IMPROVED ROD MAKE-UP: IMPROVED ROD TONG TECHNOLOGY AND PRACTICES AVAILABLE TO THE INDUSTRY

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ABSTRACT

Improved rod tongs have recently been introduced for rod connection make-up and break-out in the field, with the purpose of reducing sucker rod failure rates. This paper will compare one of these tongs to the present industry standard sucker rod tong, comparing and contrasting each tong's capabilities, advantages, drawbacks, and effect on rod string performance in the wellbore. In addition, basic job time studies, best practices, and suggested well selection criteria will be discussed.

INTRODUCTION

Beam pumping oil wells rely on a cylinder pump located at the bottom of the well to lift fluid from the formation zone to the surface. In order to actuate this pump, a rod string of either conventional sucker rods (joined together with couplings), or a continuous rod string, connects the pump to the pumping unit at the surface. This paper shall discuss the conventional sucker rod string, and the tools (known as tongs) used to join the rods together or disconnect them from one another.

The most common failures within a wellbore can be categorized within three roughly equal groups:

- 1/3rd: Tubing leaks: Due to corrosion or mechanical ware, a hole develops in the tubing wall and effective pumping is not possible
- 1/3rd: Pump failure: Corrosion, ware, becoming stuck due to sand or other sediment, and seal failure all can shut down a well
- 1/3rd: Rod failure: Corrosion, ware, damage due to improper handling, and improper make-up practices all result in rod string failure.

As this paper is primarily concerned with the performance of the sucker rod string, and more specifically the sucker rod connection, a more in depth summary of rod failure is as follows:

- 1/3rd: Rod body failures: The rod parts in the body section
- 1/3rd: Coupling failures: The sucker rod coupling fails
- 1/3rd: Rod pin failures: The sucker rod parts in the pin neck or threaded region

Therefore, roughly 1/9th of all beam pumping well failures are a result of the failure of the sucker rod pin. Factors affecting the performance of the three part sucker rod connection, comprised of the lower sucker rod, the coupling, and the upper sucker rod, include:

1. Circumferential Displacement achieved: How far each pin is designed to rotate past the hand tight 'shoulder point.' Commonly referred to as the 'CD,' each manufacturer, grade, and size of rod has a specific CD value or acceptable range of values. Furthermore, some manufacturers specify different values for the first initial make-up of the rod connection, and then the subsequent make-ups.
    a. A rod connection made up to less than the specified CD value shall not have the appropriate amount of pre-load in the pin, and shall be prone to becoming loose during operation
    b. A rod connection made up to more than the specified CD value shall over-stress the pin neck and threads, and be prone to failing under tensile load during operation
2. Sucker rod shoulder and coupling face condition: Whether or not the rod shoulders and coupling faces are prepared according to manufacturer specifications – free of any dirt, oil, grease, thread lubricant etc – that is to say, clean and dry

3. Coupling face surface area: the surface area of the coupling face which contacts the sucker rod shoulder. Inconsistent manufacturing practices resulting in less surface area than as designed, or obsolete 'bullet nose' coupling designs, will result in poor connection performance in the rod string
4. Connection make and break cycles: Rod manufacturers typically define the number of make and break cycles of a rod connection possible before performance is degraded as between seven and ten cycles.

ROD MAKE-UP: CURRENT PROCESS

The present industry standard practice for making up sucker rod connections is to use a hydraulic rod tong, which is comprised of a hydraulic motor, reduction gear train, interchangeable tong heads, a backup wrench, and manual control valve. Hydraulic supply is provided by the rig hydraulic system, through a manually set pressure relief valve.

Rod Preparation

The floor hands prepare the rods and couplings by cleaning the rod pins and shoulders, and cleaning the coupling faces. Typically a cleaning product such as Berryman® B-12 Chemtool® is used to remove any grease, oil, paraffin and dirt from the surfaces, and then the floor hands use a rag to dry the rod pins and coupling faces. A manufacturer specified thread lubricant is then applied to the rod threads for most brands of sucker rods.

Rod Make-Up

A floor hand manually threads the upper rod (hanging from the traveling block and rod elevator) on to the lower rod (resting on the lower rod flare, on a rod elevator supported by the running plate) for one or two rotations, and the tong operator engages the upper and lower rods with the hydraulic rod tongs. The lower rod is engaged by the backup wrench, while the upper rod is rotated by the tong to the shoulder point, and past the shoulder point until the tong stalls out.

