REMOTE PRODUCTION MANAGEMENT SYSTEMS (RPMS)

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INTRODUCTION

Remote production management systems involve several basic configuration components. These components can be thought of as building blocks comprising a system. For the purpose of our discussion we will represent or conceptualize major components and their respective detailed facilities by means of block diagrams.

GENERAL DESCRIPTION

Telecommunications Configuration

The arrangement of reliable and efficient communications between central host operational management facilities and the intended remote production facility locations is one of the most important considerations in determining the extent of decentralization and the types of organizational structure or levels of system architecture in the design of complex RPMS systems. It is the key to success.

Our discussion will be limited to those essential communications mediums which are most readily available and whose anticipated costs allow the most widespread application geared to small to medium-sized production operations.

Radio Communications

The most easily implemented and readily available means of communications between central management locations and remote production or transport delivery facilities within a radius of up to approximately 50 miles is UHF or VHF radio.

Radio equipment manufactured for these purposes is somewhat similar in appearance and operation to mobile or citizens band radio systems. The significant functional difference is that these radios are intended primarily for voice communications, whereas RPMS radio systems are primarily designed to permit high integrity data transmission between the central management system host computer and the remote production facilities local micro-processor based RTU's.

Telephone Communications

Telephone access lines are usually available within reasonable distances of remote locations near metropolitan or other urban areas of relatively high population density. When telephone lines can be brought to the remote location directly, they provide a highly reliable and efficient means of transmitting low to medium speed data between the central and remote facilities.

Telephone/Radio Combinations

There are many instances in which telephone facilities can provide the most reliable and cost efficient method of reaching to within radio distance of a remote production or transport facility location but cannot be extended to the facility itself in a timely or cost efficient manner. In these circumstances, combination facilities are readily available and can provide high-quality service if properly designed.

Dedicated Cable

Dedicated pole-mounted or underground cable installations are certainly available and can provide high-quality, trouble-free service in situations where they are economically viable for the duration of their intended use.

Central Location Functions

The scope of functions which might be included in any configuration involving one central location with operational responsibility for a number of remote locations either individually or in a structure of subordinate clusters could provide complete profit center management or could provide only a remotely monitored pumping unit controller capable of optimizing pumping cycles versus wellbore inflows and capable of detection of malfunctions which might cause costly repairs and unnecessary lost production.

Operationally the central location provides three primary services to the working interest owner and royalty owner; i.e., management, production, and maintenance services.

Management Services

Obtaining information continuously about the functional performance of production or transport equipment and facilities and the use of that information to optimize coordination of interaction between production activities, maintenance activities, and other support activities is the principal function of management.

Remote production management merely utilizes combinations of human and material resources in configurations which more continuously and more dynamically optimize that same coordination with significant economic benefit.

Maintenance Services

Because information is being obtained continuously regarding a large number of activities at different locations, it is essential that interruptions in the flow of that data be avoided. For this reason, quality of maintenance as well as quality of equipment and facilities are necessary to ensure the greatest success.

From the production standpoint, this type of maintenance might be considered a support activity because it involves additional tools and techniques which may

require a reasonable time for production personnel to acquire. (Persons having completed any of the petroleum technology curriculums available in West Texas would have little difficulty understanding the functions of the equipment, and this might also be the case with many currently active pumpers, etc.)

Traditional wellsite or battery maintenance activities include various personnel both inside the firm and outside. It is the objective of continuous information flow to enable each necessary or advisable action to be taken in a manner that would reasonably optimize the pace and the variety of maintenance tasks that would lead to the greatest return on royalty and working interest investment.

Remote Location Functions

RPMS functions performed at the remote location include gathering information, processing information, taking actions, and storing information for transmission to the central location when desired.

Gathering Information

Gathering information is a primary ingredient of management. This information is obtained by electronically monitoring the behavior of a variety of sensory instruments. These instruments include digital and analog measuring and monitoring equipment for temperatures, pressures, capacities, flow rates, functional status indicators, and many others.

Processing Information

Processing of information gathered is accomplished by local micro-processor, which constantly evaluates the relationship between different data to ensure that essential interactions represented by those data operate within the prescribed limits determined by the central location.

Initiating Actions

Actions are initiated by the micro-processor whenever limits are violated. These actions might include starting or stopping a piece of equipment, modifying the rate at which some event occurs, opening or closing one or more devices in a particular pattern, etc.

Formatting and Storage

Information is stored for the use of the central location and is transmitted at desired times. A configuration may include the capacity to both originate data flow and respond to requests from the central location.

CENTRAL LOCATION FACILITIES

Central Computer Hardware

The major economic benefits of RPMS have in large part been made possible by technological changes in computers. Reduced costs of computing power have made practical the assimilation, processing, and control of very large amounts of operational data with relatively small, inexpensive central location computer hardware.

