CONCENTRIC COILED TUBING JET PUMP INSTALLATION IN EZZAOUIA #8, TUNISIA

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ABSTRACT

Marathon's Ezzaouia #8 well is located in the Ezzaouia concession in the Zarzis permit area of Eastern Tunisia. The well is completed as an oil producer in a 7300' Jurassic sandstone and has never sustained steady production with the existing 3-1/2" tubing. Systems analysis suggest that the well could flow, at least temporarily, with smaller tubing or could sustain production for a much longer time with artificial lift. Installation of a rod pumping system would be an easy decision in most parts of the world, but due to a lack of workover rigs in Tunisia a rod pumping system was not selected. Furthermore, the Jurassic reservoir is a depletion drive reservoir with a extremely limited water drive and thus was not a candidate for gas lift with wireline retrievable gas lift valves.. However, an innovative artificial lift approach utilizing a coiled tubing unit, 1.50" OD coiled tubing and a casing free hydraulic jet pump was selected for producing the well. See Table 1 for additional data on Ezzaouia #8.

WELL SCHEMATICS

The well is completed with 9-5/8" casing plugged back to 7,428' with 3-1/2" tubing and a production packer at 7,040' as shown on the current wellbore diagram. See Figure 1. The proposed wellbore diagram indicates the proposed placement of the coiled tubing and jet pump equipment. See Figure 2.

WELL PREPARATION

Well preparation includes setting a wireline retrievable plug at 7050', perforating the 3-1/2" tubing at 7030'$\pm$ and circulating the well with clean lease water. (The retrievable plug will be pulled prior to the coiled tubing installation.) The tubing perforations at 7030' have a dual purpose: 1) permit circulation of lease water above the production packer for well control; 2) allows free formation gas to flow through the 3-1/2" by 9-5/8" annulus rather than the jet pump for improving jet pump efficiency and performance. The installation of tailpipe below the 2 9/16" packer acts as a gas anchor and enhances downhole gas separation. See Figure 3 for a comparison of pump intake volumes with the gas vented or unvented as a function of flowing bottom hole pressure.

EQUIPMENT INSTALLATION

The tailpipe, packer, jet pump BHA and coiled tubing are installed following the well preparation. Installation involves running 375'± of 1-1/2" OD(1.31" ID) coiled tubing tail pipe, attaching a 2-9/16" hydraulic packer and setting tool, and running this assembly immediately above the holes in the 3-1/2" tubing at 7030'. A pump out plug allows setting of the packer and also functions as a pressure barrier while the setting tool is recovered and the remainder of the completion equipment is installed. A hydraulic disconnect releases the setting tool from the packer and leaves a polished bore receptacle (PBR) looking up. A landing nipple near the bottom of the tailpipe allows a plug to be set, if desired, for future recovery of the packer and tailpipe assembly. A 1.25" OD drift ball is pumped through the coiled tubing before running in the hole with the BHA; the drift ball was also pumped through the coil before the tubing left the manufacturer's yard. The stinger seal assembly, jet pump BHA and another landing nipple are then connected to the coiled tubing. See Figure 4. This assembly is run almost to depth and the entire coiled tubing string and 3-1/2" tubing is pressurized to shear the pump out plug. At this point, the stinger is located into the PBR and space out measurements taken. The split coiled tubing packoff and slip assembly are attached onto the coiled tubing inside the access window. See Figure 5. The coiled tubing is lowered until the stinger enters the PBR, the correct slack off weight is applied, and the packoff and slips engage the coiled tubing hanger spool.

The final stages of the completion involve energizing the packoff with the lock down screws, cutting the coiled tubing, and removing the BOP equipment and coiled tubing unit. The 1-1/2" tree and fluid control valve assembly are installed and pressure tested. The well is circulated with the triplex pump before installing the jet pump for removal of any debris that may be in the coiled tubing. Jet pump operation involves dropping a throat and nozzle assembly into the coiled tubing and gently circulating the 1.175" OD pump into the jet pump housing. See Figure 6.

