NON-CABLE ACTUATED ROD ROTATOR: TECHNOLOGY DEVELOPMENT AND FIELD EXPERIENCES

Nicolas Gayubas and Martin Ruiz Palero, DALTEC OIL TOOLS
Rodrigo Ruiz, DUXAOIL TEXAS LLC

ABSTRACT

The use of rod rotators is key to extend the life of sucker rod string couplings in all intentionally and not intentionally deviated wells. Its applicability has proved to be a low-cost solution, giving an even wear on sucker rod couplings, extending considerably their run time.

One of the major issues with conventional cable actuated rod rotators is the integrity of the cable, its installation and proper maintenance. It's common to heard from operators losing the cable connection and ending up on a premature failure on sucker rod couplings due to localized wear.

Initially designed as a solution for long stroke belt driven units, where cable rod rotators weren't reliable, a telescopic arm actuated rod rotator solves the issue with minimal down time. This innovation then was implemented in conventional pumping unit setups providing reliable rotations of sucker rod strings.

This paper describes the development process for the telescopic arm actuated rod rotator and the case studies in their initial set of applications in operation.

INTRODUCTION

Sucker rod string rotators have been part of the industry for more than 70 years, with two target applications, wells with paraffin (to help rod guides cover 360° rotation) or heavily deviated where premature wear on couplings is frequent. The principle is simple, utilizing the reciprocating motion of the pumping unit to perform a small clockwise rotation angle per cycle.

The rod rotators versions widely used in the field to this date have remained in principle the same way. There have been attempts to add automation or introduce self-driven features, but all failed to compete with the cost efficiency of the historical design.

The standard rod rotators use a lever-ratchet mechanism connected to a gear-plate system. The configuration is simple, but they require external actuation of the lever with some form of connection to a stationary part of the unit. The regular type of connection is a cable tied on one side to the walking beam of the pumping unit and the other to the lever, which its required length is set at the time of installation. This cable will indeed actuate the rod rotator but there are several reasons why it may not actuate properly:

- The workover or field personnel did not connect the cable to the beam right after a well intervention.
- The wind may tangle the cable, losing the calibration and eventually breaking
- Poor calibration

Most specifically, in the case of long stroke belt driven units, difficulties to properly actuate the rod rotator are critical. The lack of walking beam push operators to place stationary structures that must be perfectly aligned with the rod rotator lever, and in most cases, it misses to actuate, or they fail prematurely.

In the last 20 to 30 years, most of the innovation for rod rotators pointed to make it “smart”, self-driven, mainly motivated by the operator need of a reliable of operation of them. The research and development process described below targets a reliable and robust way to actuate rod rotators without the need of cable.

REASEARCH AND DEVELOPMENT

Innovation on simple systems is often challenging, requiring a high level of understanding of the basic principles of operation. Based upon a vast field experience, the design was engineered to tackle two main field issues with current rod rotator designs: Actuation mechanism and overall weight.

The drive to modify the actuation mechanism resulted in a simple but powerful idea, independence from the cable and look for actuating alternatives. The alternative that prevailed all the prototyping ideas was the telescopic design, associating the reciprocating movement of the pumping unit instead of cable-to-beam system, utilize the support over sections of equipment that are always stationary, like the case of the stuffing box on the top of the production wellhead hookup.

The telescopic arm connects the lever with the polished rod self-centered shoe of the system (See Figure 1 for schematics). This shoe will get in contact with the stuffing box at the downstroke pushing the rigid arm connected to the lever upwards (See figure 2 for operation principle).

The concept was evaluated on three separated stages: Finite Element Analysis (Fatigue simulation), laboratory test and field trials.

Finite Element Analysis is widely used to evaluate geometry impact on equipment and structures exposed to cycling loading. In this case the shoe will be the one receiving a bending moment on each cycle with enough force to operate the lever even at full load (44,000 lbs) [See figure 2 for an example of the FEA mesh evaluation and Table 1 for further equipment specifications].

In order to evaluate the required lever force to proper actuate it, static loads were applied to the rotator mechanism and the force required to actuate was directly measured at the lever (Figure 4). The laboratory testing determined that, at full load (44,000lbs), the rod rotator required only an average of 4.2lbs (with maximums of 7,2 lbs) to actuate the lever. The maximum value obtained was the minimum value introduced to the FEA to validate the shoe design.

In regard to the overall weight, it was a matter of ergonomics at the moment of installation. The average rod rotator weight for the 40k lb rating is around 50lbs, that means that a technician must lift over the polished rod and on position this mass. Multiple field technicians expressed disconformity with this aspect of the design, driving the engineering design to shed as much weight possible without affecting the performance of the rod rotator.

