BENEFITS OF USING AUTOMATION SOFTWARE FOR OIL PRODUCTION OPTIMIZATION

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Introduction

The optimization software and automation principles discussed in this paper have been implemented in fields with as few as 20 wells to fields with well over 3,000 wells. These installations have been made in primary recovery fields to tertiary recovery fields undergoing water, CO_2, or steam flooding. These systems have been installed in new fields with no automation in place and in mature fields, which have been automated for over a decade. Over the history of all these installations, we have documented the benefits and rationale for implementation of these types of systems.

The paper describes the cash flow enhancement benefits of implementing a comprehensive production automation optimization system in the following different categories:

Increased Production

Reduced Operating Costs and Well **Failures**

Individual Well Management

Efficiency in Field Operations

Efficiency in Computer Operations and Automation

Conclusion

Increased Production

Fine-Tuning Wells As Well Behavior Changes

The analytical features of the automation system allow the user to make changes to the operational parameters of the wells. Changing the pump-off point is an example of a parameter change that can be used to fine tune production. By monitoring the performance of the well on a daily basis, the operator can make small changes to the pump-off point that can decrease the span of fluid level fluctuations.

The system provides both surface and downhole cards for detailed analysis (Figure 1).

In addition, using the various optimization tools, lower operating fluid levels are often achieved, which increases total fluid production. Assuming the same oil cut is applied to this increased fluid production, recovery of oil increases on a proportional basis.

Increased Runtime / Decreased Downtime

The concept of managing wells by "exception" promotes the ability to keep downtime to a minimum in two ways. First, when a well does go down, the operator *can* be notified immediately – even if the operator is off the property. Second, these automation tools provide indications that a well may be heading toward a failure of one type or another. With the second case, the user *can* prevent downtime rather than react to it by correcting the factors that are leading the well into a failure condition.

Early Detection Of Production-Robbing Problems

Problems that reduce the production of a well can be seen through trends and displays of historical data. By examining the downhole card of a beam-pumped well, a user of the system can identify problems such as traveling valve and standing valve leaks, barrel / plunger fit, friction, unanchored tubing, and gas compression.

Design Wells For Optimal Performance

The system provides tools for designing beam pumps and submersible pumps. By using "what-if" analysis, the user of the software can experiment with different parameters in a virtual environment before actually making changes in the field.

From the combination of increased runtime along with pumping installation optimization, this type of software typically improves production in the range of 2% to 10%, depending on the current producing conditions.

Reduced Operating Costs And Well Failures

Reduced Electrical Costs By Optimizing Pumping Unit And Motors

A comprehensive production automation system goes beyond a basic SCADA system's ability to merely monitor and report on the data from wells. Analytical tools are built into the software so a user can perform a detailed analysis on the data without moving the data into another product.

For beam pumping installations, the user can evaluate different pumping units and motors, as well as over one hundred other parameters in a virtual "what-if" scenario (Figure 2). Rather than actually making the expensive changes at the well, the optimization software provides the user with a way to compare various parameter changes so the user can optimize each installation for pumping unit and motor size, rod design, or displacement matched to inflow.

Additionally, the user has the ability to do "what if' analysis in designing or redesigning beam wells.

From our field experience and customer dialog, the installation of a comprehensive automation system (and optimizing electrical usage) will reduce total field electrical consumption in the range of 10% to 30%.

Reduced Routine Shooting Of Fluid Levels

By taking advantage of the wave equation for downhole analysis, the optimization tools can provide an accurate calculation of the fluid level of a beam-pumped well based on loads from the downhole card (Figure 3). The time and expense of regularly shooting fluid levels can be greatly reduced. Historical trends of calculated fluid levels are also possible.

The system can display the calculated fluid above the pump (FAP).

Reduced Chemical Costs By Optimizing The Chemical Treatment Plan

In a comprehensive automation system, the user is provided with card area trends. This trend is an excellent way to track any change in downhole conditions, including friction at the pump. If the trend is on an upward slant, it is an indication that friction is increasing. Experience with individual wells using this trend enables the operator to better schedule maintenance such as chemical treatments and pump changes.

The area of the surface card is displayed in a chart for easy analysis (Figure 4).

Chemical Treatments Are Less Frequent But Effective

By frequently analyzing the performance of the wells and incorporating a well analyst's experience with the historical information provided by automation software, the user has accurate information that can help in more efficiently scheduling chemical treatments.