OPERATING CONDITIONS

A production rate of 300 stock tank BOPD (STBOPD) is achieved by utilizing a surface power fluid pressure of 3,500 psi and 700 BPD of power fluid; input horsepower is approximately 50 brake horsepower. Anticipated pump intake pressure is 800 psi± once the well stabilizes. Throat and nozzle combinations are changed, as in any conventional casing free jet pumping system, by reversing flow direction and pumping the assembly into the pump catcher located above the fluid control valve. See Figure 7 for a graph of power fluid requirements as a function of pump intake pressure when producing 300 STBOPD.

DESIGN CONSIDERATIONS

While this installation appears relatively simple, several obstacles were overcome during the design process for achieving a coordinated jet pumping system. Not the least of these was in finding a jet pump with sufficient fluid flow capacity and designed for a casing free operation inside 1.50" OD coiled tubing. Jet pumps meeting these particular requirements are only manufactured by one company and have been used primarily to de-water coal bed methane wells. The performance of the pumps was excellent in the de-watering application and should be successful in an oil well application.

Another area which required a great deal of effort was in calculating tubing movement and forces and selecting a packer that best met the various requirements. Conventional tubing movement programs do not correctly analyze a jet pump installation because the pressure below the packer is assumed to be the same as the tubing pressure directly above the packer; however, the jet pump will act somewhat like a plugged tubing case. For a jet pump, the pressure below the packer will be the FBHP, which could be quite low depending on the reservoir and jet pump performance. The pressures above the packer, by contrast, are the jet pump discharge pressure in the annulus and the power fluid pressure in the tubing. These unbalanced pressures create a large downward force on the 2 9/16" packer. Basic equations for tubing movement and packer forces negated the use of mechanical set packers which only hold force in one direction. Thus, while simple and inexpensive, a mechanical set packer is not suited for this application. A hydraulic single grip packer, equipped with a PBR and seal assembly was selected for the following reasons:

- It is set without rotation.
- It holds a tremendous force in the downward direction and enough in the upward direction to resist seal friction.
- It is retrievable.

The Ezzaouia #8 coiled tubing installation is different from conventional velocity string and other hang off jobs because the tailpipe must be suspended temporarily while the packer and setting tool are attached. This involves suspending the coiled tubing in slip rams or in a special bowl and slip arrangement designed to fit into the lower connector of the pressurized access window. The latter method is planned for this well. The coiled tubing stub in the access window is dressed for accepting a connector on the bottom of the packer; the assembly is made up and the coiled tubing weight picked up and the slips and bowl removed.

Also incorporated in the design phase was witnessing the retrieval of a coiled tubing jet pump and the pulling of a jet pump BHA installed on coiled tubing. The jet pump circulated from the hole as planned. However, the pulling of the coiled tubing was not executed properly and revealed several problems concerning pulling coiled tubing. In the event the coiled tubing on Ezzaouia #8 must be pulled due to a mechanical problem or depletion, the experience gained from witnessing the above job is invaluable.

CONCLUSIONS

Coiled tubing can be utilized with casing free jet pumps for producing oil wells.

Remote areas with limited access to workover rigs may be ideal candidates for coiled tubing jet pumping.

Packer design for coiled tubing jet pumps is critical.

Coordination and teamwork between all manufacturers of equipment associated with a coiled tubing jet pumping installation is mandatory for designing and implementing.

Free gas will reduce the liquid capacity of a jet pump. Thus, a vent string (a tubing/casing annulus in the Ezzaouia #8) is a key factor in jet pumping a depletion drive reservoir.

Coordinating equipment from the United States for installation in a foreign country requires considerable planning.

