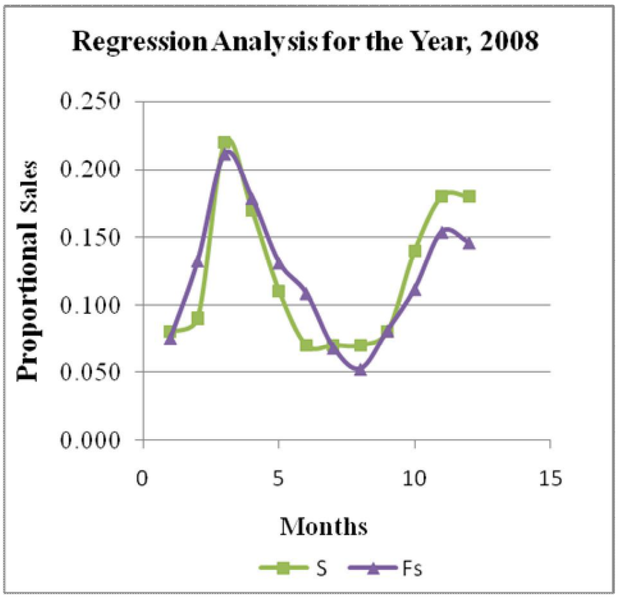

Figure 9: Comparison of actual proportional sales with forecast values for year 2005

In the graphs of 2005, 2006 and 2008 Regression Analysis shown, variation of proportional sales and forecast sales from January to December maintains approximately the same profile.

CONCLUSION

1. For the periods of 86days investigated, it is found that 1kg of cellophane produces a minimum of 20packs, each pack containing 20 sachet of water
2. For the 4 years, it has also been found that sales volumes are highest between the months of February to May while low sales volumes are experienced between the months of June to September of every year between 2005 to 2008.
3. Since the periods of high sales density and low sales density are known, it means that production activities are affected by climatic factors as it simply means that the periods of low sales are due to wet season; production will be low as the demand for water in the wet season is low and vice versa.
4. Therefore, production activities can be schedule towards effective service delivery especially for the periods of high demands. This will enhance proper inventory control of production materials especially, the polyethylene sachet used for water packaging.
5. Empirical equations relating proportional sales to environmental dimensionless temperature and humidity can be used to predict fairly accurately the sales forecast for months of year 2005 to 2008

REFERENCES:

1. Sadiq, I. O (2011) “Production Management and Quality Control of Packaging Process (A Case Study of Sachet Water Packaging), M. Eng thesis, Department of Mechanical Engineering, Federal University of Technology, Minna, Nigeria.
2. Samprit Chatterjee and Ali S. Hadi, (2006). Regression Analysis by Example, 4thEdition, John Wiley &Sons, Inc, New York.
3. C. A. Dada, (2009). Towards a successful packaged water regulation inNigeria, Scientific Research and Essay Vol.4 (9), pp. 921-928.
4. Alawode, A. J (2002). Effects of cold work and stress-relief annealing cycles on the mechanical properties and residual stresses of cold-drawn mild steel rods, M. Eng thesis, Mechanical Engineering department, University of Ilorin, Nigeria.
5. American Meteorogical society: glossary of meteorology.
6. www.wikipedia.org.
7. Perry, R.H. and Green, D.W, *Perry's Chemical Engineers' Handbook* (7th Edition), McGraw-Hill, ISBN 0-07-049841-5