From our field experience and customer dialog, the installation of a comprehensive automation system (and optimizing chemical usage) will reduce total field chemical consumption in the range of 10% to 30%.

Diagnose Problems Without Pulling Rods Or Tubing

By fine tuning the rod pump controllers, the optimization tools allow the user to minimize rod stress and fluid pound. Another less tangible benefit is the ability to prioritize well work in the field to optimize rig usage and rig timing. The necessary information becomes immediately available from the well to your desktop. Many problems and their causes are obvious based on the data received from the well. Examples of these include:

- Pump Wear
- Excess Friction
- Rod Overstress
- Gas Compression
- Gearbox Overload
- High Fluid Level Detection
- Tubing Anchor Slippage/ Movement

From our field experience and customer interaction, the installation of a comprehensive automation system (and correct diagnosis followed by the appropriate corrective actions) will typically reduce repair and maintenance expense by **10%** to **30%** per year.

Reduced Pump Failures In ESPs

Most ESPs fail because they are not sized correctly initially, or more commonly, the reservoir characteristics change over a period of time. For example, if the fluid becomes gassier, the pump can operate in a sub-optimal manner. The comprehensive automation system provides a design tool to more accurately design the initial pump installation and an analysis tool to identify changes in reservoir characteristics, so the operator can make decisions concerning future operational design changes, if needed.

The system allows a submersible pump to be designed or redesigned in a virtual, what-if paradigm (Figure 5).

It can provide detailed analysis of ESP performance based on real-time data (Figure 6).

Individual Well Management

Well Management By Exception

Rather than requiring an operator to examine each well's status every day, the concept of management by exception is used to provide information about anomalies in alarm or color-coded fashion. The software alerts the user to any parameter that is out of an ordinary operating range as defined by the user. This allows the user to focus on prioritizing recognized problems, rather than searching for problems that may or may not exist.

Early Detection Of Well Performance Degradation

By monitoring the runtimes of each well in a field, the first indication of a change in the operating conditions of the well visually prompts the user for proactive corrective measures. Further inspection may show an increase in the area or size of the card, excessive gearbox toque, and a reduction in the rate of fluid pumped, etc. For ESPs, trending anomalies in amperage, voltage, and pressure unbalance give early signs of system degradation. The information presented from each of those indicators provides the user with a strong start in recognizing problems at an early stage and taking appropriate measures to fix them.

Comparison Of Well Test To Theoretical Limits And Target Values

Users of an automation system have the ability to use information from different parts of the production operation to evaluate the state of the wells and production facilities. The well test information can be compared to the calculated fluid production of each well, and the total from the wells (feeding a particular facility) can be compared to the actual metered sales from that facility.

Notification Of Wells Operating Out Of Parameters Based On Artificial Lift Analysis

Beyond exception notification from RTU parameters, the automation system provides notification and alarms based on the analytical calculations performed within the software.

Early Detection Of Changing Wells Due To Automation

Alarms can be programmed to alert users that a well has begun to run too long or not long enough. The user can even be alerted after hours through call-out programs that can page or call with information about the alarm.

Routine Management And Reporting

These modules provide historical reports and graphs that represent normal operating conditions for a well. Since this data is a part of an overall database, it can be used for calculating accurate production data. The installation of a comprehensive automation system (and operating by exception) will redirect manpower to better focus on corrective and optimization measures. This prioritizing of operations staff time and redirection of the existing personnel to work on immediate needs is effectively equal to hiring additional staff.

Typically, effective manpower improves beyond the pre-optimization application to a point where this (effective manpower) can offset new expenses to maintain RPC / RTU equipment.

Efficiency In Field Operations

Reduced Windshield Time

Since data is presented "on-screen" in the production office, and is presented in a way that facilitates easy scanning of a large number of wells, companies that use automation software have found that they can substantially reduce the time necessary for someone to visit and personally inspect each well. Wells still need to be visited, but site visit frequency can be reduced substantially, which frees personnel for priority problem solving or other proactive activities. From past experience, site visits to each well have been reduced from daily to weekly or monthly, depending upon the operating philosophy of individual companies.

Two examples of cost reduction in "reduced windshield time" include: 1) more effective dynamometer collection and 2) more effective fluid level collection.

