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Review of Artificial Lift in Egypt

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Abstract

One of the real challenges facing the oil industry in Egypt now, is to keep up production and maximize reserves especially in mature oil fields. The application of artificial lift systems to improve the productivity, whilst ensuring the most effective use of the existing reserves, should optimize the petroleum resources.

A total of 137 oil and gas fields were placed on production since the oil industry in Egypt started in 1910. Currently there are 122 oil and gas fields on stream, among which 9 are gas production fields and the other remaining 113 are producing oil from 1311 oil wells. The natural producing wells are representing 15%, while the gas lifted wells are 24% and the pumped wells are 61%.

This paper presents the philosophy and the methodology of applying artificial lift system in the Egyptian oil fields. Pending on the production forecast and the expected well behavior and also the effects of applying the secondary recovery mechanism either by water flood or gas injection.

Also the problems encountered on well behavior are analyzed and solutions are suggested. Special emphasis is given to the marginal oil fields artificial lifting systems, because of the economical limitation accompanied with such field's development costs.

The concept is not only to equip a well with a cost effective means of artificial lift to be able to continue production, but also to manage the reservoir behavior for the maximum oil recovery.

Introduction

The decision of which artificial lift system to use, depends on many factors such as: the reservoir pressure, well depth and potential, type of the produced fluid. The most updated technology is being applied in the Egyptian oil fields, such as equipping oil wells with the suitable Artificial lift system: whether it's gas lifting or submersible pumps operated electrically, mechanically or hydraulically. This decision is very important to the long-term profitability. An improper selection of artificial lift choice can reduce production and increase the operating costs substantially. Once a decision was made on the type to install on a well, it rarely can be altered whether the method selected was and still is the best choice for existing conditions. Of course a starting point in any selection process is to review the current practices.

Fig (1) shows the spread of the oil and gas fields in Egypt. The map describes the seven major areas of the oil production as follows; The Gulf of Suez (GOS), Sinai, Eastern desert (E.D.), Western desert (W.D.), Upper Egypt, Nile Delta and Mediterranean sea. Fig. (2-A) and (B) shows the distribution of the natural flowing wells compared to artificial lifted wells; either by gas lift or pumping.

A statistical survey for the Egyptian oil fields shows that: 28 % are gas lifted wells characterized as high rate wells, Electrical submersible Pumping system (ESP's) are 31 %, about 38 % are on beam pumping and 3 % on Hydraulic and Jet pumps. Generally, the majority of the offshore wells in Egypt are on continuous gas lift or ESP. The major oil companies such as GUPCO, SUCO and PETROZEIT are using gas lift as a preferable system in offshore wells due to the abundance of gas and low operating cost. PETROBEL has used ESP in SINAI and offshore fields in the Gulf of Suez. This company is using also rod pumping system in the land wells, Agiba is utilizing all various kinds of pumps on its fields in the western desert. During the last year Agiba used the cavity pump driven by sucker rod in one well as a first trial and this application succeeded to reduce workover frequency and increase run life for one year.

Table (1) represents the oil production companies in Egypt and statistics of the different types of artificial lift used in the different location of the oil fields. Table (2) represent a summarized comparison study between all types of artificial lift.

Gas lift system

Gas lift is one of the major artificial lift systems used extensively around the world and the most common system of artificial lift used in offshore fields in Egypt. It is Favorable for offshore fields due to flexibility in its production rates, ability to handle corrosive fluids, suitable for high temperature and high gas oil ratio wells and compatibility with sand production. For all the above, the gas lift is the preferable technique for artificial lift in offshore fields in the Gulf of Suez.

The Gulf of Suez contributes over 80% from the total oil production rate in Egypt. Most of the oil production from this area comes via gas lifted wells. The majority of these wells undergoes continuous gas lift. The continuous gas lift is recommended for high rate and high static bottom hole pressure wells and it is an excellent application for offshore classic type formations with water drive, or water flood reservoirs with good productivity. Also, the gas lift is very attractive especially in case of high pressure gas availability or where gas is low in cost.

