COMPUTER-BASED RAW MATERIALS ANALYSES FOR THE GLASS INDUSTRY

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Abstract

The advantages of Computer-based automatic glass raw materials analysis cannot be overemphasized. A well-designed and instructed automatic analyzer can operate reproducibly over long periods. Consequently, it may be expected that for the analysis of a large glass batch of samples, its analytical precision will be superior to that of manual analysis. The automatic method eliminates human error and fatigue, both of which are likely to become more prevalent as the sample batch size increases. Computer facilities required for laboratory automation and economics of glass raw materials automatic analysis are training and recruitment of computer experts. Experience must, however, be integrated into computer use if results are to have far reaching practical consequences. This paper discussed computer - based automation and mechanization of glass raw materials analytical procedures and put forward the advantages of the procedures. It recommended that glass industries should invest in the training of their staff in computer usage.

Introduction

The raw materials used for glass making are numerous and they may be broadly divided into principal and minor raw materials. The principal raw materials are those used in large quantities such as sand, soda ash, limestone, dolomite, feldspar, gypsum, alumina and cullet. The minor raw materials are those used in small quantities, those include: colourants, fining agents, pacifiers, reducing agents, accelerating agents, decolourants and oxidizing agents.

Generally, the better the quality of the raw materials, the better the quality of the finished product. Sand, for example, comes in several grades, which determines the types of glass and the amount of iron content tolerated, viz: optical sheet glass sheet glass (0.2-3 Fe_20_3), common green glass (0.5% Fe_20_3) and dark green glass (3-7% Fe_20_3).

The problem of obtaining raw materials of proper quality can be subdivided into several aspects. First, the proper materials must be selected. Should it be feldspar, dolomite, soda ash, or limestone? Second, the appropriate vendor must be selected. Third, incoming raw material receipts should be monitored to assure that the quality standard is met throughout the manufacturing period. Failure to consider any of these three aspects may jeopardize the quality of the product (Gonah, 2001).

Every glass factory must have a chemical laboratory of a sort, which undertakes both qualitative, and qualitative analysis of her raw materials. Glasswares are also subjected to the same tests to ascertain their quality. In the past, these analyses were performed manually; nowadays analysis is becoming increasingly'more complex and exacting. Analysis represents a service cost and there are obvious incentives therefore to improve the quality, quantity and economic efficiency of the service. Computer-based automation and mechanization of analytical procedures are consistent with all three requirements (Christian, 1994, Gonah, 2001; and Fifield and Kealey 1975).

This paper will discuss computer-based automation and mechanization of glass raw materials analytical procedures as well as put forward the advantages of the procedures.

Computer-Based Automation And Mechanization Of Glass Raw Materials Analytical Procedures

In the past decades, computer technology and design (both analog and digital) and the development of low cost linear and digital "integrated circuitry" have advanced at an almost unbelievable rate. Thus, computers and qualitative electronic circuitry are now readily available to glass scientists and other allied groups interested in instrument design. The computer and integrated circuitry are revolutionizing measurement and instrumentation in science. In general, the material scientist is just beginning to realize and understand the potential of computer applications to chemical research and qualitative measurement. The basic applications are in the areas of data instrumentation on-line data processing and experimental control on and/or optimization in real time (Mattson. J.S. et al, 1974).

As large-scale integration of micro-circuitry continues to evolve, microcomputers replace minis and, with this latest advance in technology, it has become possible to put a computer on every piece of equipment in the laboratory, including the pipette. Where and how the next stage in the evolution of computers will affect glass raw materials analyses is difficult to say, but the scientists will no doubt use the advances to increase their efficiency and improve the quality of information obtained in their work.

There are three factors that enter the computer-glass scientist relationship. First, the glass scientist must be able to formulate the problem and decide if a computer is applicable to the problem. While computers certainly can be greatly misused, an important benefit arising from computer usage is that one must understand the problem and perhaps think about it in a different way than originally conceived in order to apply a computer approach to a solution. The second factor is programming; if they are to become proficient in the use of the new technology. The last factor is the data itself. The glass scientist must use either render the data into computer-compatible form or render the computer into data-compatible form. Both of these approaches are being actively pursued today (Justice, 1981).

Multiprocessor Systems In Glass Raw Materials Laboratory
Automation

Since the mid- 1960s, the field of analytical glass science has made continually greater use of digital computers for compiling and evaluating experimental laboratory data. The reasons, of course, is that computer systems can provide exceedingly accurate and time-savings methods of handling qualities of information. The goal is always to aid the laboratory glass analysts by lessening the efforts of his task expended on recording, classifying, and summarizing the information the glass scientist generates. This form of "laboratory automation" thus frees the analyst from much drudgery and may open up avenues of research previously unavailable because of an inability to handle great qualities of data effectively.

