Remote Telecommunication of Fracturing Data For Real-Time Analysis

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Introduction

Modern stimulation treatments involve recording of a variety of data including surface rates, wellhead pressures, liquid additive rates and other parameters related to the fluids and proppants being applied as shown in Fig. 1 & 2. In recent years, computers have been used not only to track and evaluate such treatments but also to model bottom-hole conditions in an attempt to simulate fracture geometry in real time during the treatment. Much of this work has centered around three dimensional models such as noted by Meyer[1,2] and Cleary[3]. The capabilities exists that we can now read data directly into one or more of these new models via remote telecommunications real-time, offering a great savings in time and manpower.

The proper utilization of fracture simulation software requires personnel capable of running and interpreting these highly specialized programs. Making such personnel available on location can be costly and is not always possible. Remote telecommunication of real-time data can serve a useful purpose in this regard.

Telecommunication of data offers a major benefit to operators by providing the ability to monitor treatments remotely and observe the analysis as it is being performed real-time. Personnel at the remote site may also analyze the data in real-time and provide guidance over the phone.

Application

In recent years, the advent of more economical telecommunications hardware and the expansion of cellular telephone coverage has made it more feasible to transmit routine field data back to the office. This has made it easier to obtain expert interpretation while on the well-site, opening a new arena for the oilfield service industry.

In the past, the transmission of field data was limited to special microwave, satellite or direct connect data links. In many cases these approaches proved virtually impossible, if not monetarily prohibitive. With today's technology, most of the limitations have been overcome. Except for very remote areas of the world, cellular telephone links can provide a very economical and reliable means of sending stimulation data back to the home or branch office. This data can then be analyzed by personnel that otherwise might be unavailable to go to the job site. With the addition of a voice link these personnel are able to give advice or expert interpretation related to the progress of the treatment.

Remote telecommunication of data will become more important as new, more sophisticated, fracturing models are introduced to the field. In addition it will provide other benefits. Personnel in the office can train with real-time data without the expense of being sent to remote locations. Although this will not be a replacement for real field experience, it will provide a viable means of exposing personnel to real life situations and to fine tune their troubleshooting skills before they actually go to the field.

Once in the field, on the job training can be further enhanced as personnel can use this same technique to gain access to the experts and consultants in their home office.

There is another advantage only slightly tapped in the past. The real-time data can be played though any in-house or third party software in real time, if the proper interface is provided. This could allow easier testing of new software while analyzing real-time data for critical wells. New models can be thoroughly tested prior to being released to the field. Programmers can more easily observe their software as it performs in a real-life environment. They can see potential problems as they occur, giving them greater insight on how to make the software more beneficial.

Hardware Requirements

The hardware required to send data from the field is widely available and can be purchased at virtually any computer store. One need only acquire a standard data modem, capable of 1200 or 2400 bps transfer rate. In most cases, data rates of 1200 bps have proven adequate. Some data lag might occur; we have experienced 8 to 12 second lag times using this set up. The data lag is reduced at 2400 bps, but this rate is not presently reliable over most cellular services.

The modem must be connected to a cellular phone modem link. This allows the modem to be connected to a cellular phone. The other item, which is optional but recommended, is an extended range high gain antenna for fringe areas.

Our field application utilizes PC/AT compatible computers for data acquisition. These computers are equipped and ruggedized for field use (See Figure 3). Custom software is utilized to monitor jobs. We were able to readily adapt this system to the task by using the hardware described and by making minor adjustments to software.

At the office, another PC/AT compatible computer and standard modem capable of 1200 bps is utilized. The modem is connected to a direct phone line. Care must be used in selecting an isolated phone line to avoid interference that can cause loss of connection.

One requirement of paramount importance is a voice phone line. A second communication device must be made available in the field. Voice communication is needed while data telecommunication is established and during the job for consultation.

Software Requirements

We added a dialing routine utilizing standard AT modem commands to allow the host (field) computer to dial the remote (office) computer via the cellular phone. The field data acquisition software was customized for use on the remote computer. This allowed the remote information display to be very similar to that in the field. A communication routine was added to the remote software for purposes of data acquisition.