There are three major oil production companies in Egypt using gas lift in the Gulf of Suez area; these are GUPCO, SUCO and PETROZEIT. All GUPCO fields in the Gulf of Suez use gas lift as the most suitable technique for artificial lifting since 1965 and uptill now. Also SUCO used gas lift in the two main fields, RAS BUDRAN and ZEIT BAY fields since 1985. GUPCO has some fields in the Western Desert in Egypt, Abu El Gharadig field started with hydraulic pumping system as initial artificial lift and then converted to gas lift in order to maximize production with minimum operating cost. This process was done via rigless workover by making a port in the production string which was followed by installation of the proper gas lift equipment. Also, BAPETCO is using gas lift in two wells on its fields on W.D. area.

Two case histories are available in this paper describing the advantage and limitations of the gas lift and describing analysis of the problems encountered and suggested solutions.

Ras Budran field "SUCO" case history

Ras Budran (R/B) Offshore field is one of the mature fields in Egypt "cumulative production over 200 MMSTB" consisting of massive Nubian sandstone. The field is producing from saturated reservoir where the production is maintained by gas-lift while the pressure is supported by a combined water flooding and limited aquifer drive. The production started on April 1983 and the gas lift was introduced in 1985 as the most suitable technique for the field in order to maximize production. Fast depletion rate was observed, so water injection support started on November 1985 to maintain the reservoir pressure, improve the sweep efficiency, and support the lifting efficiency.

Big efforts and engineering work were carried out in order to improve the lifting efficiency and maintain the production via continuous monitoring of the wells performance and optimization of the gas injection volumes. Many gas lift optimization studies were carried out either in-house or via consultants. SUCO stuff used special softwares for gas lift design and optimization like SAM and PIPE SIM. A routinely static and flowing bottom hole pressure and temperature surveys (SFPT) were used as a tool for monitoring and evaluating the lifting efficiency and to detect the point of injection (P.O.I.). According to the interpretation of these surveys, a suitable action was taken to improve the lifting efficiency according to the reservoir pressure and gas lift valves status. Fig (3) shows the temperature profile for a gas lift survey.

Increasing water cut is considered as the main problem affecting the lifting efficiency and gas lift performance. This problem was encountered after the water break through has been occurred. SUCO made some modifications in the gas lift valves design in order to increase the gas injection volumes via using the ORIFCE or DOWEL ORIFICE valves as a (P.O.I.). However, these trials made a slight improvement but the problem is still not solved completely. A production logging tool was used to detect the watered out zones (gas lift string is open system). Through tubing bridge plug was used to isolate the watered out zones, most of all down hole jobs and recompletion were carried out via rigless workover.

Later observations, following breakthrough of the injected sea water, revealed deposits of Calcuim, Barium and Strontium sulphate which resulted in plugging or partially plugging of the production strings and add a difficulty for retrieving the gas lift valves. Effective tubing cleaning job was carried out using preflush (diesel & xylene) followed by scale dissolver spotted at the gas lift mandrel.. A new technique is also applied to use a coated gas lift valves in some wells and it is showed a good results in the changing out of the gas lift valves.

Zeit Bay "SUCO" field case history

The Zeit Bay field " offshore and land wells" reservoir consists of sandstone and carbonates with a complex drive mechanism. The production commenced in 1984 A secondary recovery scheme of gas re-injection into the original gas cap was initiated to maintain reservoir energy and minimize pressure decline. Some wells in this field producing naturally and others are subjected to gas lift according to its productivity and reservoir pressure.