The multiprocessor system, also called the distributed system or simply multisystem, offers an optimum solution to be problem of handling many functions at once. The price/performance ratio of this arrangement is superior to separately implemented systems.

Computer facilities required for glass raw materials laboratory automation.

(i) Hardware

Computer facilities for glass raw materials laboratory automation are similar in most ways to computers used for other applications, except that the laboratory computer has special writing which causes it to branch to pre-assigned location in its own storage when ever specific switches and voltage levels are activated. This storage location will contain the address of the beginning of a programme already in storage where the computer will then begin execution. Thus an event external to the computer (the switch closure) interrupts the computer causing it to execute an action - such as, possible, read a voltage signal from a chromatograph and store it away for future use-other than what it had been doing. The laboratory computer is interrupt-driven.

Since interrupts of this type may arrive at the computer in a random fashion, there must be a method for organizing them so that programs they initiate may proceed to completion should a second interrupt be received before the first has had a chance to be completed. This organizing is called "interrupt control".

Laboratory computers may also have a special device called interface that reads instrumental data and converts it to digital form for the computer to use. The interface can also do the reverse and convert digital computer data to voltage. In addition it is capable of opening and closing switches. These functions can be used to control the instrument or experiment (Klopfenstein 1972, KTC Computer, 2000; Givva, 2000, Nmadu, 1998 and Okeke, 1993).

(ii) Software

The term "Software" normally refers to the "Operating system" which is a program supplied by the computer manufacturers that oversees the operation of the hardware. The term "Operating system" has been used loosely in recent years. A program loader and basic assemble have been called an operating system. On the other hand, a system supporting multiprogramming with task variable in size, priority of execution, and execution time is also v called an operating system.

An operating system may include many types of programs. Among these are the I following.

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- ***Monitor or Executive.*** This is a supervisory program for executing programs on a priority basis, | and control of input/output and bulk storage. If a time-sharing system is used, the monitor also . supervises the batch-processing job stream. A sophisticated bulk storage control program permits files addressable by name, thus relieving the programmer of the task of retaining absolute location] address. Other functions include routines to handle errors that might occur on a hardware unit or during program execution.
- ***Interrupt Control*** This program was discussed previously in the section on hardware for - laboratory automation computers. Its main purpose is to prevent conflicts when multiple interrupts are received.
- ***Subroutine library.*** A program composed of routines to handles frequently needed task such as ! input/output control, arithmetic functions, data conversion, floating points calculations, making : and diagnostic procedures.
- ***Programming language.*** Almost every system has an assembler language. At higher levels of ' program languages, some systems supports FORTRAN, BASIC or PL/Compilers. Higher level I languages, are very useful feature, especially for the scientific programmer who desires immediate implementation of an application programs generally by compilers, however, generally J use more storage and slower in execution than corresponding routines written in assembler. | Recent development where single instructions can expand into string of code. Micro interruptions] can be intermingled with regular assembler instructions.

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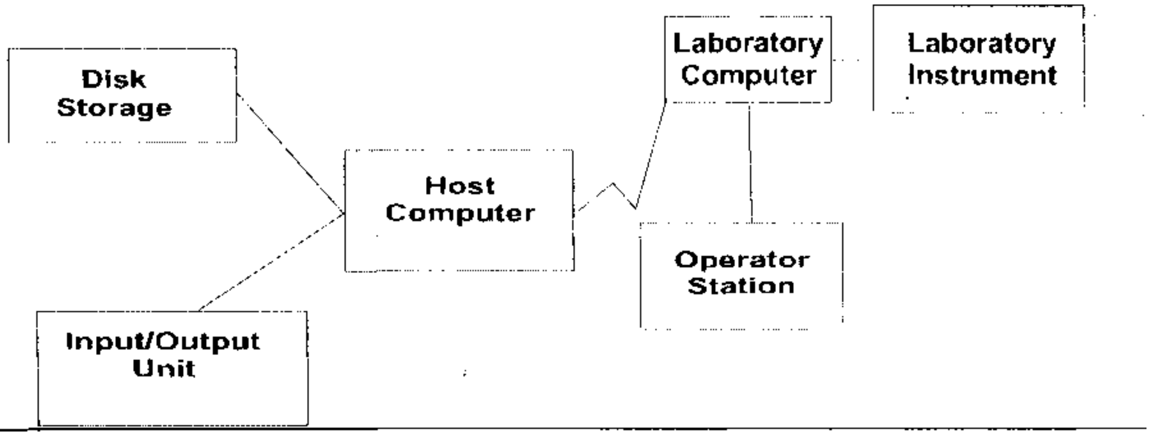
- ***Utilities.*** This facilitates installations and debugging. Furthermore they will be useful when ; changes are made in the application. Basic utility routines include storage dumps of either main or bulk storage, data transfer between input/output units and selected debugging programs to assist programme development. Selection of a computer system. If the nature of the application indicates frequent changes or additions to the programs, a high level operating system should be considered (Klopseitein, 1972; KTC Computer, 2000; Giwa, 2000; Nmadu, 1998; and Okeke, 1993).