It should be noted that the host and remote programs are not tightly coupled. Other than the sending and receiving of data, they are independent of each other. While the connection exists, the remote computer sends data at an interval specified by the operator. The remote computer receives any data that appears over the line. The host and remote computer operators can independently control the display of information on their respective computers. The information consists of user specified plots, a wellbore diagram and pressure and rate information.

Before the job can be started, the remote software is initialized so that it puts the modem into auto-answer mode. It then waits for a phone connection. The host computer operator dials the phone at his convenience to connect to the remote computer. When the phone rings, the remote modem picks up and a connection is established.

Setup information is initially sent by the host computer. This setup information is specified by the host computer operator while creating the job file to be used in conjunction with the treatment. The information sent includes wellbore specifics and initial plot setups. The setup information is saved by the remote software. In case there is a need to restart the software(e.g., after a power failure) the setup information does not have to be resent.

After the setup information has been transferred, the remote computer sends an "OK" signal. It is then ready to receive data. Once the treatment starts, data strings are received at a set interval. The data consists of elapsed time and a set of parameters being monitored by the host computer. The remote computer does not track time independently. It sets its time based on the elapsed time received. This allows the time to be synchronized. "OK" signals are periodically sent by the remote software.

Reliability is an important consideration in the design of the two software programs. There are three types of problems that have to be handled. A lost connection can be the most troublesome problem. This can result in loss of data and concern on both ends. In this event, the host computer informs the operator by displaying a message. He then redials the phone to reestablish data communications. Redialing may take as long as two minutes. The host software must therefore have the ability to continue data acquisition in the background. The data acquired during this time has to be buffered so that it can be relayed once the connection is made.

The second problem is related to noise on the line. Unfavorable weather and cellular phone traffic can result in increased noise. This may introduce errors in the data stream. An error detection / correction scheme is necessary. There are many possible approaches. Given the low data volume, we utilized a simple and effective technique. Each data string is sent twice. The remote software receives the two strings and compares them. If they are not identical, they are discarded. In addition, since the remote software was derived from the host software, it has the same error handling capabilities as the host. Therefore, if bad data is somehow received, the program is able to function unaffected.

The third problem is related to failure in the field or at the remote site resulting in restarting of either software. This can occur due to power failure, for example. The host software has been designed for this possibility. Upon a restart, it starts the background data acquisition first. It then reads from the hard disk data acquired up to the point of interruption and returns to the state that existed before the interruption. Next, it redials the remote. It then resumes display and telecommunication of monitored information. The remote software simply picks up where things stopped.

If the remote software is restarted, it rereads the setup initially saved. It then starts receiving and displaying the data being transmitted.

During a two hour job, it is possible to encounter one or two lost connections and tens or even hundreds of noise related errors. The techniques mentioned above handle these problems without loss of information.

Both the host and remote programs are equipped with flexible serial output capabilities. The flexible output allows transfer of information over a serial line to a secondary computer running third party software. The serial communication protocol (baud, parity etc.) is user specified. The format of the data and send interval are also user specified.

Third party software such as fracture modeling programs typically have serial interface capabilities that allow them to receive data from the flexible output. Therefore, it is possible to have a secondary computer in the field or the office running a fracture modeling program using on real-time data.

A different dialing option is possible than the one we used. The remote computer may be used to dial the host. This frees the host computer operator from having to handle the dialing of the phone. On the other hand, it puts this responsibility on the remote computer operator.

Field examples

Several jobs have been remotely monitored, all with success. An example is provided here.

On one particular job the customer wanted to interface the Cleary model via the remote hook-up real-time. The connection was provided in our corporate lab in Tomball Texas. This could have easily been done at the customer's office.