According to the same reasons above and the availability of gas there are two system of the gas lift. The first is high pressure gas comes from gas plant after compression and the other is low pressure gas lift which comes from gas producers, Also the gas injection into gas cap comes via high pressure gas system. A successful conversion from natural flowing to gas lift by using concentric gas lift valves via rigless workover has been done. The most serious problem in this field is a severe corrosion was happened in the completion strings, A routinely corrosion logs were ran in order to detect the completion strings status. Corrosion study was carried for the field and the result showed a corrosion erosion was done to the completion strings due to the concentration of the acidic gasses ($CO2$ & H_2S) in the associated gas which returned back to gas lift system and gas injectors. By the end of 1998 the total cumulative of workovers to change the corroded production strings was 24 and average service life for this strings 6 years. The study recommended to use the fiber glass production string in order to overcome this problem. Fig (4) describes workover frequency for Zeit Bay field.

Electrical Submersible Pumps (ESP)

ESP is the best for high liquid production rate, high water cut, low gas liquid ratio. It has been recognized for years as a high rate artificial lift technique. Good well data are required to select a pump size that operates in the recommended range. Also use of the variable speed drive (VSD) make ESP operation more versatile. If the pump capacity is higher than the well inflow, the well will pump off, and the underload current will normally shut the system down. When oversized, the pump operates in a downthrust reigon which tend to shorten its life. On the other hand, an undersized pump will not reach the desired production.

Several oil production companies in Egypt were used ESP either as the best selection from the beginning or switched on it after monitoring the system with another alternative. PETROBEL is one of the major production companies, which uses ESP's in Sinai land and offshore fields in the Gulf of Suez. Agiba and Khalda are using ESP's and also Qarun start to use it in 1997. Also ZAFCO in the Gulf of Suez and finally SUCO started to install the ESP's for Ras Fanar field in 1996.

The main factors affecting the ESP's failure are as follows; power fluctuation, power wear, high bottom hole temperature, abrasive production fluid, seal protector leak, cable damage, bad installation and low production. Workover with rig is the only way to overcome the failed pump so the operating cost is very high. ZAFCO is the only company of the Egyptian production companies which used a cable suspended system (CDPS) on 5 wells in the Gulf of Suez, this system used a pulling unit to retrieve the failed string (rigless).

AGIBA Case study "western desert"

Agiba used ESP's on it's fields in Meliha, Aghar, Aman and zarief fields. Started to install ESP's in the high production wells on Meliha field instead of Rod pumping, after 2 years some of these wells returned back to the old system because ESP was not flexible as Sucker Rod in case of the well productivity change. So Agiba install ESP's only in wells have expected stabilized production parameters for a long period. Table (3) describes ESP history in Aghar field. This field was completed with ESP mainly due to reservoir characteristics: good PI, low GOR, and constant reservoir pressure. Fig (5) represent average running days for ESP in Aghar field.

Khalda Case study "western desert"

Khalda Petroleum company "KPC" conducted a comperehensive study to select the most suitable technique for artificial lift in its fields (salam, Safir, Khalda, Hayat & Tut). Khalda installed ESP's in 27 wells on 1989. The ESP's lifetime of these fields did not exceed 300 days. Continuous effort to increase lifetime and consequently reduce wells downtime and associated costs had been done. These efforts were baically directed in two main objectives; improvement of manpower qualification, skills and equipment selection & integeration. The first objective was achieved through an intensive training program.

To improve equipment selection, a comperehensive data base program was established that include the reservoir & fluid charactersitics, equipment specifications, well bore condition, equipment failure analysis program, and equipment performance evaluation.

The results of all these efforts and other had a great impact on the ESP's lifetime of KPC fields that reached an average of 1000 days and up to 1400 days in the less problamatic fields.

Fig. (6) illustrates the Run life history for Khalda fields.

Beam Pumping system

Beam pumping system is the oldest and most widely used type of artificial lift for oil wells. Worldwide this type is most common in the wells which makes less than 10 bbls/day (Stripper wells). The system should be considered for new, low volume stripper wells and could be used for lifting moderate volume from shallow depths and low volumes from intermediate depths. If the produced fluid contains hydrogen sulfide, special rods should be used. Beam pumps used in most Egyptian oil fields " land wells" in Sinai "PETROBEL", Eastern Desert "GPC" and Western Desert in Agiba. A lot of problems were encountered in the beginning, mainly due to the high production down time caused by the very low running lives of pumps and rods. Continuous are being efforts made with close monitoring and analyzing the reasons behind the failures in addition to using updated technology the effect of water injection support. Improvement has been made in the downhole equipment re-sizing and modification.