More Effective Dynamometer Collection

Assume that a well analyst can make 400 "on site" dyno runs per year, or an average of about 8 surveys per week. Assume the total cost of dynamometer collection for one year is $48,000 or $120 per dyno survey. Further, assume that the same well analyst can analyze 100 wells using dynamometer surveys gathered by the optimization software <u>in one week</u>. At 12 times faster collection pace per year or 4,800 dyno surveys, and using the same $48,000 annual survey cost, this would equate to a per dyno cost of $10 ($48,000 / 4,800). Instead of analyzing 400 wells in a year's time, simple math dictates that 4,800 dyno surveys can be taken using the optimization software during the same one-year period.

Figure 7 depicts this example as a one-year phase-in redistribution of well analysts' time.

The real advantage of this example is time redistribution, which could then take the form of 1) more analytical time for optimizing lift equipment, 2) proactive maintenance of RPCs, RTUs, and PLCs, and 3) attention to those remote or "low impact" wells, not previously covered by the dyno surveys.

Often, just the collection of well data on so-called "low impact" wells will reveal inappropriate operating practices, which can present upside opportunities, dramatically reversing the prevailing perception of remote wells or fields.

More Effective Fluid Level Collection

Assume that a well analyst *can* shoot 10 fluid levels per day and charges $17.50/hour. Over one year, the total fluid levels collected would be approximately $33,600 or about $14 per fluid level collected. Assume that 100 calculated fluid levels per week are collected by using calculated fluid levels gathered by the optimization software. Over a one-week period, twice as many fluid levels are collected. Therefore, the fluid level collection cost would drop to about $7 each.

Assuming the same one-year phase-in as before, Figure 8 depicts the relative savings or time redistribution. This redistribution of time could be better utilized for optimization of lift equipment.

Alarm Notification And Management

Reduce or eliminate answering services

The comprehensive automation software is integrated with current state-of-the-art call-out systems. These call-out systems take over the role provided by the answering services. An answering service typically only helps in calling people when problems are detected by automation systems. Automated installations not only provide detection but also provide more specific information regarding the cause of the problem, enabling field personnel to make improved decisions in *case* of emergencies. Because of the client/server solution, personnel can also take corrective action from their homes.

Reduce or eliminate 24 hour duty

An operator can be paged or called after hours because of an alarm and be given information about the problem. More than that, the operator does not need to leave his home to get detailed information about what is happening at the field. He can use one of the remote dial-up programs or Windows NT's RAS service to connect to the system remotely and see this information.

Comprehensive power management system to reduce electrical costs

For almost all oil fields, electrical costs account for a substantial percentage of the operating costs. Because of the flexibility in configuration and various optimization tools, operating companies have used the following solutions to help reduce their electrical costs:

By using the information provided by the automation system, scheduled shutdown of intermittent pumping wells during peak power demand can optimize power consumption, saving considerable expense. The customized startup of wells can aid in controlling spikes in power consumption after a power shutdown has occurred. In essence, this becomes a reverse peak shaving scheme to reduce power consumption during general peak usage.

The optimization software can be used to ensure power utilization at any given time does not cross a certain threshold, thereby benefiting both the operating company and the power company.

Advanced Field Control Reduces Fluid Spills And Loss Prevention

Because the optimization software is an integrated field system, it allows for field wide control that is typically not present in other SCADA systems. For example, it included several standard control features for an oil and gas field, such as shutting down wells when tank levels are exceeded and controlling injection volumes in conjunction with tank levels based on pressure and volume set points.

As a result of this advanced capability, the operator has a higher level of confidence in detecting leaks and avoiding the costs associated with clean up of oil or salt water spillage. The operating company also spends less time addressing issues with landowners, landmen, lawyers, and negotiators.

Daily Production Reporting

A comprehensive daily production support is provided, which illustrates estimated production based on the downtime and the last known good well test of each well, shrinkage analysis by comparing the tested production to LACT meter readings, and estimated lost production due to downtime of wells.

Current information about daily, weekly, and monthly field and well production is shown in Figure 9.

The production summary report can be obtained daily for different areas of the field or the whole field. Based upon the information presented in the production summary report, field management and personnel can better optimize their resources and prioritize which areas need attention.

Proactive Maintenance Versus Reactive Maintenance

Since the optimization software helps identify problems before they occur, field personnel can be proactive on field maintenance work. For example:

1. Tubing anchors that are not holding, do not have enough tension, or that are slipping can be identified and tagged for immediate correction. Such proactive maintenance will prevent actual production losses, rod and tubing "friction" failures, and possible casing leaks.
2. Daily examination of data for gearbox overloads or rod string overstress can prevent expensive failures through proactive correction and/or optimization.