ACKNOWLEDGEMENTS

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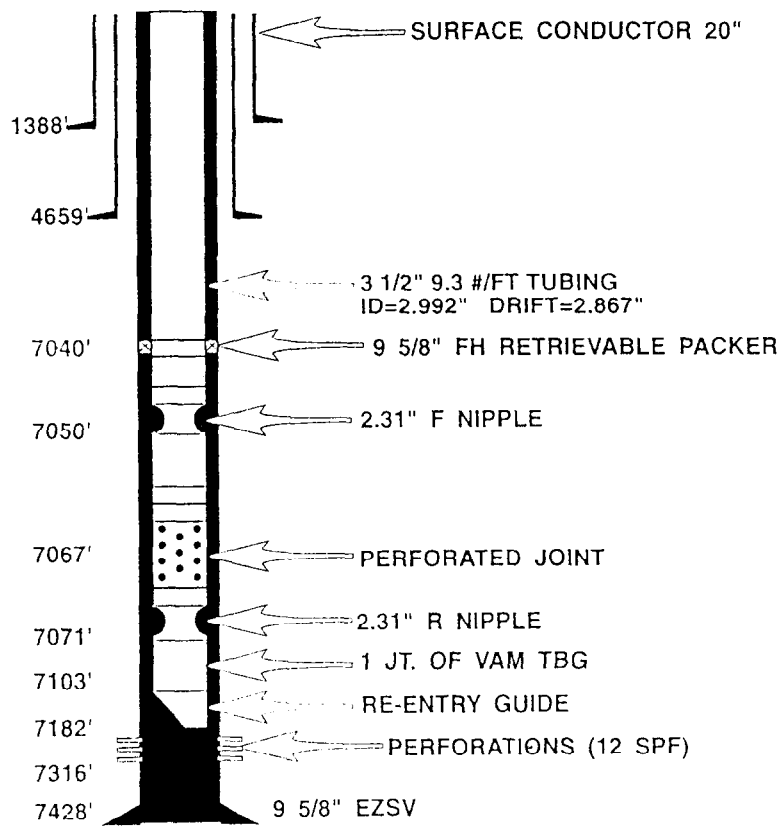

Figure 1 - Current schematic of Ezzaouia 8

Table 1

OIL GRAVITY	40° API
GAS SPECIFIC GRAVITY	0.822
WATER SPECIFIC GRAVITY	1.04
INITIAL GOR	650 SCF/BBL
BUBBLE POINT PRESSURE	2940 PSI
RESERVOIR PRESSURE	2600 PSI
BOTTOM HOLE TEMPERATURE	233°F
WATER CUT	2-10%