Western desert "Case study"

Agiba has a good experience in the field of Beam pumps. Very low running lives for the rod and pumps were reported. Most of failures were considered as rod parting together with downhole pump problems " mostly due to leak in a standing and travelling valves. In most cases the pulling unit is used to pull the failed pumps but in case of the pump sticking, a workover rig should be used (high cost). Due to all of the failures the production was affected and also the cost/bbl was increased. By continuous monitoring and analyzing the problems it was found that, the equipment performance was affected by fast declining in the reservoir pressure "depletion drive reservoir". This decline causes a decrease in the dynamic fluid level in the tubing and consequently increases the peak load on the polished rod. Also use of one size of pumps restricted the flexibility to match pump with well capability.

A continuous optimization efforts in addition to the water injection start and application of the updated technology via resizing the down hole equipment resulted in an increase in the running lives for the rods and pumps and reduction in the operating costs. Fig (7) describes the running lives for rod and pumps for Western Desert case study.

Hydraulic pumping system

The Hydraulic powered systems depending on a stream of high-pressure water or oil from a power fluid pump at the surface. The subsurface pump can be piston or jet. Jet pump is one of the artificial lift methods gained growing success in recent years. Simplicity and ability to handle solids, corrosive fluids, gassy production, heavy oil and high pour point make it the optimum artificial lift methods for many applications. It has a simple design with no moving parts with pumping action achieved by fluid dynamics. In Egypt the jet pump is used in some fields in western desert. GUPCO has used it as initial artificial lift system in 1978 at A-El-Gharadig and Razzak fields.

The continuous monitoring for the system performance resulted in analysing the problems which can be addressed as follow: The power oil quality needs more expensive treatment operation. The engine valve is the main part which was affected by the power oil quality. Also gas production, restrciction in the pump intake or production flowlines and the produced water affect the pump performance. The operating cost is higher than the other artificial lift systems but the running life and shut down times are moderate.

The monitoring of the flowing pressure is very difficult due to the pump sticking problem. For all the above and in order to reduce the operating, workover cost and the availability of gas. A successful conversion to gas lift system has been achieved for some wells via rigless workover jobs by conducting a bottom hole ports in the tubing string. Agiba has introduced the jet pump in the last couple of years in a remote area (Zarief field) at the Qattara Depression. Operationally no problem has been reported and the system has a very high flexibility because it's enough to change the pump nozzle to give different pump characteristics (operation managed by wire line). OAPCO also used this system in its field in Western Desert as initial artificial lift system and gained successful operation and optimization in production.

Hydraulic piston pump is used in PETROBEL in Sinai fields on a limited number of wells in order to handle viscous fluids. The optimization of this system is depending on the rate of the powered fluid. So a limited production volume was achieved from the pump and some wells returned back to ESP to increase the production rate.

Progressive Cavity pumping system

Progressive Cavity pumping (PCP) is essentially a single helical (rotor) which rotates eccentric inside a double helical (stator) of the same minor diameter and twice the pitch length. As the rotor rotates inside the stator a series of sealed cavities form 180 degrees apart which progress from suction to the discharge end of the pump. As one cavity closes, its opposing cavity opens at exactly the same rate. This system is used to handle the viscous fluid with all ranges of production rate and does not create emulsion and it is simple in design.

There are three wells in Egypt are using PCP as a second option after S/R pump due to high workover frequency and operating cost. Agiba and PETROBEL used conventional PCP driven by rods as a trial to reduce workover frequency, hence operating cost. The surface pumping unit cost less than five times S/R pumping unit and run life is around one year.