Efficiency In Computer Operations And Automation

There are several features in a comprehensive automation system designed to reduce the ongoing costs associated with day-to-day operations in an oil and gas field:

Reduced Installation And On Going Maintenance Costs

Adding wells, facilities, or RTUs to the system is a simple task that can be done by the on-site user of the system. This reduces the amount of time that personnel must be on location during the initial set up of the system and eliminates the need for support when new wells, facilities, and RTUs are added to an existing system.

Reduced System Administration Requirements

Production operators are provided with an administration tool that can be used for many system changes and as a trouble-shooting tool. This allows the system administrator to start and stop processes, monitor performance of the system, and set up the groups and filters that are the basis for managing by exception.

Reduced Support Costs Due To Single System Solution

Since it is an integrated software system, a user does not need to move data through several different applications for different tasks. An example of this is the use of well test information when evaluating wells. When exploring the analytical data from one module, the user merely clicks a button inside the program and is presented with the production data from yet another, different module.

No Cost Associated With Data Access To Everyone Everywhere

The system is based on Windows NT client-server technology. It fits into most corporate networks because NT is accepted as a standard in the computing industry. With the use of WANs or Intranet technology, a company can provide real-time monitoring, analysis, and optimization across the entire enterprise. There is no additional infrastructure cost associated with providing data to anybody on the network.

Reduction In Communication Infrastructure Costs

The system communicates with a large number of hardware device types in the field. It is not uncommon to have a variety of hardware protocols being used in a field. Since it can support multiple protocols on a single frequency, there is no need to have multiple licensed radio frequencies in a field. There is also greater flexibility available to customers since they can choose the best hardware solution for each area of their field and not be constrained by protocol issues.

Reductions In Computing Hardware Costs

The system is a software solution only and does not use a proprietary hardware platform. That frees the customer to purchase any hardware that runs Windows NT. The customer can shop around for the best hardware platform based on price, reliability, and availability at the time. Many companies already have a preferred equipment provider and are free to choose the hardware solution from their preferred provider.

Migration From Old Proprietary RTUs And Systems

Obviously, many oil fields already have existing hardware. Because the optimization software can communicate with multiple protocols on a single frequency, customers can migrate from a legacy hardware solution to modem PLCs on an incremental basis and not have to replace all the legacy hardware at the same time.

Simplifies disaster *recovery*

The software solution has a number of features built into it to simplify disaster recovery. Some of them are:

- The automation system can be implemented in a complete redundant "hot standby" configuration. In the event of a computer failure on the primary machine, the secondary machine takes over in less than one minute. The "hot standby" solution uses industry standard technology and is available at an insignificant cost.
- Hardware configuration parameters for each RTU are stored in the database. In case of a lightening storm or power outage when hardware devices may lose their configuration, the optimization software allows you to simply replace the hardware in the field and download all the stored configuration data back to the RTU. This alone can save hours of reconfiguration time, depending upon the level of hardware loss.

Reduced Data Management Costs

One hidden cost facing oil and gas companies is that of data management. Most oil fields have a significant amount of ongoing data management issues. The system helps reduce the data management costs in an oil and gas field in the following manner:

Since the optimization software provides solutions for facility monitoring and analysis, well monitoring, analysis and design, automated and manual data entry, there is no need to have a large number of systems in an oil and gas field. The single system approach reduces the amount of effort that companies have to spend doing data migration and management between multiple systems, such as:

- SCADA system
- Manual entry system
- Artificial lift system for analysis and design of rod pumping wells
- Artificial lift system for analysis and design of ESP wells
- Local databases for production management and reporting
- Databases for regulatory reporting
- Workover management system
- Drilling system

Because the optimization software is already integrated with reservoir analysis tools such as OFM and DSS, there is no added cost in interfacing this type of software to the reservoir tools used in most oil and gas companies today.

The system integrates seamlessly with SQL databases. It creates a shadow database, which can be any SQL compliant database like MS Access, SQL/Server, or Oracle. The data in the shadow database *can* be used to seamlessly integrate the system with other production and financial applications.

This system improves productivity in the oil and gas field because of the built in integration between the different modules. For example, a person evaluating the efficiency of beam wells is automatically presented with a surface and downhole card collected during each well test. The cards help the person determine the cause of any anomaly in the well test data.

