# Hydraulic power tongs provide makeup torque for threaded riser connections

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**THE FIRST DEMAND** for a power tong that can deliver a torque value of 300,000 ft/lbs at 21-in. diameter came from the Unocal West Seno tension-leg platform (TLP) deepwater development project in Indonesia two years ago. The scope of this project was to install 24 "hybrid" production riser strings which included production riser connections that required more than 100,000 ft/lbs make-up torque and more than 200,000 ft/lbs break-out torque.

These new types of threaded production riser connections were designed especially for spars, TLPs, and semisubmersible production platforms that require torque values never before seen. Threaded production risers are used to extend the subsea wellhead from the seabed to the floating platform and are exposed to tremendous forces and stresses caused by water currents and the motion of the vessel due to the waves.

These parameters required Weatherford to design and build a completely new tong concept within a very short time window. The new tong was called the Riser Tong 21-300, and is the first fully rotational tong with integral backups able to generate 300,000 ft/lbs of torque. In less than 12 months, two units were designed, built, lab tested, and delivered to Indonesia in 2002/2003 for the West Seno Project.

The new concept includes a hydraulic gripping system that is activated by a hydraulic motor/pump combination and works with an independent hydraulic system inside the tong rotor. With the successful application of the tong on the West Seno Project, 2004 brought a new challenge. Four of the 21-300 tongs were required in a mechanized version in a "hands-free" environment to be operated on offshore floating platforms in the Gulf of Mexico.

Never before has a power tong the size and weight of the 21-300 been operated under these conditions. A rail-mounted system consisting of a hydraulically driven frame and a specially designed supporting servo-frame were developed to safely handle the large weight of the tong. Two versions of remote control were delivered, a fully electronic computer-based remote control system and a simpler pneumatic version.

## TECHNICAL REQUIREMENTS

Characteristics that influence the required torque values in threaded production riser connections include large radial interference between the threads that increases the initial make-up of the connection, and large torque shoulders that require "pre-loading" of the shoulders after thread interference to withstand the dynamic forces of the ocean and to resist backing out under stress.

This pre-loading is called Delta-Torque and is important to the functionality of the connector and is decisive for the mechanical integrity of the connection. Due to the mechanical friction within the thread and the torque shoulder as well as to the geometry of the thread, the break-out torque values can be as high as 2 ½ to 3 times the make-up torque.

These characteristics together lead to required potential make-up torque values of over 150,000 ft/lbs and required break-out torque values of up to 300,000 ft/lbs. The typical tong gripping size of these riser connections is up to 21-in. Due to the required torque-turn curve, a rotational device was preferred compared to a wrenching device, which technically would have been an easier solution.

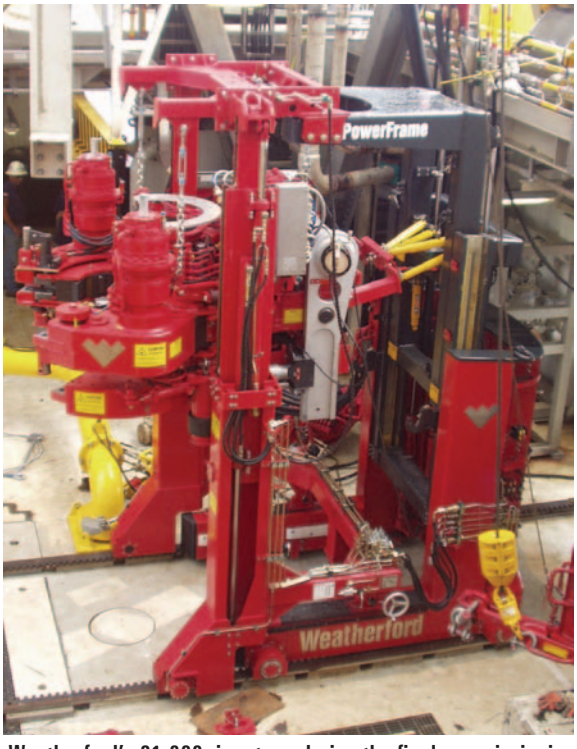
An integrated backup-tong to counteract for the reactive torque was required to be included in the design concept. The gripping area of a typical production riser connection is clearly defined and the distance between the tong and the backup is another important design factor.