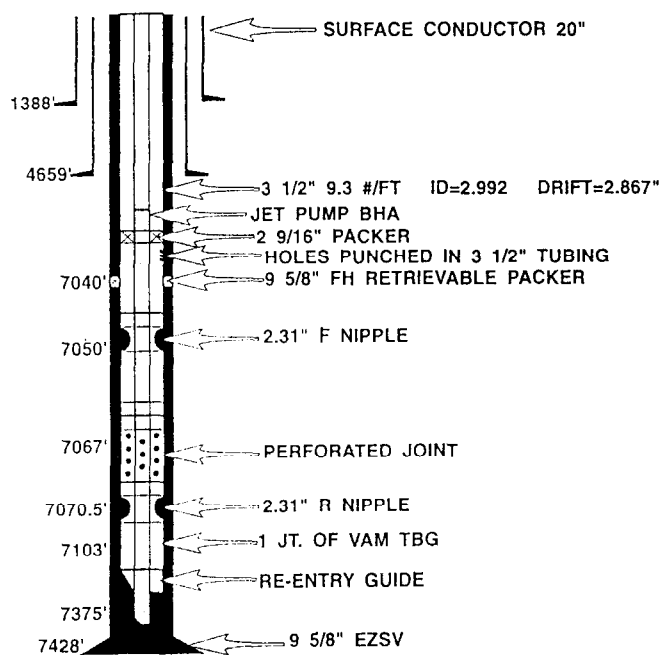

Figure 2 - Proposed schematic of Ezzaouia 8 jet pump installation

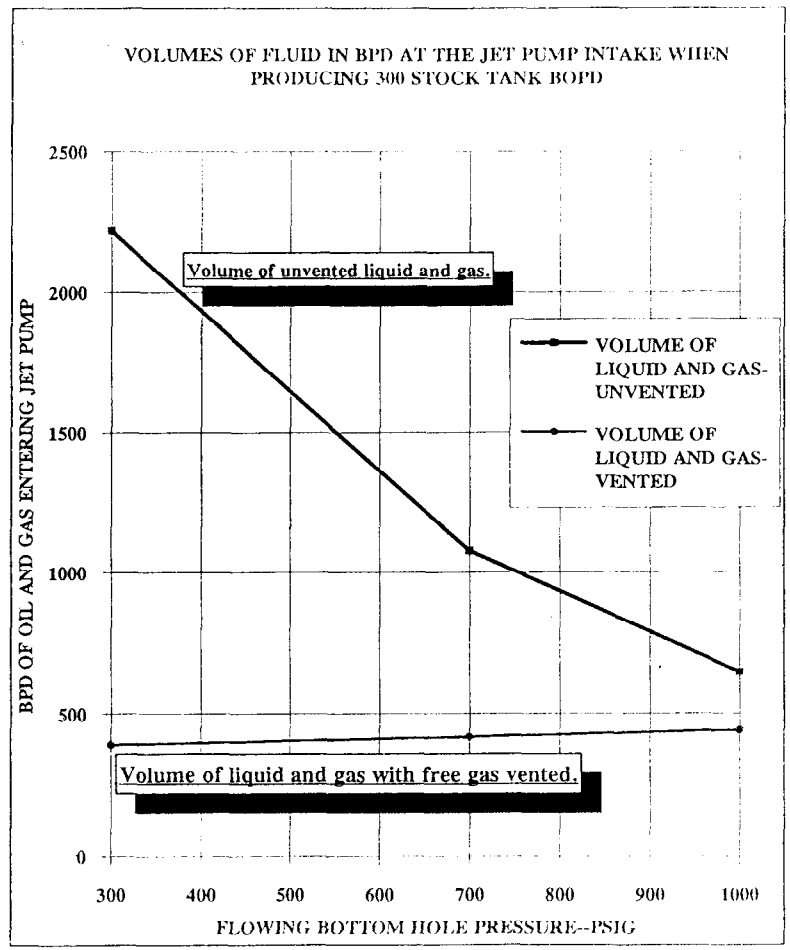

Figure 3

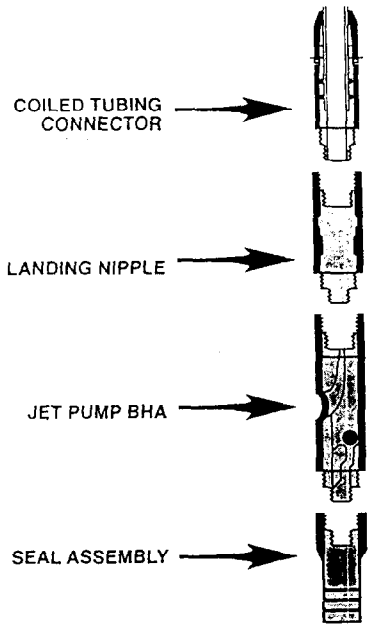

Figure 4 - Details of jet pump and seal assembly

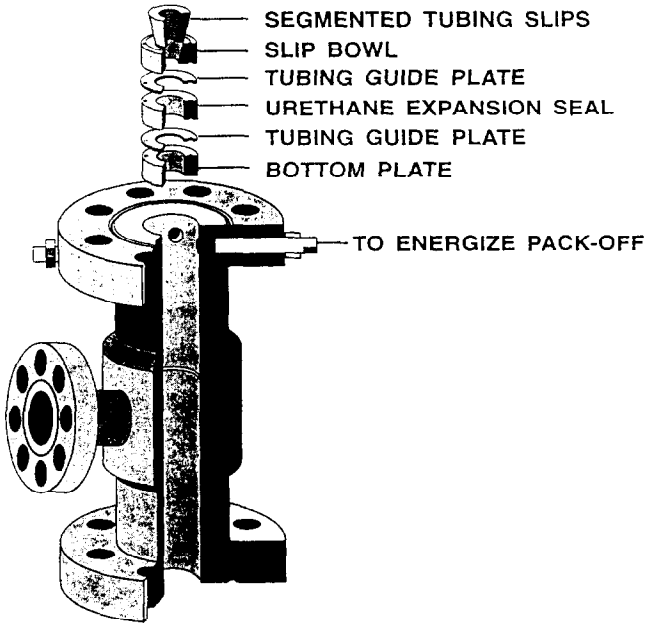