Conclusion

Implementation of optimization software will impact the entire operation of the oil and gas field. Figure 10 shows the relationship between technology, skills, and organization.

The benefits described are always a result of the combination of changes in production operations in all three areas. It may involve changes in job roles and responsibility in field personnel. The optimization software company has a skilled staff of trainers to provide the necessary training to ensure that the installation and deployment of this technology is successful.

The estimates cited in this paper are based on field experience, customer dialog, and expert input. These benefits and typical improvements do not represent any firm reliable benefits and should be used as a guide to estimate the potential benefits in your particular situation.

As the leading provider of oil and gas production automation systems, **Case Services,** based in Houston, Texas, pioneered the market for single-source automation software for producing oil and gas fields. This software is used by major oil and gas companies to tun over 15,000 wells around the world.

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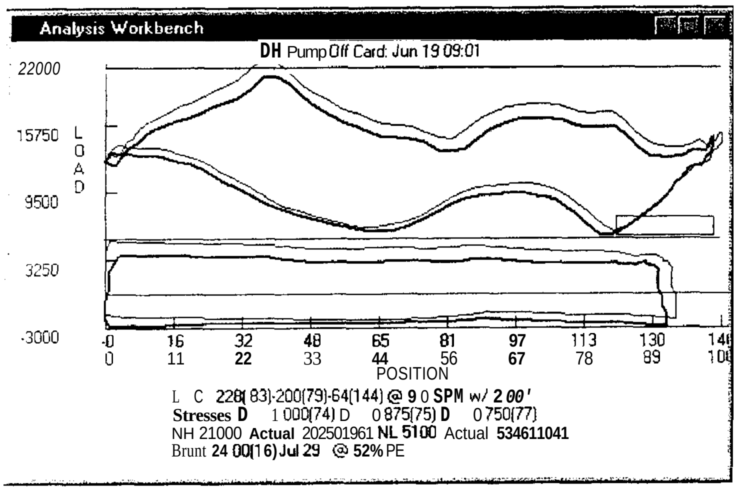