The result was a 33% in reduction of weight (17lbs), to a nominal weight of 33 lbs. This feature was initially the most sought after by the installation crews running them (See Table 2 for a weight comparison).

Furthermore, the field trials validated in conjunction with the FEA allowed for a final design that was put in production. The following case studies are examples of field trials on equipment that remains still in operation.

FIELD VALIDATION

Case 1

- Operator: A
- Field Location: Golfo San Jorge Basin, Santa Cruz, Argentina
- # of wells tested: 6 (4 in Cañadón Seco field and 2 in El Huemul field). Some of the rotators were moved on to different wells within the trial.
- Testing goal: Evaluate the equipment on field conditions and in both type of pumping units, conventional and long stroke belt driven units (See Figure 5)
- Installation: 12/15/2016
- Validation Test Closure Date: 10/10/2017 (299 days)
- Conclusion of the field trial A:
    - The field trial pushed the boundaries of the initial shoe design. It led to premature failures but through FEA evaluation and the new cast molding the new design demonstrated being robust and reliable (see Figure 6 on 2nd Shoe Generation implementation and Table 3 for a summary of the operator A trial wells).
    - Installation time goes from 15 to 30 minutes and a recalibration can be made in 5 minutes.
- Well Single Case:
    - Well A-2: (See Figure 7)
        - Turn Count (end of trial phase): 9544 (avg. 53 turns a day)
        - Observations: no visible wear, minor repairs on the arm and all parts continue in operation.

Case 2

- Operator: B
- Field Location: Golfo San Jorge Basin, Chubut, Argentina
- Type of unit: Conventional
- Test group of wells: 2
- Installation: 7/15/2019
- Validation Test Closure Date: 11/13/2019 (134 days)
- Well B-1:
    - Turn Count: 3612 (avg. 30 turns a day)
    - Observations: no visible wear, all parts continue in operation.
- Well B-2:
    - Turn Count: 1455 (avg. 12 turns a day)
    - Observations: no visible wear, all parts continue in operation.
- Conclusion from the field trial B: Final validation with a new operator with no operational issues. Shoe installed is the 2nd generation which continues to perform as designed.

CONCLUSIONS

- After an extensive research and development phase followed by several field trials, the current design of the telescopic actuated rod rotator is fully functional and reliable.
- All the equipment included in the field trials remains in operation.
- The reduction in weight of 33% (to 33lbs overall) directly impacted field adoption.
- To this date more than 1000 units had been installed in numerous conventional and belt driven long stroke units.

TABLES

Table 1: Telescopic Actuated Rod Rotator Specifications

ROD ROTATOR RR-01	
Max Recommended Load	44,000 lbs
Torque output	240 lb-ft
Polished Rod Size	1-1/8" to 1-3/4"
Shipping Weight	38.5 lbs
Height	5-1/2"
Rotation type	Helical worm gear
Actuator type	Telescopic Actuator Drive (patent pending)

Table 2: Telescopic Actuated Rod Rotator Specifications

ROD ROTATOR WEIGHT COMPARISON								
Manufacturer	**A**	**B**	**C**	**D**	**E**		**DALTEC -RR01**	
Load Rating [lbs]	44000	40000	40000	40000	40000		44000	
WEIGHT [lbs]	48	48	54	47	48	49	**33**	**-33%**
						Average		*Reduction in Weight*

Table 3: Field Trial #1: Operator A. Results

Well#	Pumping Unit	Turn Counter	Installation Date	Install Time	Days in Operation	Turns	General Comments/Observations
A-1	Conventional	Y	12/15/2016	22 min	299	8108	Plastic rings on the shoe replaced and new cast shoe in operation.
A-2	Conventional	Y	12/15/2016	17 min	179	9544	Minor repair in the arm due to improper handling. New Cast Shoe in operation. Well is TA, System got installed at Well A-5
A-3	Belt Drive Unit	N	12/15/2016	18 min	299		1st generation shoe failed prematurely at a weld. Installed new cast design. Continue on operation.
A-4	Belt Drive Unit	N	1/30/2017	25 min	154		Incident with the wind blowing a fence door and hitting the arm, replaced and back in operation. Well TA, system got installed at Well A-6
A-5*	Conventional	N	8/9/2017		62		In operation with new shoe design.
A-6**	Conventional	N	8/9/2017		62		In operation with new shoe design.
A-7	Conventional	N	8/9/2017		62		In operation with new shoe design.
A-8	Conventional	N	8/9/2017		62		In operation with new shoe design.

* Well A-5 receives its rotator from Well A-2 and continues in operation.
** Well A-6 receives its rotator from Well A-4 and continues in operation.