Summary and conclusions

1. The Poor choice of artificial lift system initially can reduce production and increase operating cost.
2. Starting point in any selection process is to review the current practices.
3. Managing artificial lift require continuous production performance monitoring.
4. Training for the company personnel and application of the latest technology is very important to achieve good performance and decrease failure in equipment.
5. Gas lift represents more suitable system for offshore and onshore locations depends on gas availability, bottom hole measurements, logging, perforation jobs…etc carried via rigless operation by wire line unit. Also the GAS lift optimization is easy via the experienced engineers.
6. Controlling of waterbreak through in active water drive and water flooding reservoirs is very important to improve lifting efficiency in gas lift
7. In a gas lift systems with corrosive environment, a routinely corrosion logs must be carried to detect the status of production string. Also, use of fiberglass as a tubing string is recommended.
8. All artificial lift system working efficiently in active water drive reservoirs, the selection of the suitable type is depend on the desired production rate, location and productivity of the well.
9. Considerable effort is required with ESP operations, Training and operating procedures are extremely important.
10. Rigless converting either natural flowing or hydraulic pumping wells to gas lift via bottomhole port in tubing or use concentric gas lift valves.
11. For the marginal fields with solution gas drive reservoirs, the jet pumping system is the easier to operate and most economical artificial lifting system

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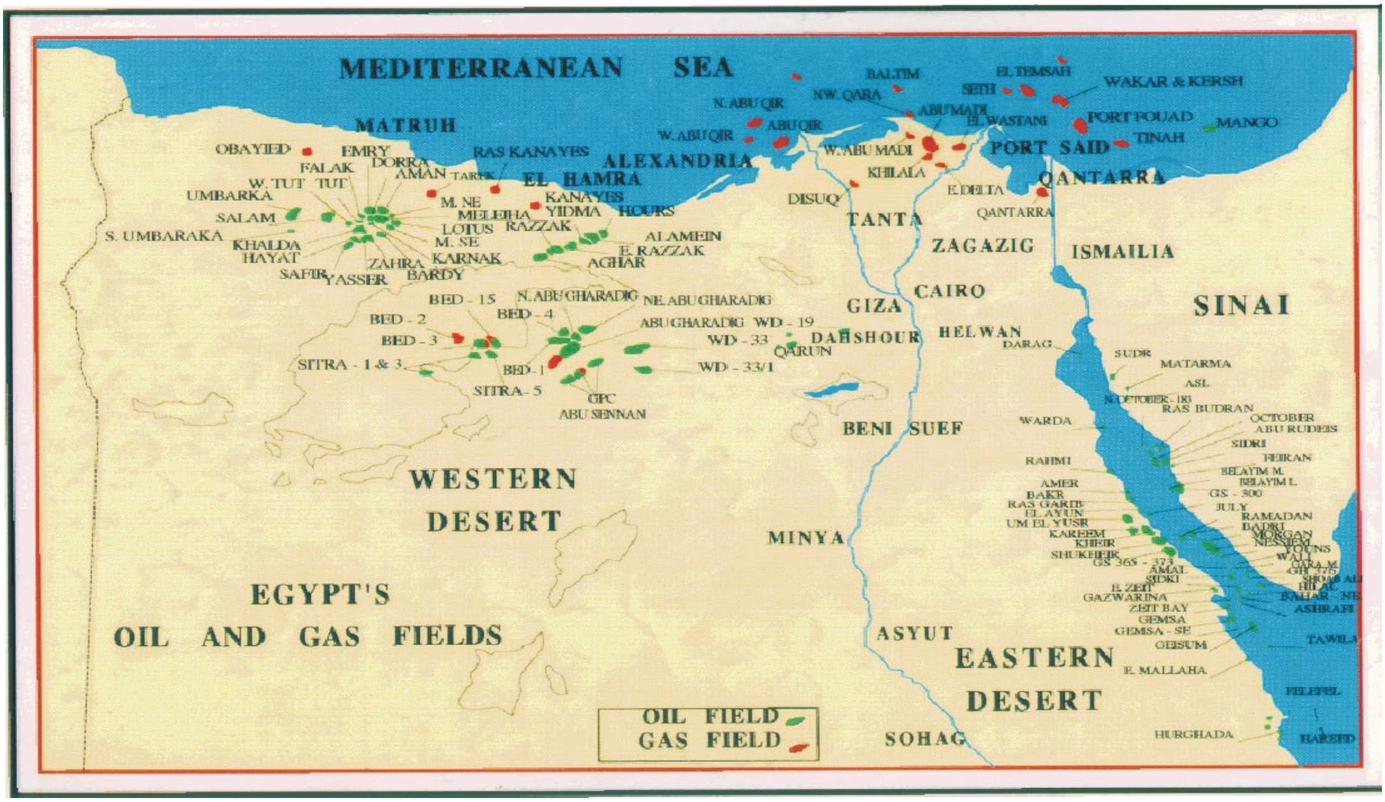

