PREMIUM TECHNOLOGY – BEYOND THE LIMITS OF ARTIFICIAL LIFT SYSTEMS- FIELD EXPERIENCES

Ezequiel Fernandez
Tenaris

ABSTRACT

The current reservoirs declination and depressurization in combination with the continuous reduction of incorporated reserves to the oilfields has challenged the engineer staff to either increase the extraction rate, with a significant increase of the water volumes applied in order to pressurize the field and/or pushing the limits of the artificial lift system (ALS) using biggier pumps and equipment in combination with deeper wells.
Despite all the safety factors that have been considered for conventional sucker rod designs, the operating companies understood that the system was reaching its mechanical limit due to frequent and premature failures. After analyzing records, field data basses and statistics we concluded the API sucker rod connection is the weakest link of the system, where around 75% of failures occur.
To face this mechanical limitation and to increase the rod pumping efficiency Tenaris developed the premium connection, which overcomes the threshold set by the API[1, 2] connection. Since 2008 to these days this technology was used in different oil fields increasing its performance and making feasible to produce wells with extreme conditions.

This paper aim is to show the sum up of the most representative experiences: higher loads, increasing production, reducing failures and extending running life; establishing new parameters in the artificial lift system.

INTRODUCTION

Oil demand and consumption

Over the years, along with the growing on global population and technology, we have seen a huge increase on the energy demand. Oil consumption has increased at least 30% since 1990, but the exceeding oil production has decreased year after year. (Figure 1)
The oil and its derived are one of the most important energy sources, but as we know, every year it is harder to obtain mainly due to the depressurization of the fields and also because of the lack of new conventional fields findings. (Figure 2) [3]
The industry is moving its efforts to unconventional reservoirs, deeper wells and bigger production rates, driving the development of new equipment capable to handle the new challenges.
Rod Pumping is the most common ALS in the world, engineers from many companies have spent years studding its components and limitations aiming to increase efficiency and predict its behavior, the output of this experience is that the sucker rods is the limit of the rod pumping system because it was possible to design bigger pumping units and bigger pumps, but due to a space limitation it was not possible to introduce a bigger sucker rod connection.

ARTIFICIAL LIFT LIMITS, ROD PUMPING

Rod pumping limit and API connection application limit

The limit of the rod pumping system is given by the weakest point, the sucker rod connection. For string design proposes we can use the Modified Goodman Diagram (MGD) [1] which limits the working loads on the string within the sucker rod fatigue safe area, even though this method was originally designed to predict the rod body behavior, it can be fairly accurate to be used on connections due to the modification it has had based on the field experience.
The limit of the API connection can be reached for the combination of many different factors such as, oil density, dog leg severity, compressive loads, depth, and production rates. Usually the most important in a standard application are:

Depth, that can vary anywhere from 1000 to 13000 ft.
Production rate usually no more than 1500 bpd.

Connection will be working on the edge when this combination of factors produce a loading of 100% of MGD.

API Connection

The API[1, 2] connection is the standard connection for sucker rods, being weaker than the body it becomes a cause of inefficiency. Some of the reasons for that is that this connection has non uniform stress distribution along the thread profile resulting on very high stress concentration, tendency to back off and the high risk of being easily over / under torqued. Because of that it shows that it was not designed to handle extreme loads and as a result the user usually find frequent connection failures being forced, sometimes, even to change the ALS to a different production system.

PREMIUM CONNECTION CONCEPT

Main characteristics

The premium connection was designed aiming to solve all the API connection weaknesses improving the performance of the ALS and reducing the connection failures in demanding applications.
The new design reduces the stress an improves its distribution along the thread profile due to its geometrical characteristics:

- Tapered trapezium thread profile
- Flank-to-flank contact
- Diametrical interference

A detailed explanation of this connection is presented in a different paper, Premium Technology – Connection Design and Laboratory Tests.

This characteristics allows to increase the MGD working area of a Grade D rod class just over a standard high strength rod. (Figure 3 and Figure 4)

Increasing efficiency and working capacity

The premium connection will increase the working capacity of a system when the limit is the standard rods. The example bellow shows how we can have a system limited by one component.

Pumping unit, 1284-427-216
Depth, 9000 ft
Production rate, 600 bpd
Structure loading, 96%
Standard Rod loading, 100% MGD, rods are the limit of the system.

Standard rods are working on their limit, now if we remove that barrier we could push the limit of the pumping unit to 100% and the production rate would be 830 bpd, with is 26% higher.
This capability to use bigger pumping units and pumps at bigger depth is increasing the limit of the rod pumping system in 10%, and this allow to use rod pump systems where ESPs are installed.

FIELD EXPERIENCES AND APPLICATIONS

The premium connection rods have being proved in four different applications:

- As a replacement of an ESP
- Aiming to increase production
- To reduce connection failures in beam pumping
- To produce pcp rod pumping system

Even though the experiences started in Argentina, 9 wells are working in North America with this technology. (Table 1)
In the following pages we can see some of those applications in detail

ESP replacement

This well installation aimed to maintain the production rate that was reached with the ESP system by using rod pump and a big pump bore, ESP was replaced and well efficiency increased due to electric cost improvement.