## DEVELOPMENT AND CONCEPT

Several concepts were discussed in order to find the optimum design. Conventional power tongs often use a cam-curve system to engage the gripping elements.

The advantage is that the gripping force directly depends on the torque value applied, which is especially important for thin-wall casing and tubing connections. The required maximum torque value of 300,000 ft/lbs, however, requires a much higher radial gripping force than a cam-curve system can deliver.

The solution was to utilize a hydraulically activated gripping system that had already been used for smaller tongs. A hydraulically activated gripping system is capable of applying the necessary clamping force of 800 kN (180,000 ft/lbs). To prevent riser damage, a three-jaw gripping system with a six-point gripping arrangement is used.




Weatherford's 21-300 riser tong during the final commissioning on BP's Mad Dog spar in the Gulf of Mexico. The spar is in Green Canyon Block 782 in approximately 4,800 ft of water.

The gripping system is activated hydraulically with adjustable gripping force by a separate hydraulic clamping circuit driven by a motor/pump unit. Three spring-loaded hydraulic clamping cylinders within the rotor force the jaws against the riser connection OD.

During make-up or break-out operations, the riser to be rotated is first enclosed in the tong and backup and the tong and backup doors are closed and latched. Then a motor/pump unit (at the tong and backup) consisting of a hydraulically driven motor mounted to the tong housing and a piston pump mounted on the tong rotor produces hydraulic pressure for the clamping cylinders.

The piston pump is equipped with six pistons. Two pump pistons supply the pressure for each clamping cylinder. This ensures that each clamping cylinder gets exactly the same amount of oil to provide symmetrical and centric clamping forces for the jaw grip. The rotor then rotates the riser. Finally, the jaws release and back off from the pipe. Changeover between make-up and break-out operation can be accomplished at every rotor position. The size range of jaws is designed to accommodate all variations in riser and casing diameters within their nominal size range from 9 ½-in. through maximum 21-in. diameter.

## MOTOR ARRANGEMENT

With its two different gear shifting systems, a shiftable planetary gear reducer for the two operation modes (riser and casing mode) and a hydraulic gear, shifting covers a total rotating speed range from 0.2-16 rpm. Three parallel-driven hydraulic motors located on the tong casing to rotate the riser and to distribute the forces symmetrically from three sides drive the system. A large rotary gear accomplishes closure and rotation of the riser-gripping jaws. Mechanical power is transmitted from the hydraulic motors to turn the rotary gear in either direction.

The rotary gear is a large-diameter gear that has been segmented into three sections with pivotal hinges and latching mechanism. The smaller rotary gear segments pivot open to encircle the riser being worked and then close and latch while working the riser. The internal diameter of the gear has an insert surface for the clamping unit, which is driven by a separate motor/pump unit on top of the tong case to secure hydraulic pressure during rotation.

The gear train consists of the three hydraulic motors mounted on a planetary gearbox in a separate housing on the tong rotary. Each hydraulic motor drives directly a pinion, which in turn drives the rotary gear.

## FREE-FLOATING BACKUP

The free-floating backup underneath the tong restrains it from moving around the pipe when torque is applied. No backup line is required that would cause a possible safety hazard at the high torque values the tong can deliver. It also contains three hydraulic clamping cylinders to provide sure string grip with maximum gripping forces. The free-floating type of reaction system eliminates any shear and bending loads across the tool joint, thereby subjecting the joint only to torsion loads and minimizing the risk of damaging thread flanks or shoulders by galling.

The StabMaster during riser running operations.

The separable free-floating backup is mechanically and hydraulically (via hoses) linked to the tong and is self-compensating for connection thread travel in both make-up and break-out directions. A load cell (torque cylinder) is fitted between tong and backup and, by selection, can be used to record make-up or break-out torques. Three jaws provide the gripping means.