Figure (1) Location map for the Egyptian oil fields.

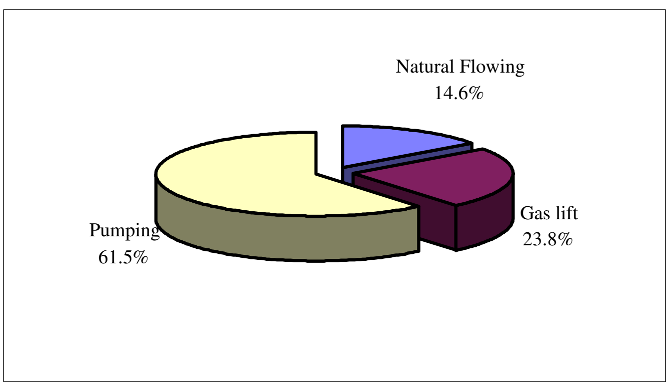

Figure (2-A) Comparison between natural flowing and Artificially lifted wells.

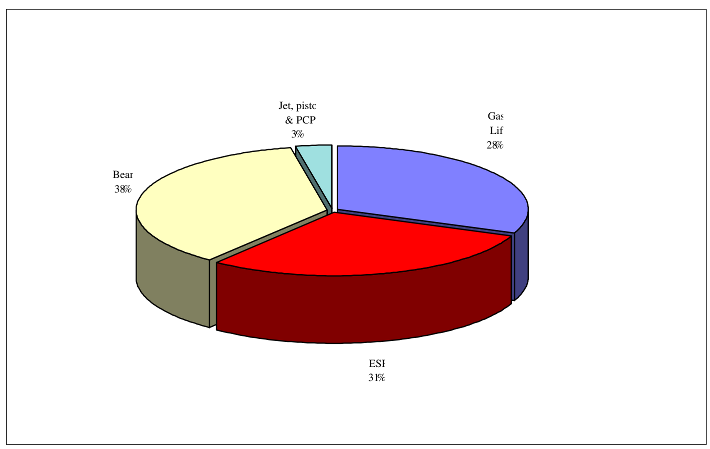

Figure (2-B) Status of Artificial Lift in Egypt.

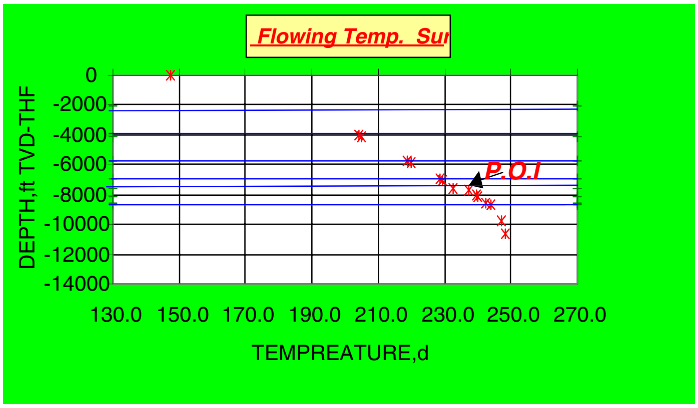

Fig (3) Temperature profile for Gas lift well.