Current well characteristics

- Pumping unit: 912-365-168
- Pump bore: 2.5”
- Pump depth: 8,749 ft (2,667 m)
- Flow rate: 628 bpd (100 m3/d)
- Strokes per minute: 8
- Stroke length: 168”
- Rods loading: 200% MGD sf 0.9

Results comparison

- Production ESP…….523 bpd
  Rod Pump……....628 bpd

The well have being working for 2.4 years with no failures, production was increased in 20%.

Production increase

This well was in production with a 2.5” pump bore but it was needed to use a 2.75” to produce its maximum potential, the API connections where overloaded and failed twice a year.

Current well characteristics

- Pumping unit: 912-365-168
- Pump bore: 2.75”
- Pump depth: 6,348 ft (1,800 m)
- Flow rate: 565 bpd (90 m3/d)
- Strokes per minute: 6.3
- Stroke length: 168”

Results comparison

- Rods Failures API grade D ……... 2 failures/year
  Premium Rods …… 0.7 failures/year
- Production API grade D ……... 434 bpd
  Premium Rods …… 565 bpd, production increase 30%.

Connection failure reduction

This well had 10 rod failures in 4 years, the installation of premium connection aimed to reduce the intervention rate.

Current well characteristics

- Pumping unit: long stroke equipment.
- Pump bore: 2.75”
- Pump depth: 7,480 ft (2,280 m)
- Flow rate: 899 bpd (143 m3/d)
- Strokes per minute: 4.5
- Stroke length: 288”

Results comparison

- Rods Failures API grade D ……... 2.6 failures/year
  Premium Rods …… 0 failures/year (3 years working)
- Production API grade D ……... 735 bpd, pump 2.5”
  Premium Rods …… 899 bpd, pump 2.75”

Intervention rate reduced from 2.6 failures per year to 0 failures in three year.

PCP systems

This well was new, the aim was to test premium connection reliability under high torque requirements, avoiding the most common failure in this system, broke threads and bodies.

- Pump depth: 3,323 ft (1,013 m)
- Flow rate: 1,283 bpd (204 m3/d)
- Pump: 400-150-ST62
- RPM: 350
- Torque: 900 lb*ft

The well is producing 1283 bpd and has being working for 2.4 years with no failures.

CONCLUSIONS

- The new demanding applications and environments will push the limits of the ALS in the near future. Premium Products will be a standard for the industry, in rods, pipes and all the involved equipment.
- Premium connection rods have increased the efficiency of the ALS and moved the technological barrier related to the API connection limits.
- It has been tested for over 5 years in more than 50 wells increasing the working area of the rod pumping system and achieving the following results depending on the application:
    - Rod failures were reduced from 2,6 per year to none in 2,4 years.
    - Production increased in an average of 30%.
    - Whole system lifespan were increased.
    - Showed to be a reliable connection under high torque requirements.
- Downtime was reduced and rig & material replacement savings were obtained.

REFERENCES

1. API RP 11BR, “Recommended Practice for Care and Handling of Sucker Rods”, API, USA. April, 2008.
2. API Spec 11B, “Specification for Sucker Rods” API, USA. 27th ed., May, 2010.
3. (Figure 2) International Energy Agency’s (IEA’s) *World Energy Outlook 2010.*
4. (Figure 1) International Energy Agency’s (IEA’s) *Oil Market Report “annual statistical supplement 2010”*

Table 1
Premium Connection Installations in North America by Region

N	Company	country	region	well	working	Instalation date	SPM	Months	MM ciclos	Failure Cause
1	A	Canada	Canada	A1	yes	14-Sep-09	5	29	6.36	No Failures
2	A	Canada	Canada	A2	yes	21-Dec-09	8	26	9.05	No Failures
3	B	Canada	Regina	B1	yes	22-May-11	7	9	2.71	No Failures
4	B	Canada	Regina	B2	yes	5-Aug-10	7	19	5.63	No Failures
5	C	USA	Midland	C1	no	23-Aug-10	8.2	2	0.71	Corrosion
6	C	USA	Wyomin	C2	no	14-Dec-10	6	6	1.56	Tubing Failure
7	D	USA	OK	D1	yes	23-Jun-11	7.5	8	2.56	No Failures
8	E	USA	OK	E1	no	24-Nov-08	14	11	6.65	Make Up / Over torque
9	F	USA	ND	F1	yes	19-Aug-11	7.6	6	1.97	No Failures
10	G	USA	OKC	G1	yes	23-Nov-11	6	3	0.73	No Failures
11	H	USA	ND	H1	yes	2-Feb-12	6.5	0	0.12	No Failures
12	H	USA	ND	H2	yes	12-Feb-12	5.7	0	0.02	No Failures