(Hi) Multiprocessor Systems:

A system involving two or more computers linked together is called a


Disk Storage
Host Computer
Laboratory Computer
Laboratory Instrument
Operator Station
Input/Output Unit

"Multiprocessor" or "Multisystem". This is illustrated in Figure!.

Figurel: Multi-Process System

The linkage may be either directly wired or via teleprocessing and permits data to be transmitted between the computers. In multisystems as with single, it is the operating system that dictates, at what level the system functions. The two basic levels or types of multisystem that can be identified are satellite and distributed systems.

In the satellite type, a small computer acts as a slave central system that has complete control of the entire operation. The role of the satellite or slave is to provide for the real-time need of laboratory experiments such as data acquisition and instrument control. The other type of multiprocessor system is known as a distributed system. In addition to the functions already described for the satellite configuration, additional software is provided to permits a greatly expanded level of interchanged between the central or host processor and the laboratory computer so that the entire system acts as a unit with this configuration, it is possible for either processor to be temporarily in control of the entire system. An .extension of the standard operating system makes the greatly expanded level of communication possible. There are three categories of operation which encompass various types of information transfer between the central and the remote computer: data exchange, task exchange and program exchange. All request from either a laboratory or host computer must carry with them identification in case more than one laboratory is attached to the host (Kloptenstein, 1972; and Abatan, 1989).

Economics Of Glass Raw Materials Automatic Analysis

Automatic analysis, like other analytical instruments, must be purchased or designed and built within the laboratory. In either case, money is involved and it is standard practice to seek to justify the investment in terms of the advantages, scientific or economic, which will be derived from it. Although scientific advantages may result from the installation of automatic analytical equipment and these are discussed below, the main incentive for most laboratories to convert manual analysis to full or partial automation is economic. The basic cost of an analysis performed manually (C_M) may be expressed as:

$$C_M = F_M (T_S A_S + 1_P A_P + T_M A_M + T_C A_C) \text{------------------------ ----------------------------------} (I)$$

Where T_s, T_P, T_M and Tc Represent the time taken for sampling, pretreatment (physicochemical), measurement and computation respectively, and the corresponding A terms are the fraction of T for which the operator is directly involved at each stage. Thus, A would approximate to unity for operations such as weighing, titration or solvent extraction but would be significantly less for ashing, dying, incubation, etc. F_M is a tariff factor to convert time into money and therefore includes salaries and overhead expenses. The cost (C_A) of undertaking the same analysis under conditions of full automation is:

$$C_A = F_A (T_A A_A + T_M A_M) \text{---------------------- ----------.......——} (II)$$

Where the subscripts A and M refer to automatic analysis equipment maintenance respectively.

Two additional features are evident from equations (I) and (II). Where the automatic method is more rapid than the manual procedure, i.e. T_A is less than T_M, then the capacity .of the laboratory to perform the analysis is increased, and if the laboratory is under pressure to increase its sample through put, then the costing becomes proportionately more favorable to the automatic method. Alternatively, the automatic method will enable a given sample load to be analyzed more rapidly and thereby release staff for other duties. Secondly, although most automatic methods are more rapid than the manual counterpart, equations (I) and (II) indicate economic benefits can accrue even when this is not so. A reduction of the A values is equivalent to saving operator time and provided the reduction is insufficiently large, the operator will be free to carry out other laboratory works. It is not uncommon for a manual method requiring full-time operator attention to be automated in such a way that A_A in equation (II) is very small, say 0.1. In many laboratories increased operator availability represents a benefits as valuable as increased sample throughout and capacity.

A potentially large economic advantage offered by fully automatic analyses is the capacity to perform long runs of repetitive analyses during non-working hours. Depending on the laboratory requirements the additional freedom so gained can be utilized to achieve a more rapid turn-round of samples or to increase the overall analytical capacity.