Figure I

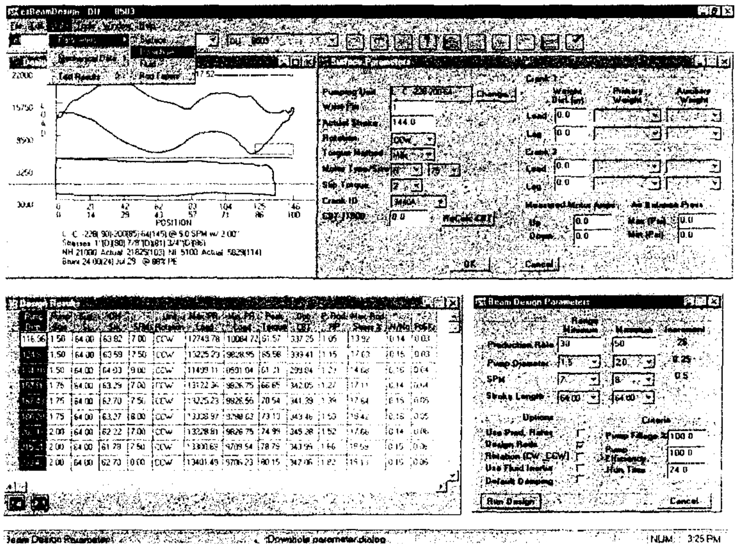


Figure 2

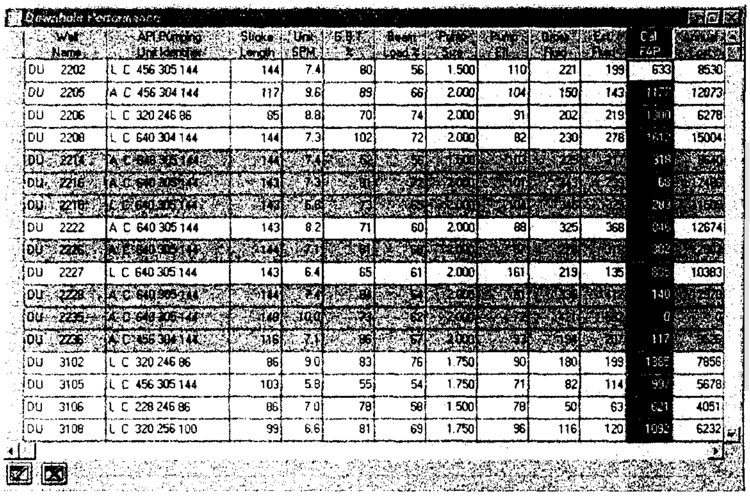


Figure 3

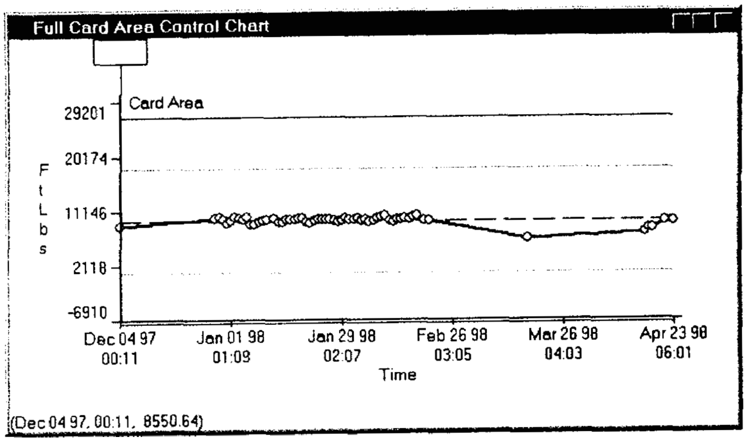


Figure 4

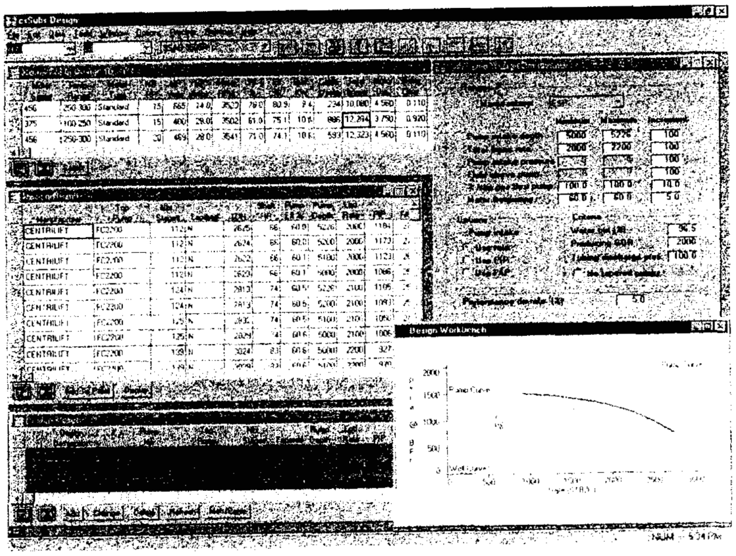
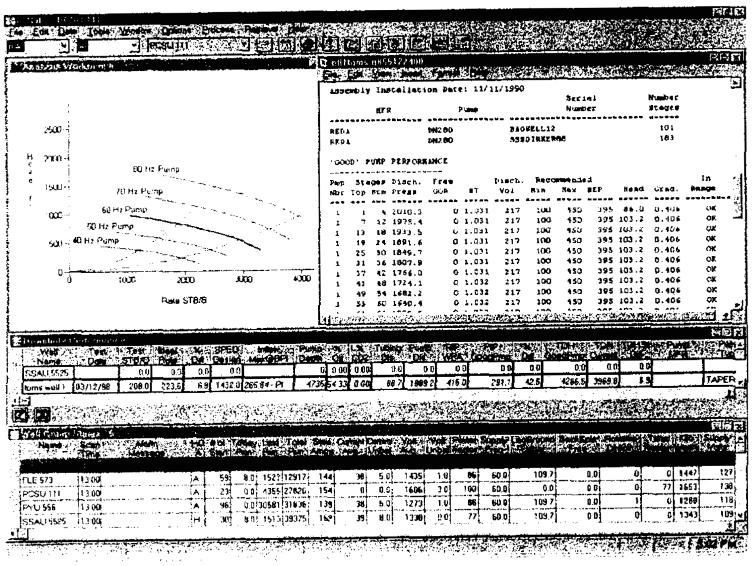


