An Approach to Automatic Oil Field Production Operations

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In today's competitive economy, the problem of managing producing properties so as to achieve maximum profit is becoming increasingly difficult. The problem is compounded by rising costs, production restrictions, widely dispersed operations, and the difficulty of utilizing information regarding operations in time to be effective. Added to these are problems in the area of data reliability caused by weather, limited surveillance of operations, and poor instrumentation that all contribute to the difficulties of both engineering and management personnel in the analysis and decision making functions.

Many solutions to production problems have been achieved. Oilfield automation is a proven method of improving operations, including automatic well testing and LACT. Data Processing techniques have been used extensively to provide production management with useful and necessary information. Computers have been used for years to provide answers to complex engineering problems.

While these methods have contributed to the solution of distinct problems, they are lacking in one respect. They do not provide management with true operational control of the producing operation. This is caused by many factors, but several are quite pertinent. Previous automation installations, while capable of monitoring operations, normally did not have capabilities for automatic processing of results and performance data. There was delay between an event in the field and the reaction in the central office. Data processing reports have normally been historical in nature in that they report a previous month's results well after the close of the month. Again, a delay between the event and the action required. The same effect is present in engineering computation of many kinds, and in most cases available analytical tools have not been used because of the delay in getting results.

Our approach to this problem is to merge the techniques of oilfield automation, data processing, and engineering computations into a single integrated system, whose express purpose is to provide for and meet the needs of production personnel so that they may for the first time have the capability of monitoring their entire operation and can react in time to be most effective. This philosophy of operation makes it possible for a single integrated system to monitor and control remote oilfield operations on a 24 hr. basis, accumulate statistical information regarding the operation, provide data logs, generate routine periodic or exception reports, perform engineering calculations, and serve as data reduction device for corporate processing. In addition, all these operations can be specifically designed for a given operating area. This system is designed for operating personnel and, as such, is available when needed and for the purpose required.

By designing a system composed of functional modules, we can arrange these modules to meet the diverse needs of operating management. Basically, there are three major categories of modules; the central control unit, the communications unit, and the remote units. Notice that these correspond closely to the three major phases of a producing operation; the district or area office, the communication method, and the field itself.

At the central location, the system provides the monitoring and control function, has full data processing and computing ability, is error checked and provides full man-machine and, hence, man-production operation capability.

The communication module is completely checked and can be used on any communication media i.e., telephone, microwave, etc. In addition, a communication module can handle a number of lines and, hence, can provide contact to many widely separated operations.

The terminal module is highly flexible in that it has a variable number of addresses and can use these addresses for such functions as contact sense, contact operate, analog to digital conversion, digital input, binary input, etc. What this means is that this terminal can be configurated depending on need. For example, this terminal can be used for many types of well configurations, testing systems, gasoline plants, stock tanks, etc.

In order to better illustrate the manner in which a system of this type might be utilized, let us examine several of the functions the system can perform.

Production Monitoring and Scheduling

It is possible to monitor and control production on an individual well basis in a large number of fields, regardless of production characteristics; for example, pumping wells, flowing wells, gas wells, input wells, prorated wells, and unprorated wells can be controlled concurrently. Important factors such as performance characteristics, allowables, unscheduled downtime, and others can be incorporated into the production scheduling operations. Variable off-on times are easily handled as well as flow-no flow, and production allocation. The degree of sophistication is entirely dependent upon the requirements. This single function can range from quite simple to very complex.

In addition to the monitoring and scheduling aspects, the system can remotely gather data, accumulate month to date and daily production figures, and generate these on demand or in the form of management reports. Another important aspect is that the system accumulates data as required and stores it in large mass memory for engineering and other uses.

Automatic Well Testing

As the system monitors production it can concurrently test a large number of wells, each with different test duration, if needed. If bad tests occur, the system can automatically initiate a retest using as a criteria previous test information. In addition to testing, the sequencing is controlled with optional manual override. As test data is generated it also is accumulated for future use in reports or engineering analysis. A good example of the power of this approach is that during a given well test periodic results can be generated so that performance as a function of time can be analyzed. This technique would be used to great advantage in designing improved and more efficient production methods.

Secondary Recovery Monitoring

This area offers perhaps the greatest potential in improving production and recovery. The system makes it possible for the engineer to monitor, evaluate, and control water floods as never before. Injection characteristics such as sweep patterns, sweep efficiency, water cuts, production, allocation, all achieve new meaning in this system. Because of the large amounts of data pertaining to waterfloods, this system is ideally suited to provide more opportunity for production increases.

The above functions are what might be described as on-line; however, the system also has complete capability for off-line computing and analysis in the areas of engineering computation, statistical analysis, data reduction and report generation. Remember that these areas are all strengthened by the fact that the majority of operating data is contained in the system and is available for use.

The schematic in Fig. 1 illustrates the basic system organization.