Advantages Of Computer-Based Automatic Glass Raw Materials Analysis

(i) A well-designed and constructed automatic analyzer can operate reproducibly over long periods. Consequently it may be expected that for the analysis of a large glass batch of samples, its analytical precision will be superior to that of manual analysis. It does not follow that in absolute terms, the automatic method is more precise than the highest performance achievable by a skilled analyst, but the automatic method eliminates human error and fatigue, which are likely to become more prevalent as the sample batch size increases. Note that the precision of analyses performed manually or with simple mechanical aids worsened over the course of a working day, while that obtained with an automatic analyzer remained consistent.

(ii) Of special significance is the timing sequence. This enables reaction conditions to be controlled, hence, improved performance can be achieved where the method involves staged reactions do not proceed to completion or where the parameter being measured is unstable. Separation techniques such as dialysis and solvent extraction, in which recovery of the desired species is frequently incomplete, can give highly reproducible performance in an automatic analyzer and it is possible to employ colorimetric reactions where the colour stability would be considered inadequate for a manual method. Indeed a feature of instruments having closely controlled sequencing such as the ‘Autoanalyser’, is that reproducible results can be obtained even when the analytical reaction is incomplete provided standards are processed in exactly the same way as the samples. This approach can increase the range of potentially useful analytical reactions provided that suitable standards are available. A further extension becomes possible where the automatic analysis is carried out in a close system, in that materials, which are toxic or unstable in air, can be more conveniently processed than by a manual method.

(iii) Computer-based data processing of results from automatic analysers provides savings on manual data gathering and glass engineering calculation time.

(iv) The computer would take over the function of recorders, thereby saving production costs.

(v) For computation of flows, the computer program library will contain accurate conversion equations to relate the measured (analog) variable to the flow. The resulting saving in square root hardware was established to be N200 000.00.

(vi) The ability of the computer to scan and alarm any selected procedure variable would result in savings on applicable electrical hardware.

(vii) The computer system, accurately logs all the important process variable and given the results of important calculations such as yields, efficiencies, and flow rates, these desired data can assist the laboratory analysts, supervisors, scientists and accounting department in having a better feel for the actual operation of laboratory instruments.

(viii) The computer can collect information about the glass plant during upsets. Usually during this upset period, the operators are too busy looking after the glass plant to record process information. However, it is precisely at such a time that this process information can be extremely valuable in obtaining a better insight into the process mechanisms. It can give one a good insight into what the mechanisms in the process are. The development of system models and the glass process analysis required for implementing computer control often results in gaining more exact knowledge of the operation. This, in turn, can lead to permanent improvement in glass product yield, efficiency and quality.

(ix) A computer has the ability to change more than one variable at a time and can readily take into account the interaction of these variables.

(\) An on-line computer collects, measures, and records large amount of data. By the use of specialized techniques, the computer filters and smoothens the data, resulting in much more accurate process information than that obtainable by manual means. The computer can also perform complex calculation to determine such catalyst efficiencies, heat transfer coefficients, etc.

(xi) Improved glass safety where there exists potential explosion hazards or the possibility of runaway reactions, the computer substantially can improve the safety of operations since it continually scans and monitors critical variables in the laboratory and glass process, and can instantly indicate when hazardous conditions are imminent. It can also perform glass materials balance calculations as a crosscheck on the process stream analyzers for flammable limit conditions. Alarms can be given far enough in advance so that corrective measures can be taken to avoid catastrophes.

(xii) The computer output can be used as an integral part of an overall management information system to obtain accurate scheduling and glass inventory control. This information can be punched out on paper tape or cards and then fed to business computers for further processing. This enables plant managers to schedule production more accurately and maintain closer inventory control in multi-product operations. Not only can glass raw material costs be lowered by eliminating surplus inventory, but considerable savings in space, equipment and manpower can also be effected by using these techniques (Albach, 1974).

Conclusion And Recommendation

There cannot be advantages without the disadvantages. However, the disadvantages are no much to the advantages. Computers offer a wide avenue in the complex glass manufacturing industry. Computer today is economical, easy to use and provide analytical capabilities vital to competitive and profitable operations. Areas of improvement range from the inability of the computer-based automated instruments to analyse at times wide variation in composition to the degree of control of the equipment available to the operator is minimal once a run of samples has been loaded into it.

l he computer age is now. In order to avoid costly computer errors, the glass industry must invest in the training and recruitment of computer experts. Experience must, however, be integrated into computer use if results are to have far reaching practical consequences.

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