Figure 5 - Coiled tubing
Tubing head and spool

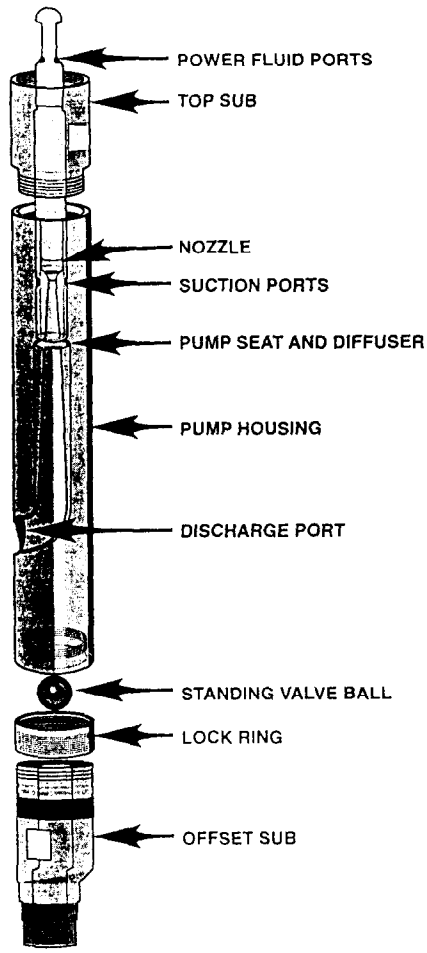

Figure 6 - Coleman pump

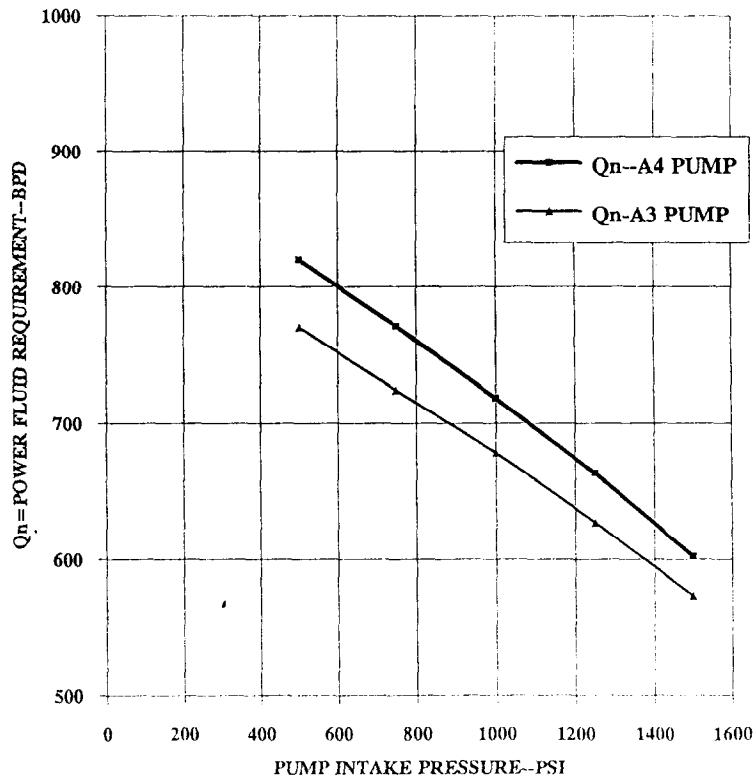

Figure 7 - Power fluid requirements as a function of pump intake pressure @ a constant rate of 300 BOPD