The job was approximately 30 minutes long. Pump time was scheduled to be 10 AM central standard time. The Computer and field monitoring setup occurred as normal. The remote computer was set up in stand-by mode in about an hour. Once the operator's technical team arrived, a laptop computer was hooked up to the serial port of the remote computer. Voice communication was established and it was agreed to perform a test run. The host (field) software was started. It dialed the remote and a connection was established. Test data was sent. Flexible output was sent to the laptop that was running the Cleary simulation program. There were no problems encountered. The link was then broken.

Just before the treatment started, the field operator called the office. The remote software had been reinitialized and was in standby mode. The remote link was reestablished and soon the job and the data transmission started. During the treatment, the connection was lost four times. The reason for this is believed to be as follows. The phone line in the office was borrowed from a copier that is called periodically for maintenance. These calls probably resulted in the lost connections, pobibably due to a call waiting feature . However, due to quick reconnects, data loss was negligible.

During and immediately after the treatment, the technical team continued to experiment with the Cleary program. It was desirable to simulate a fracture consistent with the design while ensuring that fluid rheology and fluid and proppant volumes were as per design. Reservoir parameters such as rock properties within range deemed to be applicable were adjusted. The result was successful as indicated by the match of the actual post-treatment pressure decline with the predicted decline. By 2 PM, the treatment was deemed to be a success.

There were over one hundred noise related errors encountered during the treatment. These were handled transparently by the software.

On another occasion a minifrac was performed to calculate in-situ leak-off prior to the main job. While the decline data was being received, personnel at the customer's home office adjusted the model's parameters based on experience with offset wells in the same field. Once all the minifrac data had been received, the data link was broken. The minifrac data was analyzed and job redesigned. This new design was passed on to the field and to treatment was pumped.

Conclusions

- Routine use of remote telecommunication of stimulation data is a viable option.
- Off-the-shelf hardware and software customized for modem communication are requirements.
- Software has to handle lost connections, noise related errors and program restart.
- Cost savings are achieved since experts do not have to be sent to the field.
- Real-Time 3D modeling can be utilized remotely for design modification and validation.
- More people can observe the treatment for training or for providing assistance.

References

1. Meyer, B.R., "Frac Model in 3D" - Parts 1-4, Oil & Gas Journal, June 17, July 22 and July 29 1985.

2. Meyer, B.R., "Design Formulas for 2-D and 3-D Vertical Hydraulic Fractures: Model Comparison and Parametric Studies," SPE 15240, 1986.

3. Cleary M.P., "The Engineering of Hydraulic Fractures - State of the Art and Technology of the Future" Journal of Petroleum Technology, January 1988, *(Distinguished Author Series)*.

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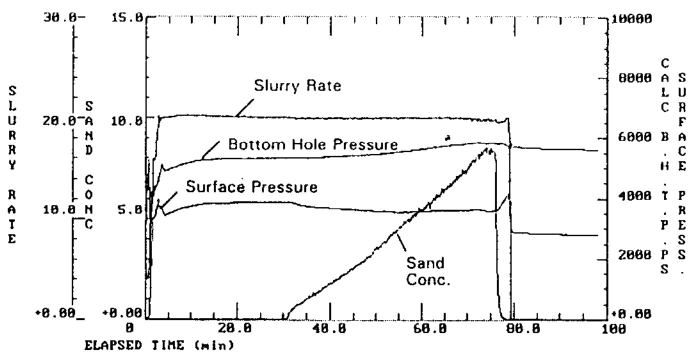