The process of calibrating the standard hydraulic rod tong to advance the proper amount past shoulder point and stall out, setting the correct CD, is required for accurate make-up. This process requires the tong operator to set the relief valve for the tong supply to a pressure below what is anticipated to be required, mark the hand-tight connection using the correct rod card with a paint pen or grease pencil, and then make-up the connection until the tong stalls. The operator then slowly increases the relief pressure until the required CD, as indicated by the previously applied paint marks, is achieved. Thus a relationship between hydraulic relief PSI at stall and CD is relied upon to set rod connections.

PROBLEMS INHERENT TO STANDARD ROD TONGS:

- System Variability: As a job progresses, the PSI at stall vs. CD relationship is subject to change. As hydraulic fluid temperature and the temperature of the tong gear train grease increases, the PSI vs. CD value changes, resulting in incorrect CDs set if corrective action is not taken to adjust the relief pressure. For this reason rod manufacturers recommend checking CD values every 10 connections and adjusting the relief valve as necessary, and some operators specify every five connections.
    - The cause of this variability is due to the derived relationship between pressure and CD set at stall. With no method available on a standard rod tong to measure the actual torque applied by the tong, or to measure the number of degrees of rotation past the shoulder point, the relief pressure at stall is the only measurable variable available to the tong operator and under his control. However, as the hydraulic fluid temperature changes, the efficiency of the tong motor changes. The result is that the applied torque at the start of a job on a cold morning at 1000 psi is lower than the applied torque an hour in to the job at 1000 psi when the hydraulic fluid is at a more optimum temperature.
- Inability to set independent upper and lower connections: A standard rod tong is not able to set the upper and lower rod connections independently of one another. Without a means of grasping the coupling, doing so is not possible. The result is that a proper CD value may be achieved on one side of the coupling, while the CD value on the opposite side is not within the acceptable range.
- Reversal of tong heads required to change from make-up to break-out configuration: Standard tong heads are one-directional, and must be removed and reversed to change their direction of operation. This is a common source of hand injuries, as crews often neglect to disconnect the hydraulic flow lines to the tongs and accidentally actuate the tongs while removing or replacing the heads.

- Inability to remove couplings: A standard rod tong can break only one side of the three part rod connection, leaving the unbroken side of the coupling attached to the rod, with no control over which side is broken loose. As a result, if a rig crew must remove a damaged or worn coupling they must use friction wrenches, which are time consuming and a source of injury.

BENEFITS OF STANDARD TONGS

- Common and known to the work force
- Compatible with service rigs
- High rotational speed of 100+ RPM results in connection times of less than 10 seconds from swinging the tongs on to the rods to swinging them off

ROD MAKEUP : WITH *CIRCUMFERENTIAL DISPLACMENT TONG*

The Circumferential Displacement Tong (or CDT) is a sucker rod tong which provides accurate performance setting rod connections, with the unique ability to set the lower and upper rod connection independent of one another. This tong was developed by Robota Energy Equipment, a subsidiary of Basic Energy Services. The ability to set lower and upper connections independently of one another is achieved through the use of a coupling wrench, which grasps the coupling in a manner that does not damage the surface or deform the coupling. This wrench rotates relative to the lower rod backup wrench in order to set the lower connection, and then acts as the backup wrench for the upper connection. A secondary benefit to this system is that a tong operator can efficiently remove and replace a coupling while pulling or running rods without any time spent changing or flipping tong heads, which no other tong is currently capable of doing over the well.

The CDT hangs from the rig winch line in place of the standard rod tongs, and requires an air connection to the rig air supply. However, the CDT is supplied with a small engine driven hydraulic power unit, and requires no hydraulic connection to the service rig. A tag line is not required, as the CDTs are rotation limited by design.

As the CDTs are rotation limited by design, they cannot spin a rod to the shoulder point. To reduce the time spent by the crew using hand wrenches to spin up the rods, a low torque pneumatic air spinner is supplied, which is a stand-alone device requiring only an air connection to the rig. This spinner has sufficient torque to spin a triple string of 1” rods, but not enough torque to go past the shoulder point.

In order to make a rod connection with the CDT, the operator uses a control box to select the manufacturer, grade, and diameter of the rods to be run. The operator then inspects the tong to ensure that the correct backup wrench inserts, coupling wrench inserts, and upper rod wrench inserts are installed. The operator does not monitor any stall pressure or concern themselves with any calibration procedure.