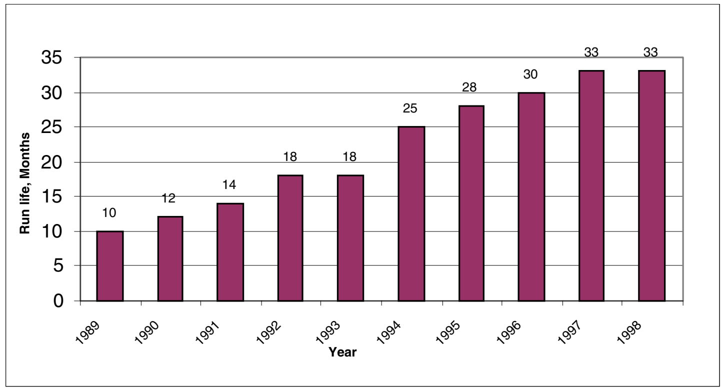

Fig. (6) Avg. running lives for ESP "Khalda Pet.Co.".

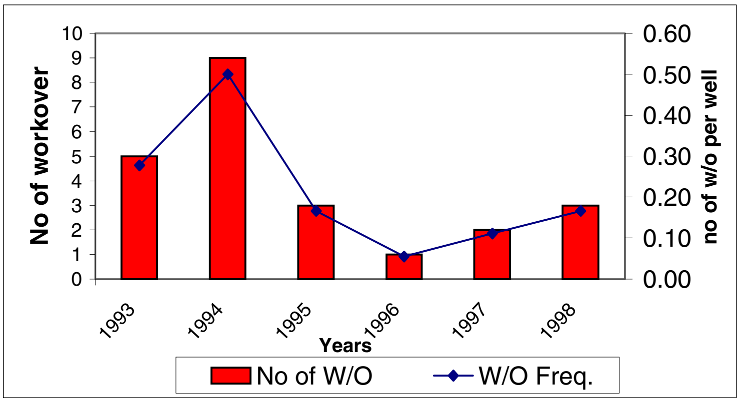

Fig (4) No of W/O jobs for Zeit bay field and W/O frequency.

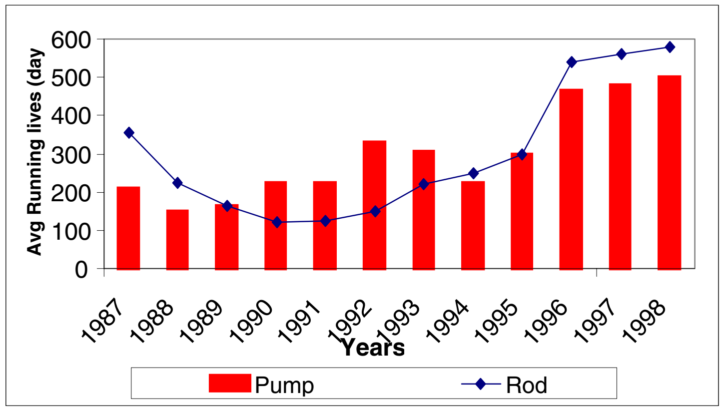

Fig. (7) Avg Running lives for rods and pumps for Agiba case study.

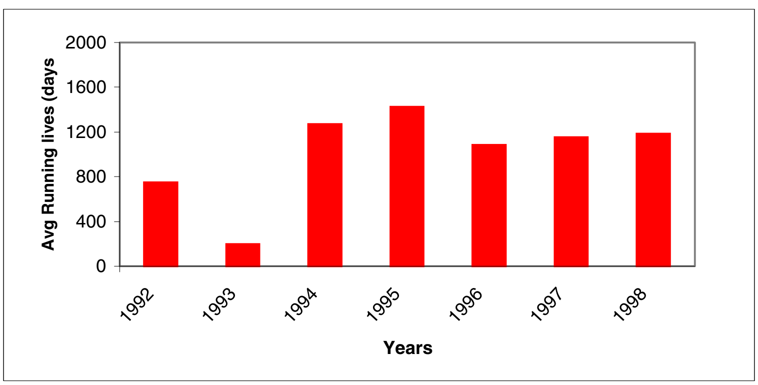

Fig. (5) Avg. running lives for Aghar field ESP " Agiba western Desert".

