NEW CONCEPTS OF WATER INJECTION SYSTEM APPLICATION ON MARGINAL OIL FIELD

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SUMMARY

The purpose of this paper is to discuss the general concepts of artificial lift to be implemented in a water source well in a marginal field rather than consider detailed design of selected type of lift.
An attempt is made to consider all major factors influencing, Timing, Cost and Sound operating practices.
The overall artificial lift guidelines have been broken down into two main areas of discussion:
1. Logical artificial lift concepts with regard to selection of the most suitable lifting system.
2. Timing of artificial lift to maintain producing capacity and meet Reservoir management objectives.

In light of the hazard and remote area the criteria used to select the proper system merely to minimize the costs and to evaluate the system against the following considerations:

- Flexibility to meet the desired water production rate.
- Equipment and facilities required.
- System reliability and maintenance required.
- Remoteness and topography of the area.
- Expected workover frequency based on similar applications.
- Company sound operating practices.
- Capital and operating costs estimation.

Based on well capacity and on the above considerations the final setting of artificial lifting is the **Jet Pumping System**.

INTRODUCTION

Agiba Petroleum Co. currently has six producing fields (off-shore and on-shore) in which El.Faras Oil Field is located in Western Desert of Egypt (Qattara Depression).
El Faras field was put on production in Nov.1996 and is producing presently artificially at a rate of 5000 BOPD from six producing wells .

In order to maintain rates and recover additional reserves. Water flooding is planned as a secondary recovery method for the Field.

Ideally, the selection of a proper lifting system should consider the following parameters:

- Remoteness and topography of the area.
- Capacity to Handle large volumes of fluid.
- Possibility to Handle some sand.
- Flexibility to changing subsurface conditions.
- Equipment and facilities required.
- System reliability and maintenance required.
- Expected work-over frequency based on similar applications.
- Capital and operating costs estimation.
- Company sound operating practices.

DISCUSSION

The Selection and design of the most suitable artificial lift system is important to achieve the best efficient system. The optimal system is ultimately based on economic considerations, however there are constraints which may eliminate one or more possible lift methods.

Two types of lift methods were considered as candidates to meet the criteria; Electric Submersible Pumps (ESP) and Hydraulic Jet Pumps.

Basic data for Selection are the following:

1) Environment and Topography of Area

El Faras Field is located in a harsh area which is covered either by sabkaha layers at which the under ground water is at a depth of 25 centimeter or salty layers at which the under ground water is at a depth of 150 centimeter. Wells Locations have the following topographic characteristic: -

1.	Elevation on Sea Level	- 84 Mt.
2.	Air Temperature(^{0}c)	4/55 min/max
3.	Air Humidity(% wt)	70 max.
4.	Environmental	sandy and salty
5.	Rainfall (mm)	very occasionally

The selection of artificial lifting method should meet with the following:
- ♦ Easy, in-expensive installation.
- ♦ Rigless workover.

2) Well Data

Hole characteristics include, pumping depth, casing and tubing sizes, completion type and hole deviation. Most of these characteristics have great effect on the volumetric efficiency of the system volumetric efficiency as well as the horsepower requirement to lift the desired produced fluid.

• Casing size	7	in
• Liner	4.5	in
• Total depth	4400	ft
• Target Injection Flow Rate	8000	bwpd
• Target Injection Pressure @ Injection Well Head	1000	psig
• Estimated System Life	15	years

3) Fluid Physical Properties

Considering artificial lift system, Fluid composition has a great effect on the equipment performance against corrosion phenomena.

Sand and Abrasive Materials

Production of such materials causes erosion problems for all types of artificial lift except gas lift. Furthermore sand fill-up on down hole pump may cause retrieval problems (pump stuck).

Scale

Scale deposition reduces the tubing inside diameter and some of the down hole equipment. This leads to a decrease of the overall system efficiency.

Corrosion

Down hole corrosion accelerates equipment failure, which increases the operating cost due to decreasing the equipment running life and increasing well downtime to replace the corroded parts.

