THE DOWNHOLE VIDEO CAMERA -- OPEN AND CASED HOLE APPLICATIONS IN THE PERMIAN BASIN

By Lee Sanders and Cary Joe Burkhart
Halliburton Energy Services
Midland, Texas

Introduction

The downhole video camera provides an on-site and real-time image of wellbore conditions in both the open and cased hole environments. In the cased hole environments the camera is utilized for such conventional applications as the following:

- to inspect for the condition of the casing,
- to view the presence of the various fluid phases, and
- to determine the location and orientation of obstacles in the wellbore.

In the open hole the applications have involved:

- the visualization of both natural and hydraulically induced fractures, and
- the identification and location of hydrocarbon entry into the wellbore where previously undetected by conventional wireline logging analysis.

With these many features and benefits, the downhole video camera provides an expeditious solution to many problems encountered in the Permian Basin.

The Downhole Video Service

The downhole video service (Fig. 1) consists of the following:

- the downhole video camera,
- fiber optic cable,
- optical receiver,
- slip ring assembly, and
- the surface electronics system.

The downhole video camera (Fig. 2) is composed of the following elements:

- the camera
- light source,
- electronic assembly, and
- the cable head.

The OD of the camera assembly is 1 11/16 inches. The length of the assembly is 72 inches and the assembly weighs 31 lb. The aperture of the lens is 4.8 mm and has a field of view of 120 degrees. The maximum operating temperature is 225 F and the maximum operating pressure is 10000 psi. (Table 1). The light source is positioned directly behind the camera to illuminate the surface of the wellbore. The quartz halogen light source is adjustable through the surface electronic system to maximize the image contrasts, yet minimize the high reflectivity of some borehole anomalies.

The fiber optic cable assembly (Fig. 3) is 7/32 " in diameter and consists of the following:

- the fiber optic element,
- buffer,
- stainless steel tube,
- copper braid,
- polypropylene insulator, and
- the armor wires.

The fiber optic element consists of a 50 micron core with a 125 micron cladding. The copper braiding and double-armored cable serve as a single conductor that transmits signals and power to the camera and light source. An optical receiver positioned at the reel flange decodes the downhole electrical impulses sending the signal to the slip ring assembly and finally to the surface electronic system. The surface electronic system consists of three viewing monitors and a digital recording system for providing a record of the downhole images. The images can be then recorded on a VHS tape, an 8 mm data tape, or an individual image can be displayed on a thermal print.

Real time video imaging is possible in most operations but is also dependent upon the clarity of the fluid in the borehole. A special lens surfactant is applied to the camera prior to entry into the wellbore. This compound allows for viewing under most circumstances. The field of view on the video display will be a 360 degree image of the wellbore looking downhole as the camera assembly traverses the wellbore from top to bottom. If the image lacks clarity because of the fluid, circulating a clear fluid to displace the current phase may be a solution.

Example 1

This example is from a producing well in Midland County, Texas. With declining production from the subject well, the pump rods were pulled from the wellbore. The operator determined from the damaged rods that the 8 5/8" intermediate casing had collapsed around the 4 1/2" production string at a depth of 1500' and severely damaged the pump rods. The 4 1/2" production casing was cut at 1720' and pulled from the wellbore. The operator made numerous attempts to swage out the 8 5/8" casing . In the process of working on the 8 5/8" casing, the operator lost a string mill in the wellbore. Unable to fish the string mill, a "metal muncher" was deployed (Fig. 4) to recover the string mill. After spending several frustrating days in an unsuccessful attempt to recover the fish, the downhole video camera was run into the wellbore.

The downhole video camera showed that there were three problems (Fig. 5). The first problem was that the casing had parted and not collapsed as originally thought. Secondly, the "metal muncher" had milled through one side of the 8 5/8" and had milled on the outside of the casing (Fig. 6). Thirdly, the "metal muncher" was actually reaming out a new wellbore (Fig. 7). The original fishing job took 19 days. The downhole video camera allowed the operator to position the fishing tool , remain inside the 8 5/8" casing, and recover the lost string mill.

Example 2

This example is from a newly completed cased hole well in Ward County, Texas. During a conventional cement bond log run, the wireline wipers and the line cutters from the rig floor were inadvertently dropped into the 11 3/8' surface string. There were several attempts to fish the obstacles from the wellbore but to no avail. The downhole video camera was used to identify the position and orientation of the various tools in the wellbore. Because of the murkiness of the borehole fluid, the downhole video camera was deployed through a 2 3/8" working string into which clear water was pumped to displace the muddy fluid. Figure 8 shows the mounting hole on the collar of the line cutters as displayed by the video camera at the base of the working string. Once the depth and orientation of the tools were determined, a 4' x 1" steel rod was welded with one 5/16" chain hook . The video camera was positioned above the line cutters and the fish was lowered to latch onto the line cutters. This example demonstrates the manner in which the video camera was used to orient the fish and simultaneously guide the operation on surface while monitoring the subsurface activity (Fig. 9).