Primary Processing Computer

The primary processing unit in the central management facility can include one or more production or process control workstations. These workstations are interconnected with external telecommunications facilities and also interconnected with other management workstations utilizing various parts of the same data base. Because reliability and data integrity are so important, the multi-station approach can be beneficial by ensuring that backup units are continuously available in the event of individual equipment failures. These primary process workstations need only have adequate capacity for those processing functions that involve on-line activity; i.e., communications polling of remote units, transfer of polled data to appropriate files, and the detection and processing of data which falls outside prescribed parameters.

Disk Drive Memory

Each workstation should have access to one or more disk drive facilities for the storage of data files and operating software. These memory devices should be sized to accommodate the complete central software package and full operating data base for all responsibilities contemplated.

Peripheral Devices

The list of necessary workstation peripheral devices would include display monitor, printer, graphic plotter, and communications modem(s) as appropriate. Quantities and specifications for these devices would be determined by evaluation of available combinations versus those functions to be comprehended by each workstation.

Central Computer Software

Software development for the central host computer is virtually certain to be the single most important task in terms of cost and complexity in planning the implementation of any RPMS system. Three fundamental areas of activity require substantial software development. These are interactive telecommunications routines, primary analytic processing of data obtained from remote production or other facilities, and automation of desired reporting and control function.

Telecommunications Routines

Because a variety of different communications methods may be employed to transfer data between the central computer and each of the remote locations and because different types of local RTU's may be utilized depending on the requirements of each remote location production process configuration, the highest importance must be attached to smooth, efficient, and reliable communications flows.

Analytic Processes Routines

Primary analytic functions of the central computer facility include preparation of remote production facility files containing sufficient relevant data to compare production design criteria with historical and ongoing data parameters appropriate for each separate remote location.

Natural Gas Example

For natural gas transmission metering run this would include all the computational variables affecting the volume and composition of natural gas compounds under continuous sampling.

Oil Well Example

For aided recovery systems in oil well production this would include pertinent completion data and reservoir analysis, as well as surface equipment and down hole equipment design specifications, in addition to operational variables being monitored continuously.

Reporting and Control Routines

The display and printing or graphic representation of items or sequences of significant operating events as they are recorded or evaluated by both the remote micro-processor and the central computer require software which is designed to illustrate the effects of interactions between uncontrollable variables in the production processes and those controllable parameters whose effect is intended to optimize production.

In addition to the equipment-oriented reporting and control software functions are those related to the capital and expense budgeting of human and material resources associated with the overall responsibility for each management center.

The extent to which field reporting of downhole production (as a function of production transfer or treatment in relation to tank capacities and custody) is securely automated and the extent to which RTU's are utilized to input data of a personnel and maintenance nature will greatly affect both the magnitude of software development and the level of decision responsibility between the central location and field personnel.

Central Communications Facilities

The primary components of central communications facilities are computer workstation multiplexers, communications interface modems, base station radios, and telephone lines.

Multiplexers

Multiplexers are devices which enable the interconnection of workstations, memory disk drives, modems, and peripheral devices for multi-user access to software routines and data base files.

Computer Interface Modems

The primary communications interface between central computers and any radio, telephone, or other transmission medium is called a modem. It is the function of the modem to translate information from a form that is suitable for internal interactions within the computer or between workstations and peripheral devices into another form which is suitable for a particular means of transmission. Smart modems are available which can be independently programmed or directed by the central computer to alter their protocol according to the needs of particular remote destination communications equipment.

Base Station Radios

The modems are then interfaced to individual transmission base station radios for selected remote destinations or are interconnected to multiplexed or bridged configurations for multi-application use to reach a variety of remote destinations and transmission modes. Base station radios may be designed to transmit and receive data only, voice only, or a combination of data and voice communications.

Radio Repeater Stations

Radio repeater stations are utilized to extend the range of base station radios or to extend from a remote telephone line to additional locations within radio range.

Central location base station radios may be configured to operate through commercially available repeaters installed at various geographic locations on high transmission towers. These tower access services enable coverage of wide areas of terrain because of their height, and in most cases a monthly recurring charge based on height and/or usage is levied.

Many users of multiple channel radio system base stations erect their own towers in configurations convenient to the central computer facility to minimize transmission losses and to tailor systems to their own particular needs either as independent tower-mounted systems or in conjunction with repeaters owned or leased from others.

Telephone interface systems vary in design complexity depending on both available telephone facilities and the needs of a particular remote destination.

Virtually every conceivable production facility is capable of some acceptable form of communication at reasonable cost.

REMOTE LOCATION FACILITIES

The facilities of interest to the RPMS system include sensing and control devices, data processing and memory storage devices, and communications facilities.