Density	1075 Kg /m3	Total Alkalinity as $CaCO_3$	160
P.H.	6.5	Total Hardness as $CaCO_3$	19339
Salinity	81558 mg/l	Hydrogen Sulfides	Nil mg/l
Salinity as Na Cl	134571 mg/l	Oil in Water	Nil mg/l
Iron Content	58 mg/l	Temporary Hardness as $CaCO_3$	160 mg/l
T.S.S	0.5 mg/l	Permanent Hardness as $CaCO_3$	19179 mg/l

Unusual conditions are :
❖ Action for abrasive sand ❖ Corrosions ❖ Paraffin ❖ Emulsion ❖ Scale deposition Tendency

4) System Flexibility

The selected system should be easily and quickly adjustable to optimize its performance with any change in well conditions.

Jet pump	❖ Has a wide variety of nozzles and throat combinations available for replacement. ❖ Down hole pump retrieved hydraulically. ❖ Controlling of power fluid injection can be made easily by Adjusting RPM of the surface pump .
Electric Submersible Pump	Up to certain limit, Redesign of the down hole equipment requires a workeover rig

5) System Reliability and Maintenance Required

As the operator has no experience with the ESP technology, there were concerns over the field support and maintenance for this lift system by their own field technicians.
The lack of a specialist vendor pump repair shop in the vicinity was an intangible negative factor to be considered.
The production deferral problem created by delayed services / pulling unit availability for pulling ESP for overhaul and replacement is to be considered.

6) Practical Experience

Electrical Submersible System (ESP)

ESP is a multi-stage centrifugal pump, capable of producing high volumes of fluid. It is able to handle some free gas in the pumped fluid. The system consists of a transformer and motor controller at the surface and three phase electrical motor, seal section and a multistage centrifugal pump plus additional components as required by the well.

Centrifugal pumps do not displace a fixed amount of fluid, as do positive-displacement pumps, but rather create a relatively constant amount of pressure increase to the flow stream. The flow rate through the pump will thus vary, depending on the back pressure held on the system. The pressure increase provided by a centrifugal pump is usually expressed as a pumping head.

The run life of the ESP system differs from field to field and from country to country. The average run life is a couple of months for some fields and reaches a couple of years for others. This depends on many factors such as handling sizing design and operating environment. Care of these factors can increase the average run life.

ESP was applied in 11 oil wells at Aghar and Meleiha fields. The ESP is running very smoothly without any major problem so far and high performance is probably due to active water drive in the reservoir.

In Feb. 1989 Four-source water wells at Meleiha field were equipped with ESP system utilizing a central power station in which many problems were faced due to failure of down hole pump and / or tubing leak.

In Oct. 1995 One source water well at Zarif field (Remote area)have been equipped with ESP system operated by local power Generator which faced many problems mainly due to down hole pump failure that reflected very poor performance of the system especially in this case.

Jet Pumping System

As Jet pumps having no moving parts , dirty or gassy fluids can be produced without wear effect, which usually appear in positive-displacement pumps. It has also the advantage of being run at any depth. However, drawbacks to jet pumps are their low efficiency (generally in the 20-30 % ranges) and the need for high suction pressure to prevent cavitation in the pump. Jet pump installations are designed using characteristic pump charts in a manner analogous to the design of centrifugal pumps. In addition, careful calculations of the pump depth needed for providing sufficient suction pressure for preventing cavitation is required to design a jet pump for a well.

By controlling power pressure and/or power fluid rate ,Jet system can perform well for a wide range of production .Also,as it is simple, it can be easily maintained and repaired at the well site.

The subsurface jet pump consists of the pump, bottom hole assembly, standing valve, swab nose, dummy pump, blanking tool and lubricator (Figure – 1).
Briefly,

- Bottom hole assembly (BHA) is the receptacle, which holds the pump.
- Standing Valve acts as a check valve during pumping operations.
- Swab nose is the locomotive attached to the top of the pump to provide a larger surface area while pumping out.
- Dummy pump is circulated into the bottom hole assembly to check tubing drift diameter and tubing pressure integrity.
- Blanking tool to protect bottom hole assembly seal sleeves during service work.

Production rate of the jet pump is limited primarily by two factors:

1- Cavitation which can be avoided by proper sizing of Nozzle and Throat combination.
2- Friction losses which can be minimized by careful design of flow passages and fluid crossover.