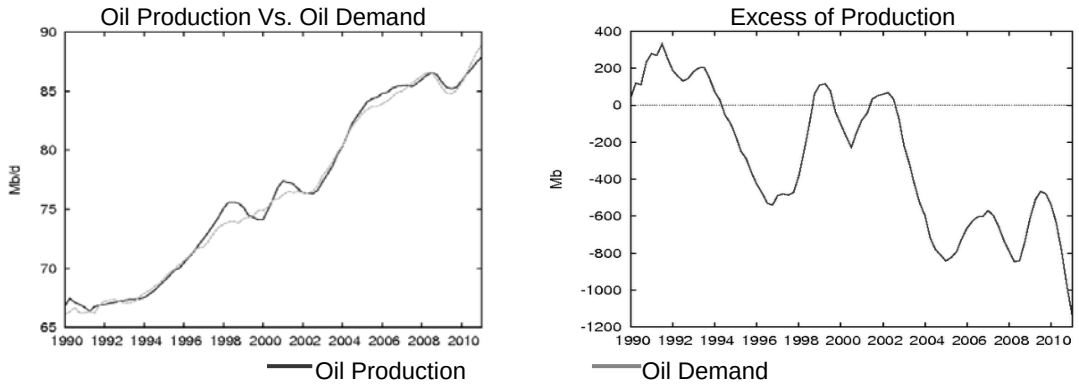

Figure 1 - Oil Demand vs. Consumption and Excess of Production

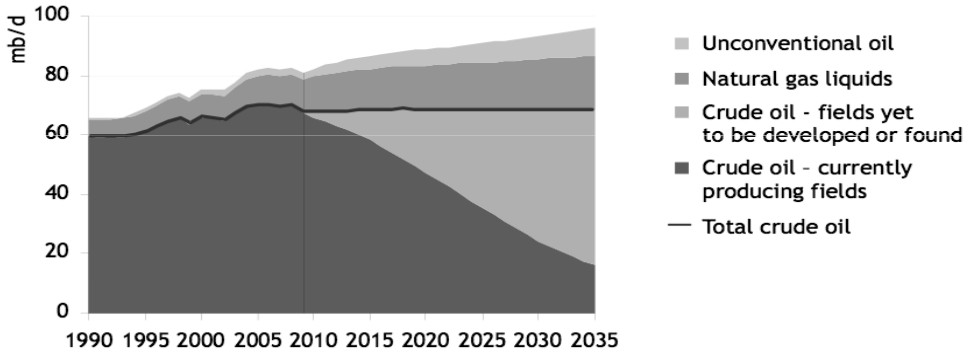

Figure 2 - Oil Production Forecast by Class

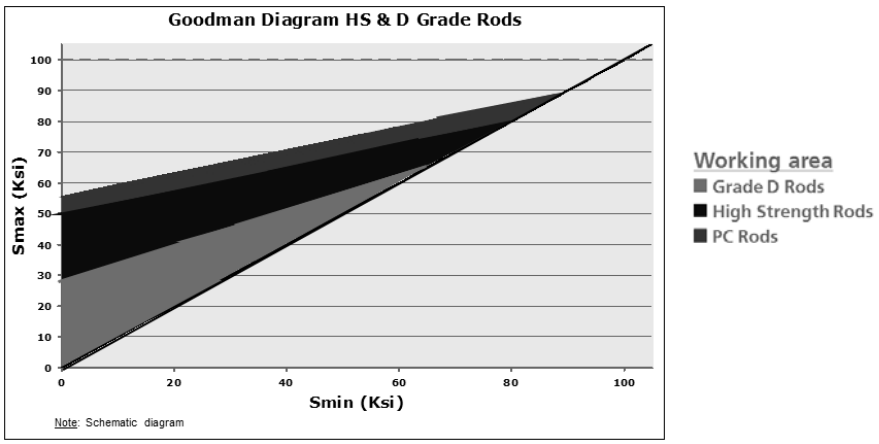

Figure 3 - Modified Goodman Diagram

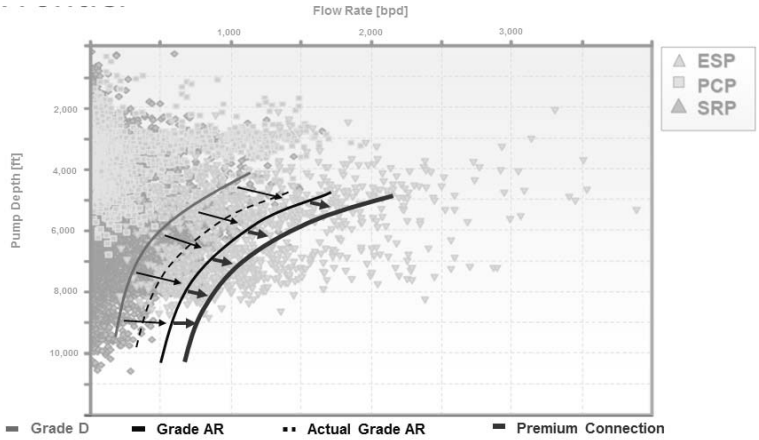

Figure 4 - Working Area Expansion