Example 3

This example is from an open hole wellbore in Terrell County, Texas. The well was air-drilled and logged without loading the wellbore with fluid. This procedure is followed to avoid swelling clays that may arise with conventional drilling fluids. The open hole logs indicated a possible productive interval based upon the presence of a temperature anomaly and a neutron -- density "crossover". Both of these measurements are considered to be a signature of a reservoir containing natural gas (Fig. 10). In this area the better gas production, from an economic consideration, corresponds to those reservoirs that are naturally fractured. The problem in this example well is that the conventional logging fracture- finder devices require fluid in the wellbore to operate. Because of the absence of fluid in the wellbore, a downhole video camera was run to determine the presence of natural fractures. Figure 11 shows the zone of interest as imaged by the video camera. There are two factors to consider. First, the presence of gas entering the wellbore is indicated by the swirling vortex of sediment that is being eroded from the entry passage. Secondly, the gas entry appears to be associated with the matrix porosity. There is no evidence of fracturing on the video display. Although there existed two independent sources (logs and the video camera) that confirmed the presence of gas, natural fracturing was not present in the zone of interest. In spite of this absence of fracturing, the well was cased and perforated. One month later the well was plugged because of insufficient production.

Example 4

This example shows how the downhole video camera was used to identify the presence of hydraulically induced fractures in an open hole well. The operator of the well had questioned the effectiveness of the stimulation work that had been performed on the interval of interest. The downhole video image (Fig.12) clearly shows the presence of a break in the rock over several feet in the zone of interest. By being able to visualize the presence of the fracture in the wellbore, the operator of the well was satisfied that the stimulation of the well had been achieved.

Conclusions

First, the visualization of the downhole environment with the downhole video camera takes the guess work out of problem wells such as have been discussed. Secondly, the simultaneous use of the video camera in conjunction with the fishing operation provides a coupling of processes to solve most downhole problems. Finally, the video camera can be used in the formation evaluation of zones under wellbore conditions that preclude the use of conventional imaging tools.

Table 1
Downhole Video System Specifications

Components	Size\Dimensions
Camera assembly	1 11\16"
Fiber optic cable o.d.	7\32"
Cable tension limits • cablehead • surface	 500 lbs. 1200 lbs.
Maximum pressure	10000 psi.
Camera assembly length	72 inches
Light source	Quartz halogen
Camera lens	4.8 mm w\120 degree field of vision
Horizontal resolution	570 lines
Signal\noise ratio	50 db

Downhole Video Service System

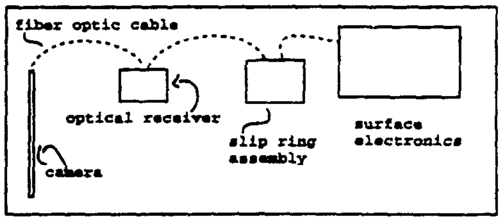


Figure 1 - The elements of the downhole video camera system

Downhole Video Camera

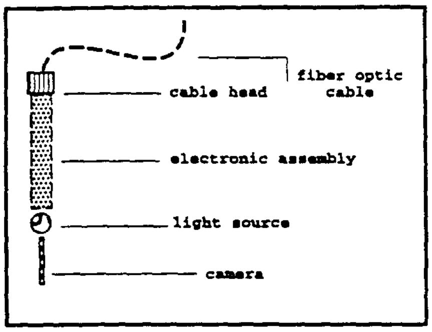


Figure 2 - The elements of the downhole video camera

Fiber Optic cable assembly

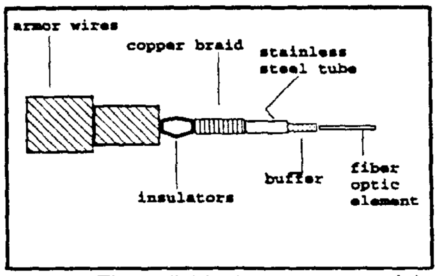


Figure 3 - The individual components of the downhole fiber optic cable assembly.

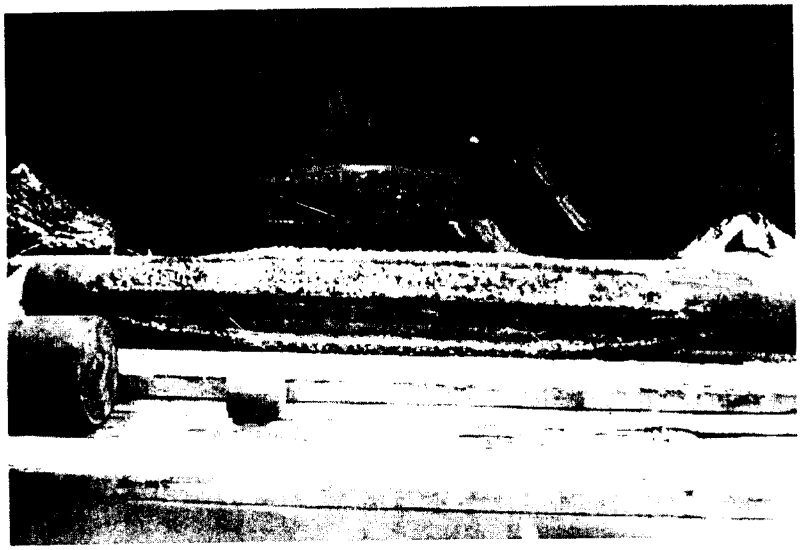


Figure 4 - The photograph of the "metal muncher" used in the fishing operations for the string mill.