Figure 1 - Simultaneous plot real-time

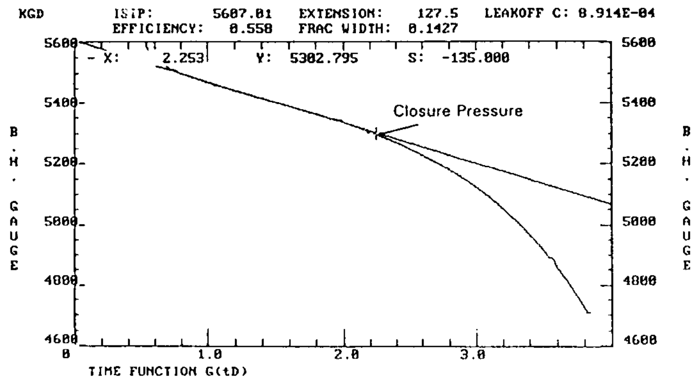

Figure 2 - Loss volume plot, minifrac analysis

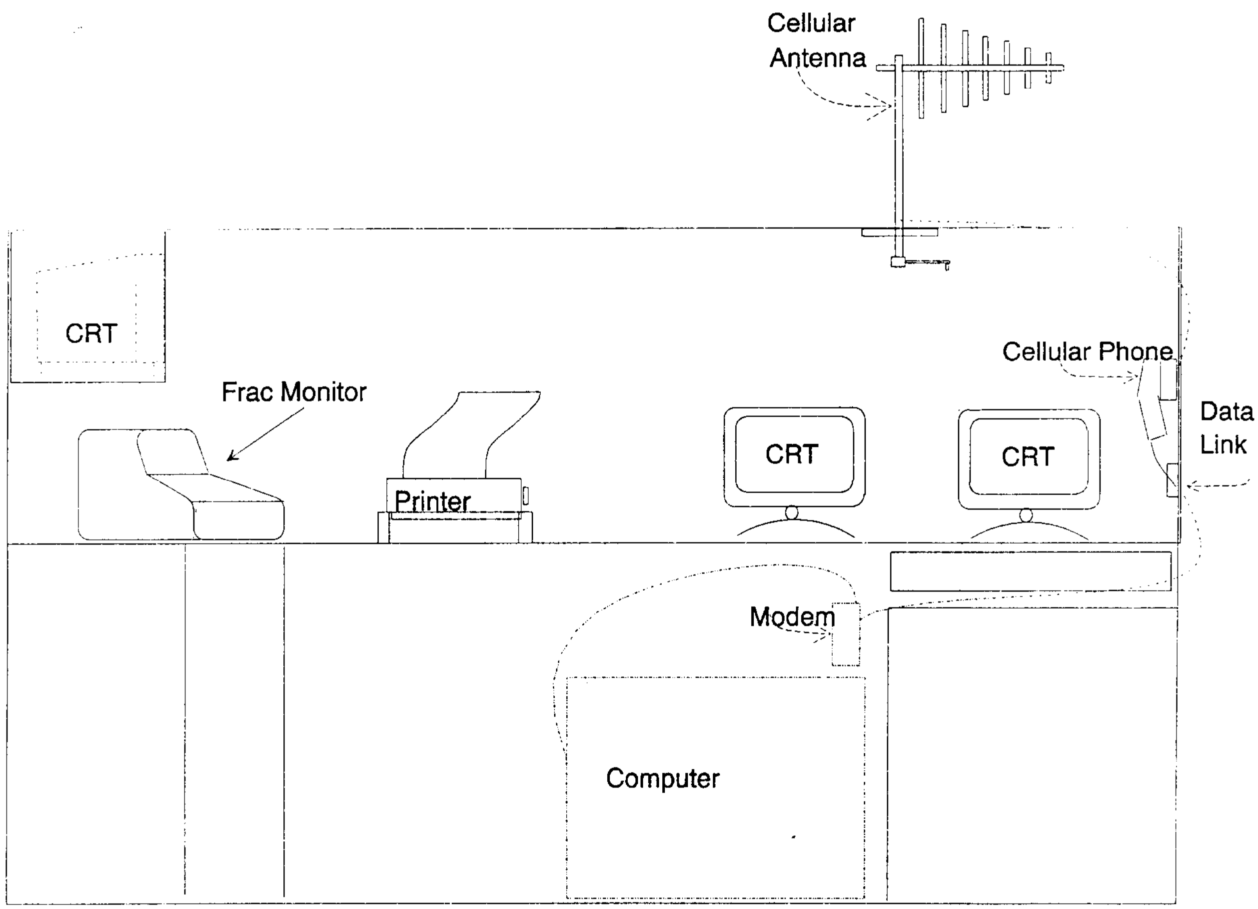

Figure 3 - Cellular hook-up treating van