Table (1) Statistical survey for the Egyptian oil companies.

Company name	Location of fields	NO of wells	NaturalFlowing wells	Gas lift wells	ESP wells	Beam Wells	Hyd., PCP Wells
GUPCO	GOS&W.D.	318	37	265	16		
PETROBEL	GOS&SINAI	224	1		153	66	4
SUCO	GOS&E.D.	56	20	28	8		
AGIBA	W.D.&GOS	100	9		10	76	5
KHALDA	W.D.	116	15		94		7
BAPETCO	W.D.	19	4	15			
GEISO	GOS	24	18				6
SEAGUL	GOS	10	10				
ZAFCO	GOS	7			7		
OAPCO	E.D.&W.D.	5	1				4
ALAMAL	W.D.	5	5				
OSOCO	GOS	3	3				
WEPCO	W.D.	21				21	
QARUN	W.D.	36	11		25		
GEMPETCO	E.D.	3					3
PETROZEIT	GOS	8	3	5			
GPC	E.D.&W.D.	282	38		4	240	
ALALAMIN	W.D.	6				6	
EBIDICO	W.D.	29			29		
MAGAPETCO	E.D.	2	2				
ASHEPETCO	GOS	3			3		
SAMPETCO	W.D.	32	14			18	
PORAPETCO	W.D.	3				3	
TOTAL		1311	191	313	348	430	29

Table (2) comparative study for different types.

Item	Gas lift	ESP	Hydraulic	S.Rod
Workover Frq.&tool	Low rigless	High rig	Moderate rig/riglss	High rig
Shut down	low	High	Moderat	low
Run life year/well	v.good	medium	Good	v.low
Movable parts	none	exist	None	exist
Wire line operation	easy	difficult	Impossible	impossible
Capital cost	high	high	meduim	meduim
Operating cost	low	high	Moderate	high
High GOR	effective	Inefficient	Inefficient	Inefficient
High w.cut	restricted	effective	Unsuitable	Unsuitable
High rate	effective	effective	Ineffective	Inefficient

Table (3) Summarize Aghar field ESP history.

Well	Reason for pulling	Run days	Pump Ser. Mod. Stgs. Type	Intake Ser. Mod.	Seal Ser. Mod.	Motor Ser. Mod. HP. Volt. Amp.	Current status
Agh-2	Pump oversize	78	513-GPMT-61-GC2200	513-GPINT	513-GST	562-KME-42-1042-23	motor & seal rerun
	High w.cut	305	513-GPMT-60-GC1200	513-GPINT	513-GST	562-KME-42-1042-23	Switched to S/R
Agh-3		2278	513-GPMT-53-GC-4100	513-GPINT	513-GST	562-KME-54-1041-30	Still running ESP
Agh-5	High w.cut	300	513-GPMT-63-GC-1200	513-GPINT	513-GSB-1	544-GME-42-1012-25	motor & seal rerun
		1791	400-FPMT-140-FC-925	400-FPINT	513-GSB-1	544-GME-42-1012-25	
		56	513-GPMT-71-GC-1150	513-GPINT	513-GSB-S	544-GME-42-992-23	Still running ESP
Agh-6		1888	513-GPMT-63-GC-1200	513-GPINT	513-GST	562-KME-42-1042-23	Still running ESP
Agh-7	Resize the pump &	644	513-GPMT-63-GC-1200	513-GPINT	513-GSB-1	562-KME-29-1042-16	
	add new perforation	775	513-GPMT-93-GC-1200	513-GPINT	513-GST-S	544-GME-63-908-42	Still running ESP