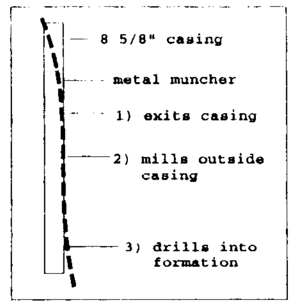


Figure 5 - This figure illustrates three problems associated with the fishing operation:
1) metal muncher milled through the 8 5/8" casing
2) milled outside the casing string, and
3) drilled into the formation

Figure 6 - This is a downhole video image of the outside of the 8 5/8" casing where the metal muncher milled the casing. The video camera is on the outside of the casing imaging the milled section.

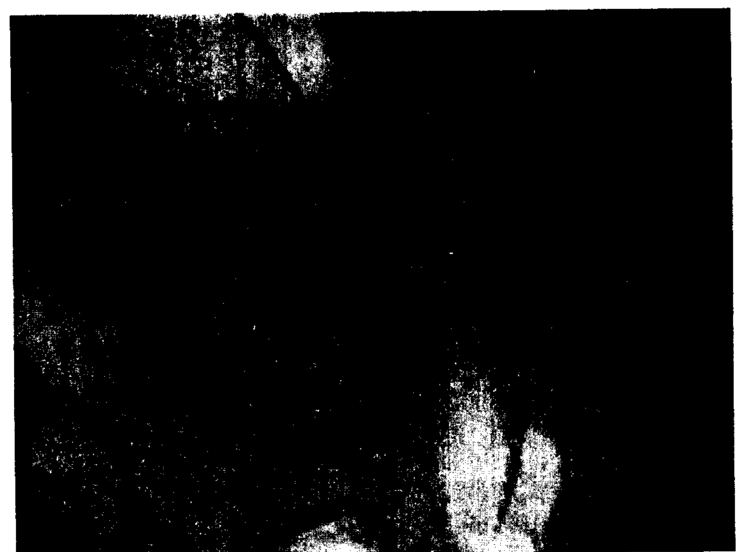


Figure 7 - This video image shows the new wellbore drilled with the metal muncher.

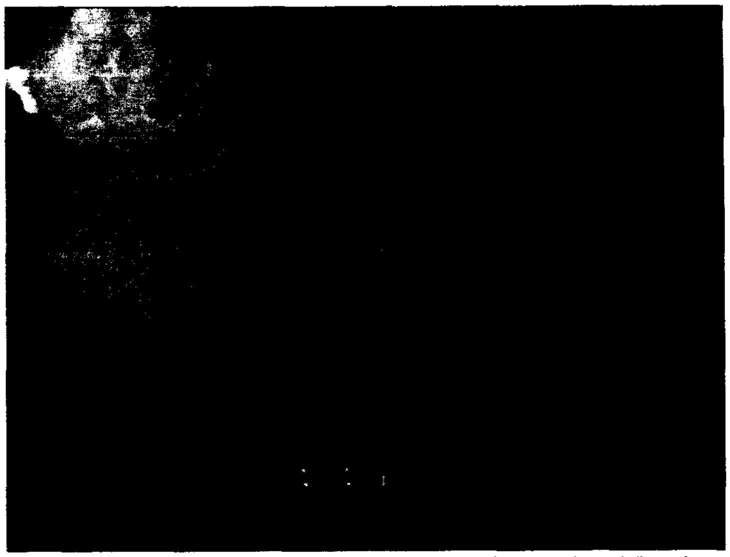
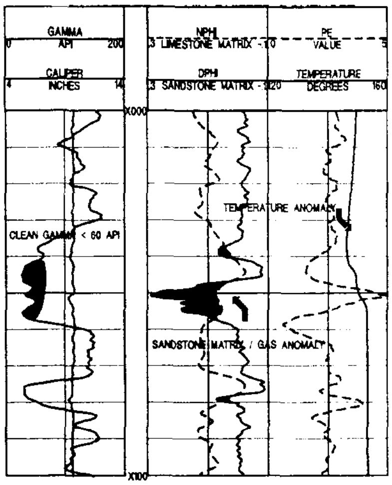


Figure 8 - The video image of the line cutters lodged in the 3/8" surface string.

Figure 9 - This image shows the chain hooks in position to latch to the line cutters.



Wolfcamp Sandstone
Terrell County
downhole video comparison
open hole log - air drilled borehole

Figure 10 - This is the open hole gamma/neutron/density/temperature log which shows the presence of gas as reflected by logging criteria.

Figure 11 - This image shows the entry of gas into the wellbore in the upper left corner of the display. There do not appear to be any natural fractures.

Figure 12 - This is an image of induced fractures splitting the wellbore.