The high velocity jet stream passes through a small open space in the pump between nozzle and throat, Well fluid driven by formation pressure flows into this space through side ports in the pump. The jet stream of power fluid entrains the produced fluid and drives it into the pump throat.
Pressure rises in the produced fluid through energy transfer from the power fluid, during the turbulent mixing process that occurs in the straight bore of the throat. The combined stream of power fluid and produced fluid passes through the throat and into the diffuser section of the pump.
In the diffuser section, the velocity head is converted to additional pressure to lift the mixture of exhaust power fluid and produced fluid to the surface (Figure – 2).

In May 1994, Four oil wells at Zarif Field were equipped with Jet pumping system, This system was replaced by Sucker Rod pumping system mainly due to decreasing of well productivity to the limit that can be produced by S/R Pump.

In 1997 the Jet Pumps made free from Zarif field were installed at El Faras and Raml Fields for oil wells to maintain the field production level.

In early 1998, another Jet pump was installed at AGHAR Field to produce well AG.- 8 from both Heavy and Light oil .

7) Equipment and Facilities Required

The main item of surface equipment required is the power supply. in the fact that El Faras Field is located in a very bad area from the Environmental and Topography point of view. Local generator will be considered.

8) Operating Cost Estimation

With the omission of pulling expenses, remaining operating costs were judged to be reasonably close for each lift method, But with the required pulling expense included, total operating costs for the Jet pump system would be significantly the lowest one, although capital expenditure may be relatively high in the jet pump system.
An economic comparison of installation equipment cost had been prepared covering the two-candidate lift systems. Cost information was developed by vendors for capital investment items required for each system(tables – 1&2).

CONCLUSIONS

From the above considerations it is conducted that , the hydraulic jet pumping system is the most viable method of producing the water source well (F-4) at El Faras Field.
The advantages of the system can be summarized as:

- Easy, in-expensive installation.
- Lower operating Costs: -
  1- Low maintenance.
  2- Rigless work over
- Low down time.
- Continuity of water injection.
- No time waste, down hole Pump is hydraulically retrievable.
- Wide range of production can be achieved by controlling the surface pump rpm.

The positive advantages encouraged application of the Jet pumping system especially in remote areas, harsh topography and extreme weather conditions.

APPLICATION

Salt water (formation water) is to be produced from a source well (F-4) by suitable artificial lifting system, filtered and conditioned before being injected into injector wells (F-2 and F-8) 3.5 Km. Faraway .

The water source well is cased with 7" casing to the depth of 3280 feet and
4 -1/ 2 " liner to the depth of 4500 feet. Jet pump bottom hole assembly is lowered on
3 -1/2 " tubing and located at depth of +/- 2750 ft (Figure – 3).

The system is self contained hydraulically operating system. The high pressure power water provided by two multiplex pumps in parallel. Power water, stored in the water reservoir, is forced at high pressure into source well passing through a subsurface down-hole Jet Pump

Water from the source well is then firstly stored in the water reservoir for solid deposition and gas flashing.

The mixture is sent to cyclone cleaners to remove residual sand and solids before being partially injected in the source wells and partially to the produced water conditioning system (Figure – 4).

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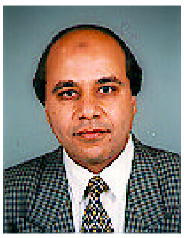
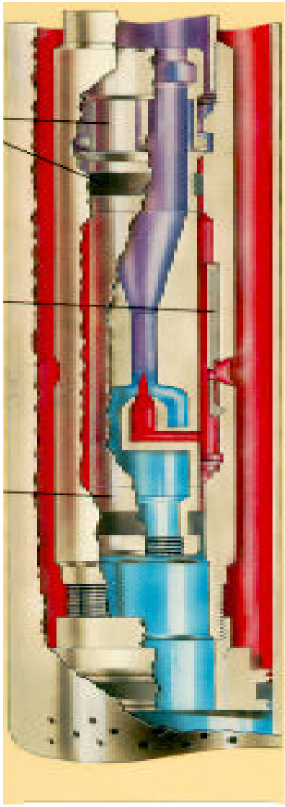