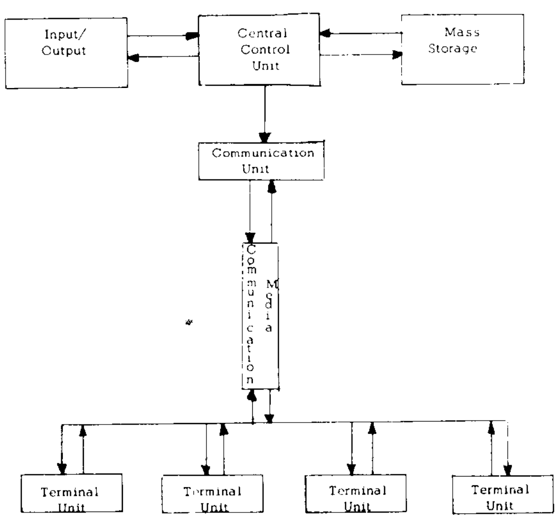


FIG. 1 Basic System Organization

The following definitions apply to Fig. 1:

Input/Output - Provides the means of man-machine communication at the local level. Options include card, tape, typewriter, or display.

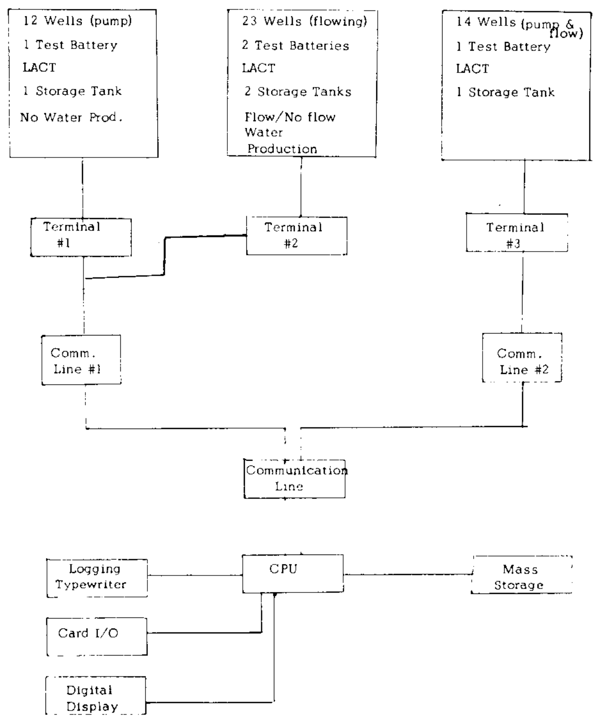
Central Control Unit - Contains the stored program logic required to provide full system flexibility. Arithmetic ability, error checking, control console, register, and large memory are its main characteristics.

Communications Unit - Provides the interface between the system and the communication media. Performs automatic polling of terminals and is error checked to guarantee reliable transmission.

Terminal Unit - Provides contact with the operation itself and is modular in that each terminal may have a different configuration of function and addresses.

Mass Storage - Contains operating programs that are not in use, historical data, and off-line programs that may be required.

Applied to an actual operation the system would have a configuration that might appear as shown in Fig. 2.



Note the variety of conditions at fields 1, 2, and 3

FIG. 2 Application of Basic System Organization

An important consideration is that if in the above schematic we wish to add 5 more fields to the system, the only change would be that 5 additional terminals are needed. No equipment need be added at the central location. In other words, the majority of the logic required in the system is at the central location and is so flexible that changes in the terminal configuration are incorporated easily through program modification and not hardware changes.

As a final illustration of system capability, Table 1 shows possible types of outputs that can be obtained from a full scale district operating system. For simplicity we have broken the output into two categories; data logs and control reports.

DATA LOGS: (Routine or on Demand)

- 24 Hour Production
- Month-to-date Production
- Well Status
- Test Status
- Well Test Summary (24 Hr. Basis)
- Alarm Status
- Individual Well Production

ROUTINE REPORTS:

- Monthly Production
- State Allowable
- Well Test Summary
- Well Test File
- Production History
- Waterflood Summary
- Downtime
- Well Status

And Many Others as Required

Table 1. - Possible Types of Outputs Available From Full Scale District Operating System

In summary, it should be stressed that our oil field operational control system is not just an oilfield automation system, is not just a data processing, is not just a technical computer, but rather is all three of these combined. The combining of these characteristics makes the system a powerful new management tool and provides a new concept in the management of today's producing operations.

This is apparent in several ways. First, it makes possible the automation and remote monitoring of producing areas that, by themselves, could not economically be justified. Previously only large fields have been candidates for automation. Now by using the terminal modules, not only large fields, but small isolated leases can be included in the system. By this procedure it is possible to incorporate over a period of time an entire district operation, starting first on a selective basis and then adding terminals as the system evolves.

Another interesting aspect is in the area of manpower utilization. One possibility is to use the system for district monitoring and to then dispatch maintenance manpower as alarms occur. This procedure, when combined with routine maintenance, makes possible the more efficient use of manpower. Engineering manpower is obviously made more effective through the availability of more reliable and accurate data, historical files, and a tool for engineering analyses in related areas, such as well analysis, decline curve analysis, waterflood calculations, economic forecasting, and others. All of these factors when combined must add up to improved operating control, and hence increased profits.