FIGURES

Figure 1: Telescopic Rod Rotator Schematic

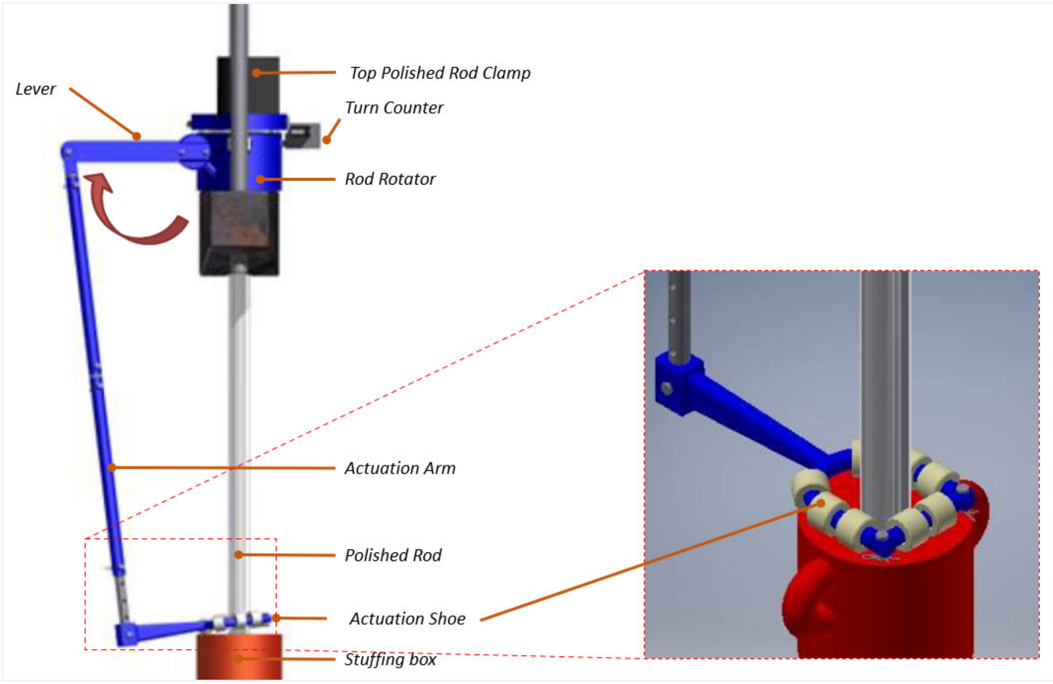
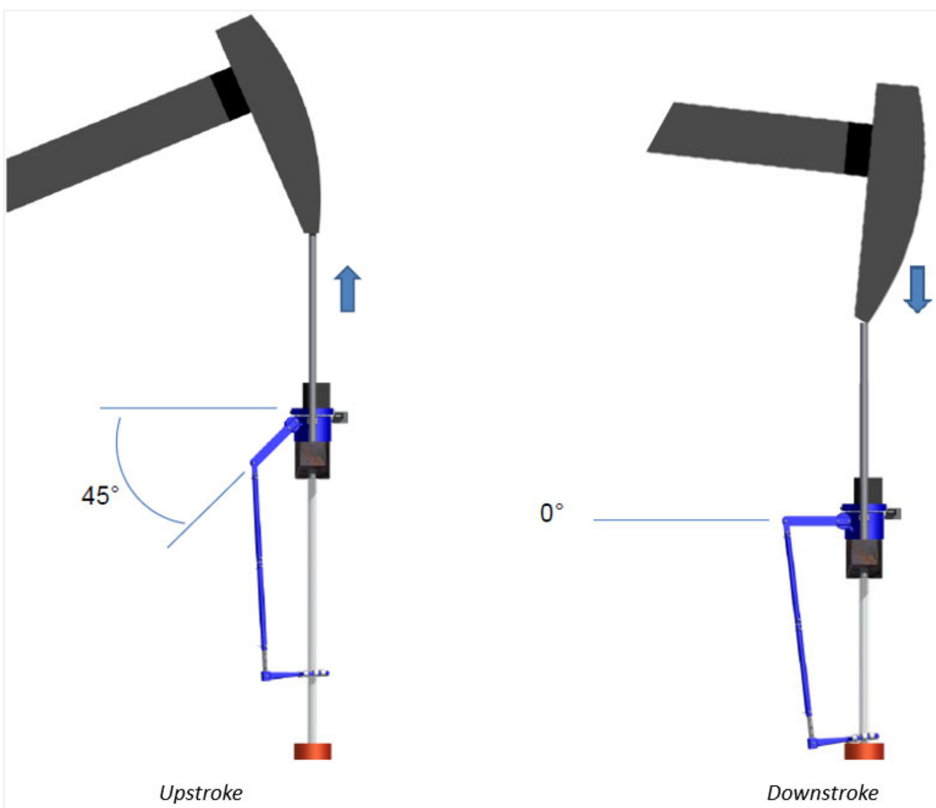