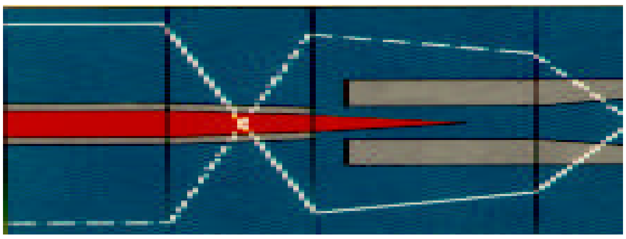
Item	Equipment	Cost (M$)	
		Jet Pump	E.S.P
1	Generators - 900 KVA	********	175
2	Generators - 66 KVA	75	********
3	Ferritic Metallurgy ESP Pump ,Monel Motor with accessories	********	360
5	cable and Accessories	********	40
6	Filters	75	75
7	Lifting (Power)Pumps w/ Diesel Engine (2)	500	*********
8	Injection Pumps w/ Diesel Engine (2)	170	*********
9	Hydrocyclone System	Included	*********
10	Power Vessel	Included	*********
12	Accessories	Included	25
13	Down Hole Pump w/ Specific BHA	35	********
	TOTAL	855	675

Table - 1
Economic Comparison
Estimated Capetal Cost(M$)

Item	DESCRIPTION	JET	ESP
1	Workover Cost(1 Job / Year)		
	* Rig Move	******	70
	* Rig Operation	******	50
2	D.H.Pump Repair	10	200
3	Power Cable	******	40
	D.H.Pump specialest		10
4	Wire Line Operation	1	1
5	Surface Equipment Maint.	20	10
	TOTAL	31	381

Table - 2
Economic Comparison
Estimated Operating cost (M$)