Figure 5



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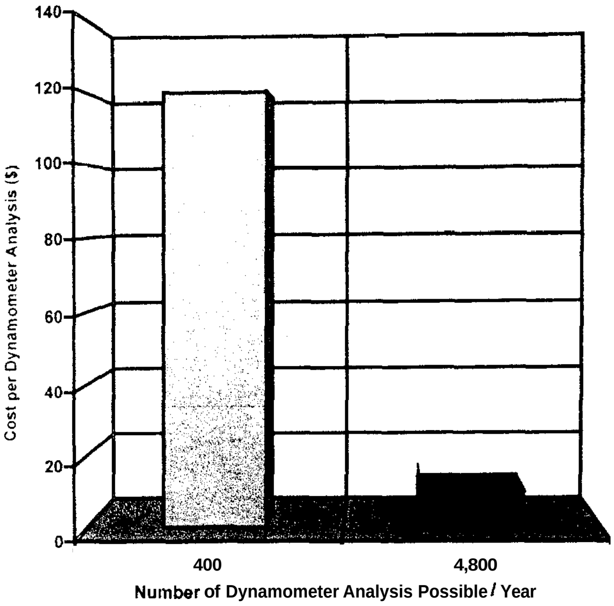

Figure 7 - Dynamometer Time Redistribution

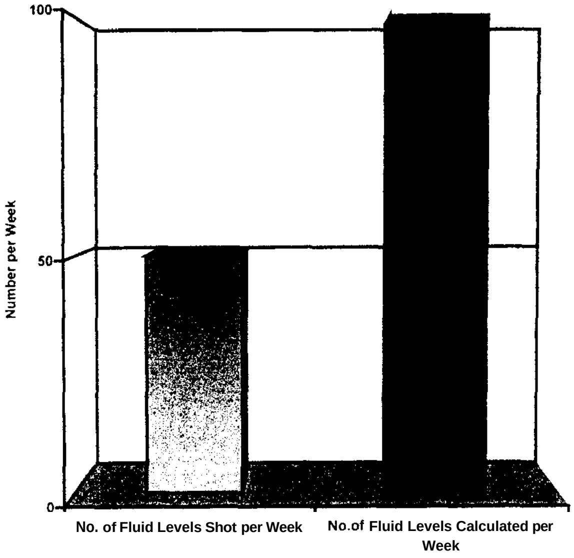

Figure 8 - Fluid Level Collection Time Redistribution

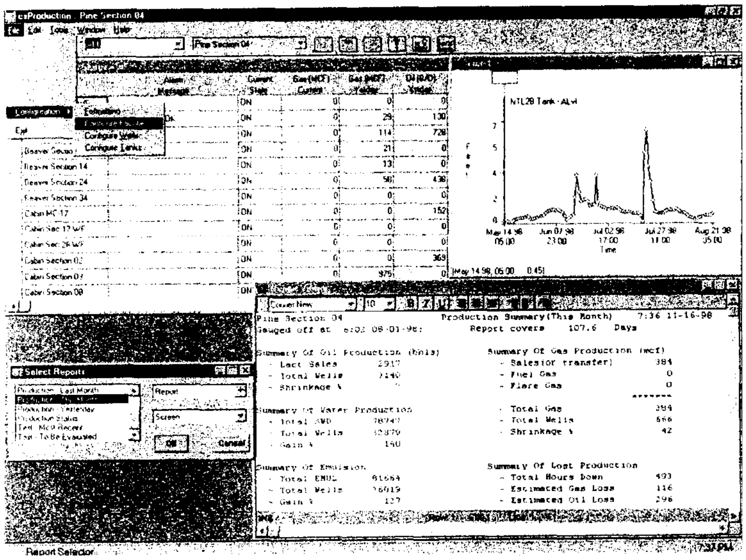

Figure 9

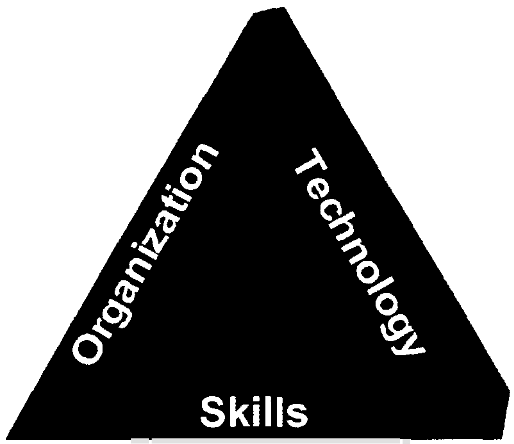

Figure 10