Remote Sensing and Control Devices

These devices are considered here together even though sensing devices differ from control devices in that while control devices are able to respond dynamically to instruction from the remote micro-processor, the sensing device merely transmits data it is receiving without the ability to modify any action. They are similar, however, in that they comprise almost the same range of instrument function.

Transducers

Transducers in general are devices which translate phenomena which obey the general laws of physics into quantifiable electrical voltage or current impulses. The transducers used in simple RPMS systems include temperature, pressure, and tension transducers and transmitters.

Status Indicators

Many of the important position or status indications needed for successful RPMS operation are derived from switches, lamp circuits, rotary or rectangular motion detectors, or other devices which are capable of either analog or digital status representation.

Accumulators

Accumulators are devices that count. They are used for the measurement of time, rate, or quantity. All of these are encountered in RPMS.

Electromagnetic Devices

Although this is actually a subcategory of the others, it is particularly related to the control functions in that it provides a means of translating a message of data into an action causing equipment to modify its physical condition or position. These devices comprehend almost the entire scope of industrial activity. If a little imagination is applied, the engineer can usually find a method suitable for his needs.

Remote Data Processing and Storage

Remote data processing and storage are essential to successful RPMS functions between of the infeasible costs associated with on-line communications facilities between the central computer and the remote location. The primary roles the local micro-processor plays are detection of equipment malfunctions, detection and recording of production variables out of their normal parameters, and the continuous recording and storage to memory of those data which will be sent to the central computer upon request.

Malfunction Processing and Storage

Although detailed analysis of basic production process source signals might accomplish the same purposes, it is usual for the largest number of sensory devices to be installed to monitor specific actions of industrial equipment to provide the earliest possible remedial action to avoid excessive repair costs or lost production. For this reason key items of production equipment must be capable of modification immediately without central computer or field personnel intervention. In these cases the sensory device provides a means of feedback to verify that processing an instruction to the control device resulted in the equipment modification intended and that the effect of the change was sufficient to achieve its intended purpose. These actions together with their results must be recorded in a manner which allows their reconstruction by the central computer.

Production Processing and Storage

Production variables include temperatures, pressures, rates, volumes, densities, chemical properties, voltages, currents, etc. Selected combinations of these variables are interrelated in predictable ways as a result of the production facility design and the laws of physics (or OSHA). For example, the rate of flow into a vessel and the time required to reach a certain fill capacity in the vessel are related in a fixed, predictable manner. These relationships enable the local micro-processor to initiate appropriate actions without direct supervision from the central computer or field personnel and to record and report those actions in accordance with the priorities assigned to them.

Control Processing and Storage

The housekeeping functions of receiving, processing, storing, and transmitting information under supervision of the central computer are complex by themselves. They are vitally important and must be carefully designed.

Remote Communications Facilities

In most instances the remote location facility will be a mirror image of the central transceiving facility. In some cases, however, combinations will differ in how the remote unit reaches another form of transmission facility. Each facility will include a modem interface with the micro-processor, a modem interface with the radio, telephone, or other transmission medium, and each will include a source of

power sufficient to sustain communications capabilities for any period of anticipated power outage due to weather or maintenance effects on lines.

Remote Modem Interfaces

Recent advances in technology coupled with market demand have caused most manufacturers of remote applications equipment for RPMS to be designed with built-in communications modems capable of both voice and data transmission and reception. Nearly all are somewhat intelligent and very reliable at moderate cost.

In some cases the micro-processor may require a separate interface if it does not provide a commonly used protocol.

On the transmission side, many modems provide for programmable configurations to interconnect with a variety of radios or wire cable pairs or telephone lines. Not all, however, are capable of tasks like answering or terminating a telephone call. These matters are considered on a case by case basis because cost differences may be significant.

APPLICATIONS CONSIDERATIONS

Practical application of this newly available technique for remote control functions is beset with many potential pitfalls which cannot be entirely avoided even by the most careful planning. The following sections will attempt to raise some of those frequently encountered pitfalls.

Economic Considerations

RPMS is no longer an experimental idea for many processes and in particular has been widely successful for certain tasks in the petroleum industry. Not every remote function can be economically included in the sort of systems configuration contemplated here. There are certain minimum capital and recurring costs associated with any basic central computer hardware and software project, any remote location facility project, and for any interconnecting telecommunications project. Some of these ballpark costs will be illustrated here.

Central Office Hardware Costs

The actual hardware required to implement a simple small scale project for remote production management still needs the basic components described in the section on Central Computer Hardware in CENTRAL LOCATION FACILITIES. The use of good quality PC micro-computers and related peripheral and other devices can now be achieved for central location hardware costs of approximately $15,000 to $25,000 for the initial workstation and approximately $3,000 to $10,000 for additional workstations depending on their complexity.