Once the CDTs are on the rig, the HPU is powered on, and the control box is set up for the particular rods to be run, the tongs are ready to make connections. The procedure for making a connection of new rods is as follows:

1. Floor hand threads the upper rod on to the lower, and spins the rod and couplings to the hand tight shoulder point for the upper and lower connections with the pneumatic spinner.
2. Tong operator swings the CDTs on to the rod, engaging the lower rod with the back-up wrench
3. Tong operator clamps the coupling with the coupling wrench, and sets the lower connection using a manual control valve. The control system automatically cuts hydraulic flow once proper CD is reached.
4. Tong operator leaves the coupling wrench clamped on the coupling, and engages the upper rod with the upper rod wrench. The operator then sets the upper connection using a manual control valve, and the control system automatically cuts hydraulic flow once the proper CD is set.
5. The tong operator then disengages the upper rod wrench and the coupling wrench, centers them within their respective rotational axes, and swings the CDT off of the rod to their stored position.

PROBLEMS INHERENT TO THE CDTS

- The limited rotation design of the tongs allows for rotation sufficient to set a CD from the shoulder point, but not to spin the rod up to the shoulder. As a result, a make-up or break-out process is slower than a standard

rod tong. A pneumatic spinner is supplied to reduce time required to make a connection, allowing a crew to set both the upper and lower connection in a time of 35 seconds.

- The CDTs are larger and heavier than standard rod tongs
- The CDT is a more expensive tool than a standard rod tong

BENEFITS OF THE CDTS

Safety:

- The crew is able to remove couplings of any type with the CDT, without requiring friction wrenches, cheater bars, and hammers to break couplings off. Some well operators recognize the safety problems associated with manual friction wrenches, and instruct rig crews to just lay a rod with a bad coupling down to avoid injury.
- The CDT is rotation limited by design, and cannot break loose from the tag line as a standard tong can and wrap up or strike the operator

Job Quality:

- Independently set upper and lower connections to accurate CD
- Does not rely on derived pressure vs torque relationship to set CDs – every connection set based on actual amount of rotation

Additional Capability:

- Rig crews can remove and replace couplings with the CDT while running in or out of the hole. For well operators who do not allow crews to use friction wrenches to remove worn or damaged couplings, the CDT saves transportation costs of sending a laid down rod in to the rod shop and delivering a replacement rod to the well.
- An operator can decide to break connections with the couplings facing up on one job, and then with couplings facing down on the next job, reducing the number of make/break cycles for a particular connection over the life of a rod string.
- The control system records break-out torque values and degrees of rotation required to reach the free turning point, so an ability to analyze the previous job quality is available.

Job Time Comparison

Case Study: 8800’ Well, new string installation from the ground

	Standard Tong	CDT, Actual Job Data
# Rods Run	347	347
Rig Time running rods, min	260	465
Average Trip Time, s	45	82
Rig Cost: $350 / hr	$1516	$2713
Additional CDT Cost: $175 / hr	-	$1356

Case Study: 8800’ Well, running triples from mast

	Standard Tong	CDT, Actual Job Data
# Stands Run	118	118
Rig Time running rods, min	78	127
Average Trip Time, s	40	65
Rig Cost: $350 / hr	$452	$746
Additional CDT Cost: $175 / hr	-	$373
Time to remove a coupling, min	20	.75
# of couplings removed for equal rig time	3	
# of couplings removed for equal cost	6	

Well Selection

The CDTs do add additional time and cost to a rod job, and as a result they may not provide a positive return for every operator and every well. Rod strings which are not highly stressed in wells which do not have a history of rod pin and coupling failures may not realize a benefit from a decreased failure rate in that area. However, individual wells and particular fields which do have a history of rod pin and coupling failures, and rod string designs loaded to near maximum stress, will realize a benefit from connections set with accurate, independent circumferential displacement of the upper and lower connection.

In addition, if an operator were to replace more than six couplings in an 8800’ string while running triples, the cost of the rig time and CDT rental rate would be lower than that of a of rig with a crew using manual friction wrenches to remove the couplings. Therefore, if an operator intends to replace greater than six couplings in a rod string, renting the CDT to make up the connections will pay off immediately, as well as reduce the failure rate of the string following completion of the job. The CDT is also able to break out and remove worn couplings while running in the hole if they are identified in the middle two couplings without requiring the operator to change the tong head direction, further improving the efficiency when compared to standard tongs.