Figure 2: Telescopic Actuated Rod Rotator Operation Principle



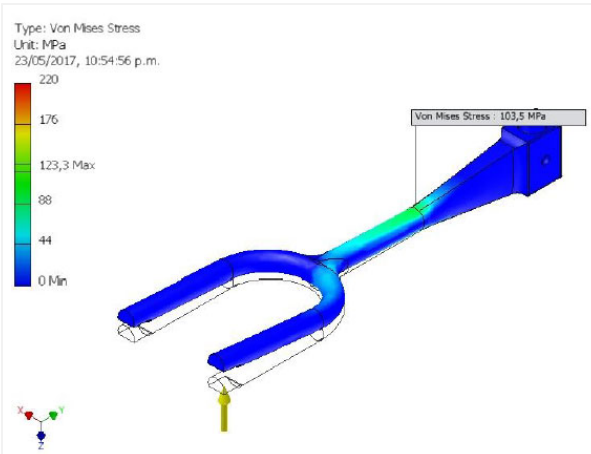
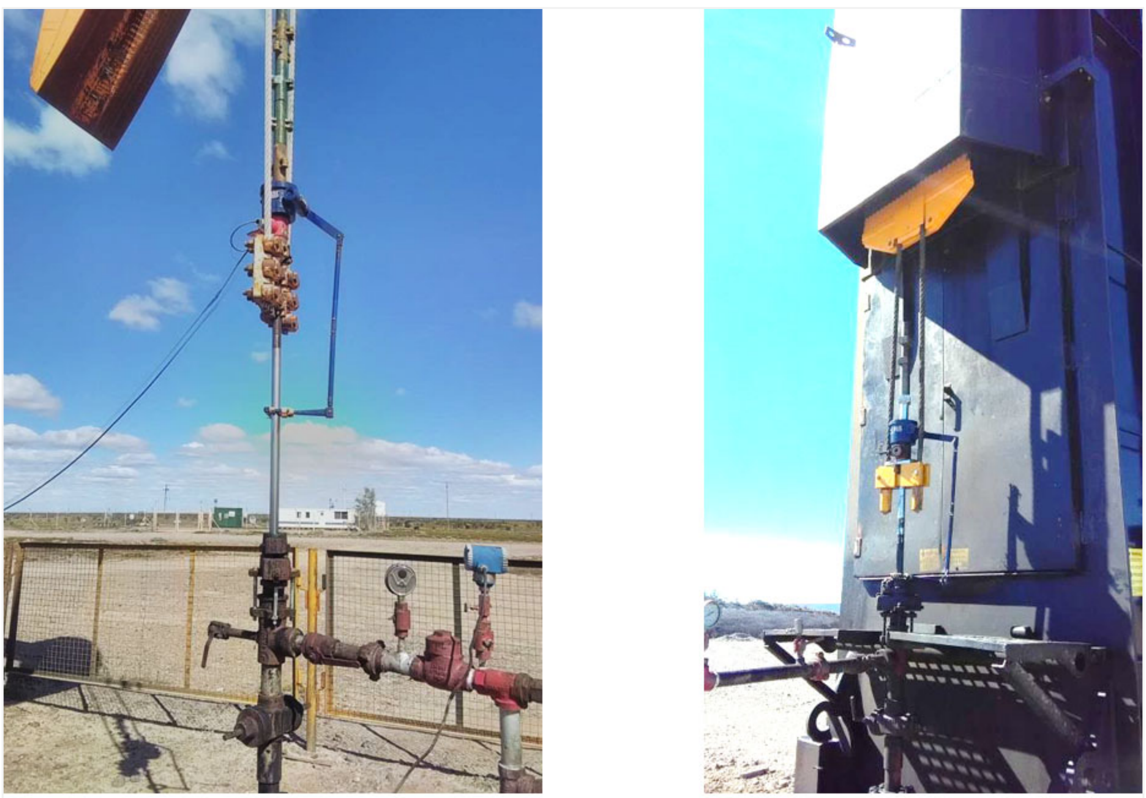


Figure 3: FEA on the new cast shoe design.

Figure 4: Laboratory validation

Figure 5: Installations at Conventional and Belt Driven Units



RR01 in a Conventional unit

RR01 in a Belt Driven Unit

Figure 6: 1st and 2nd Shoe Generation.

1st Shoe Generation Failure at Well 3

2nd Shoe Generation install in all Operating units

Figure 7: Well A-2 Installation