Central Office Software Costs

It was indicated in the CENTRAL LOCATION FACILITIES section on Primary Processing Computer that the most difficult and costly portion of an initial RPMS project development would likely be the software preparation and debugging. Vendors of remote facility RTU's and controllers usually can provide considerable assistance to programmers in developing protocols for interacting with those units and for understanding the various methods they have used to accomplish analytic and control processing. This kind of assistance aids but does not diminish the magnitude of overall data management implied by integrated operations for RPMS. As a rule, the software development should be expected to cost at least twice as much as the hardware.

Central Office Communications Costs

The initial primary base station radio configuration with all necessary features should be expected to cost between $5,000 and $10,000 for hardware with an additional $2,000 to $5,000 for each add-on system. Labor costs for installation, frequency coordination, and testing should be expected to approximate the costs for hardware.

Repeater Station Costs

Costs for repeater facilities depend on whether tower space is rented from others or whether dedicated facilities are contemplated. In the case of rental tower space the principal cost is for purchase and installation of the repeater radios and associated power and cable facilities. These costs should be expected to fall in the $5,000-$10,000 range or sometimes less.

Remote Facility Hardware and Installation Costs

Costs for remote RTU's or controllers which include the capabilities described in the sections above should generally be expected to fall in the range from approximately $3,000 to $15,000 depending on capabilities and quality.

Remote instrumentation required to bring appropriate data sources to the micro-processors and to enable controls to be implemented should be expected to cost from a few hundred to a few thousand dollars each depending on both the reliability required and the complexity of the phenomena measured or process to be controlled.

Installation Considerations

Because all electronic equipment likes to live in cool, quiet, vibration-free, and electrical interference-free environments, there are certain installation considerations essential to long-term operating success.

The topics that follow are not comprehensive, but long experience has taught the writer to pay close attention to them.

Mechanical Installation Integrity

The troubles that baffle us the most and those whose intermittent character renders them the most time consuming to discover are virtually always due to poor installation quality control with respect to mechanical assembly, electrical assembly, proper tools, and proper attention to detail. Nearly all production processes involve vibration and shock. It is therefore of primary importance that each mechanical assembly or fitting be secure enough to prevent unintended motion.

Electrical Installations Integrity

As in the case of mechanical assemblies, the most frustrating difficulties involve insecure connections or assemblies.

The additional factor involving electrical connections or signal path connections is the fact that every partial or insecure connection acts as an antenna to attract interference from electrical power lines, from electrical equipment, from unwanted radio signals, or other noise sources.

Electrical Grounding Integrity

Proper design of grounding or earthing systems, as well as the integrity of their interconnections to equipment chassis are essential to trouble-free operation and also essential to avoid equipment losses from power line transients and lightning storms. Ground loops and ground faults can be avoided with careful design.

Radio Signal Propagation Variations

Certain radio signal variations occur seasonally due to electromagnetic or meteorological phenomena that are not well understood. These effects can sometimes be of great magnitude and cause disruptions in data transmission if not considered in communications link or system design. Usually a careful signal path survey and conservative design will prevent problems of this kind.

Operational Considerations

Generalizations are perhaps not appropriate here, but several recurring issues have significant impact on the operational success of new RPMS installations. These include insufficient personnel orientation, insufficient direct personal contact between central location personnel and on-site field personnel, and insufficient training of central location personnel in actual production processes.

Field Personnel Orientation

It is typical and to some extent unavoidable that the value of detailed orientation of personnel regarding future activities that they may be required to participate in are underestimated. Many otherwise sound and beneficial projects

have failed because insufficient orientation was provided to enable operations personnel opportunities to participate in the implementation planning and execution.

Because RPMS is such a valuable tool for field personnel in optimizing their respective production performance, knowledge and experience in its possible uses in the hands of field personnel provide the most obvious source of performance improvement ideas if properly cultivated.

Personnel Isolation

One tendency that is hard to systematically overcome is the reliance of central location personnel on RPMS data alone. The fact that large amounts of current accurate and useful data are being received continuously regarding the remote production processes tends to promote reliance on that data alone. RPMS does not cover all the bases, and it cannot perform all the duties nor comprehend all the problems and opportunities that field personnel can only communicate effectively at first hand. Conversely, field personnel cannot fully comprehend or appreciate the complexities of functions performed or perspective of management needs at the central locations unless those of communications needs are expressly satisfied in a systematic ongoing program of direct contact.

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ACKNOWLEDGMENTS

My whole career has systematically contributed to a perspective of management that has led to this involvement, and I cannot think of a single associate who has failed to make some lasting and beneficial addition to the steps along that path of either a technical or operational nature.

Special stimulus was given me through association with the following friends: Mr. Ed Poulter, Midland College; Mr. Dean Woodward, Mr. Allen Lindsey, Mr. David Hidinger and Mr. Russell Strait, all of Automated Oil Production, Inc.