Jet Pump Principle
Figure - 2

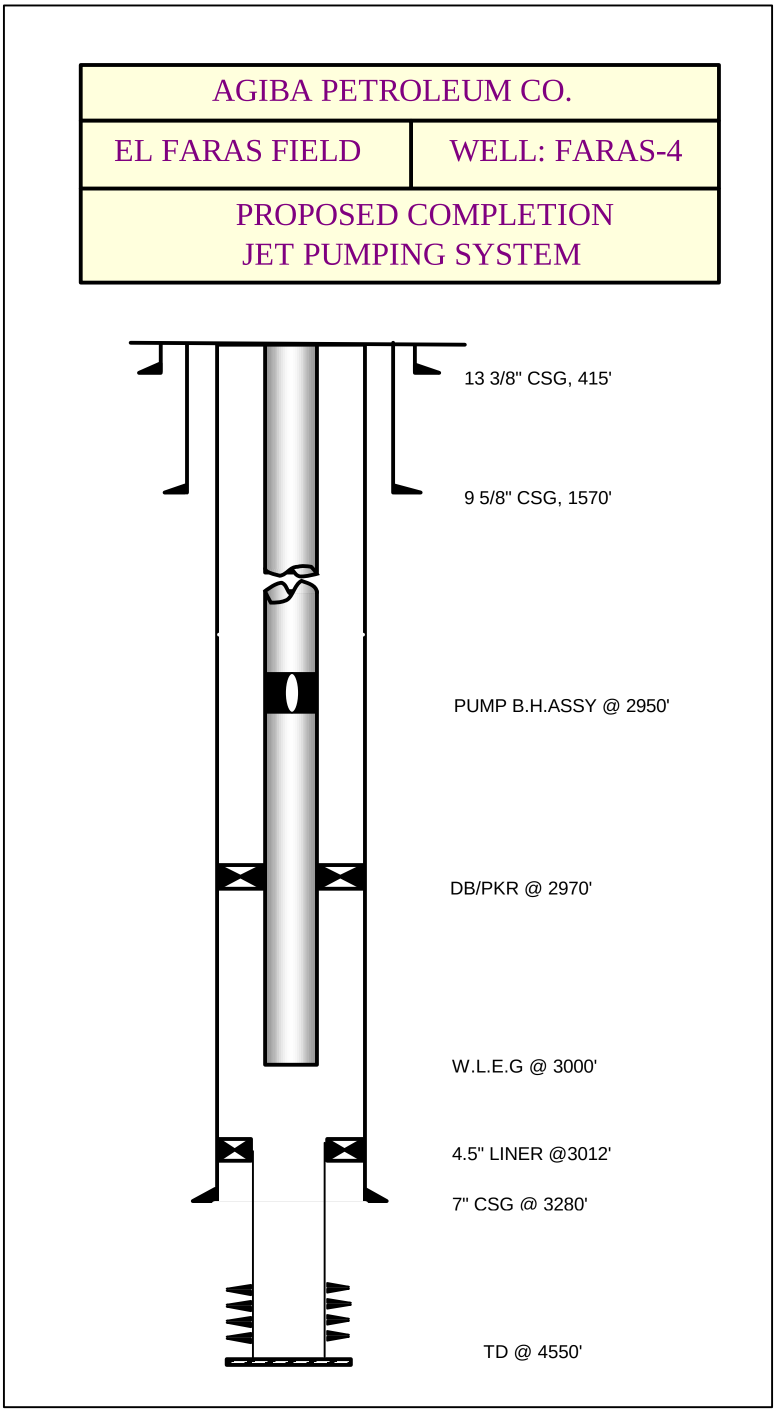

AGIBA PETROLEUM CO.
EL FARAS FIELD
WELL: FARAS-4
PROPOSED COMPLETION
JET PUMPING SYSTEM
13 3/8" CSG, 415'
9 5/8" CSG, 1570'
PUMP B.H.ASSY @ 2950'
DB/PKR @ 2970'
W.L.E.G @ 3000'
4.5" LINER @3012'
7" CSG @ 3280'
TD @ 4550'

Figure-3

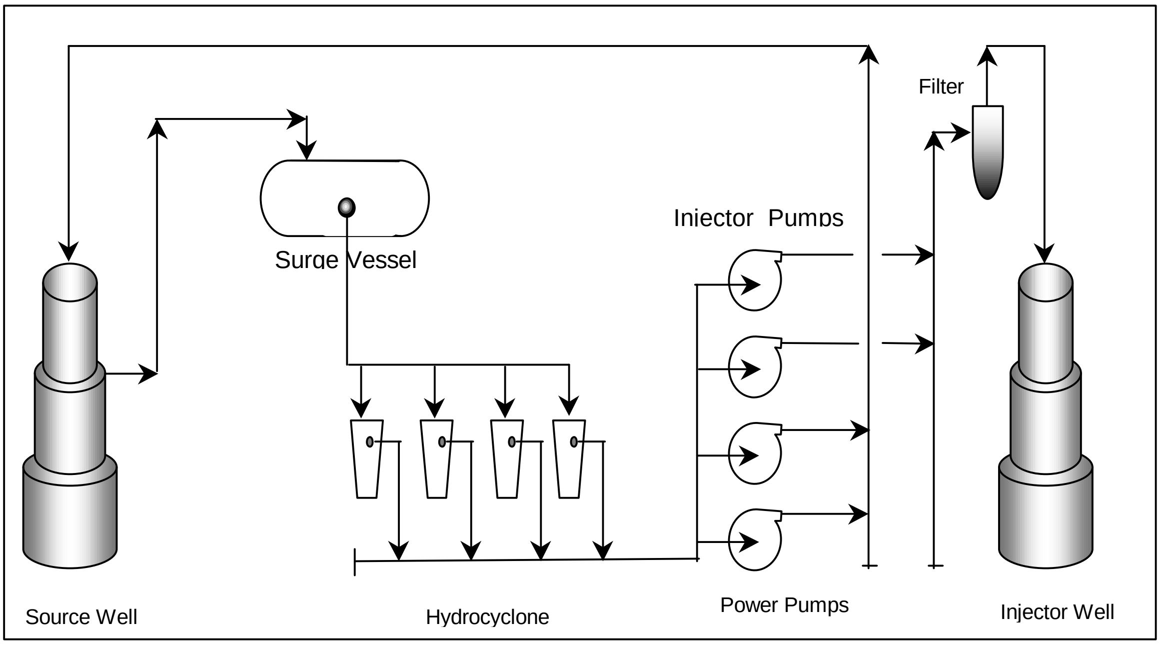


Figure-4
Process Flow Diagram