A gripping system in the same manner as in the tong (also with separate hydraulic circuit) ensures a centric clamping action of the hydraulic clamping cylinder. The backup clamping range is designed to accommodate all variations in collar diameters within their nominal size range from 9 ½-in. through maximum 24-in. diameter.

## TORQUE MEASUREMENT

Bending and shearing forces are eliminated by the free-floating backup system as these forces are symmetrically distributed into the torque posts, allowing measurement of applied torque to be made very accurately. A torque measuring system combined with a power tong with free floating back-up eliminates oscillations and additional interfering forces. Consequently, make-up and breakout torque can be measured with the same accuracy.

Torque load is measured with an active compression-type load cell. The force is directly measured within the torque reaction system of the free-floating backup. If desired, a make-up or a break-out with the Riser Tong 21-300 can be controlled using a torque/turn system that records the torque over turn graph while making-up (or breaking-out) the connection. That halts the make-up process when the pre-selected optimum torque value is reached. Many of the production riser connectors used today are externally shouldered and require “pre-loading” of those shoulders to ensure they will withstand the bending stresses caused by the environment while not backing out.

This is achieved by applying “delta torque” to the connections after the connection has shouldered. Manufacturers require that this delta torque is applied and controlled within very tight tolerances. New proprietary software was designed to analyze the connection torque/turn data in real time, then applying a predetermined amount of delta torque or delta turns to the connection for final makeup.

## TONG MANEUVERING

The Riser Tong 21-300 was designed with various types of rigs in mind. The tong can either be suspended from a lift cylinder and manipulated to and from well center with the Weatherford PowerScope, or the other option is to integrate the Riser Tong 21-300 into the Weatherford rail-mounted PowerFrame and ServoFrame system.

Depending upon the application, all functions of the tong can be controlled either directly from the hydraulic control panel at the side of the tong or via a remote control panel. Remote control can be accomplished through an air-over-hydraulic control or electronically with the tong being an integral part of an electronic control system. In this case, the tong and the tong carrier device can be connected to the rig's zone management system to prevent collisions between different devices such as PowerFrame, top-drive, or pipe handling systems.

## CASE HISTORIES

*Indonesia*. Two 21-300 tongs were delivered for the West Seno Tension Leg Platform (TLP) operated by Unocal in the Makassar Strait in Indonesia. The challenge presented to Weatherford was to run approximately 3,000 ft of 13 ⅜-in. steel casing (below mud line), titanium tapered stress joint (crossover joint), and approximately 3,000 ft of production risers (above mud line) as one string in a severely deviated open hole. The production risers consisted of joints with weld on connectors in the high stress areas that required more than 100,000 ft/lbs of make-up/breakout torque, and specialized threaded and coupled connectors for the remainder of the string above the mud line. Due to fatigue concerns, the requirements for handling the production risers were minimal marking to the OD of the risers.

As a result, 13 ⅜-in. Micro Grip (non-marking) slips were developed for the project and used in a 500 ton **BJ Services** spider with a remotely operated retractable base plate. The slips did not penetrate into the pipe body and the spider was remotely and safely retracted from well center to accommodate all large OD riser string components.

Two tongs were rigged up simultaneously opposite each other on the rig floor to handle the non-marking requirements of the threaded and coupled risers and the high torque requirements of the weld-on

riser connections. Due to open hole conditions, it was imperative to reduce time on slips for the pipe string to avoid stuck pipe. A semi-mechanized 24-80 tong with a pneumatic/hydraulic gripping device and aluminum inserts was used to make up the threaded and coupled risers, leaving no penetration into the pipe body wall. This tong was positioned on and off the pipe remotely with the hydraulic PushMaster, and the tong doors were actuated remotely open/close.

The semi-mechanized 21-300 tong was used to make up all weld-on specialty connections and was positioned on and off the pipe with the PowerScope. The tong doors were also actuated remotely open/close. All production risers and casing was installed with no human stabber in the derrick. The derrick mounted StabMaster was used to vertically align all joints during makeup.

All equipment was manufactured by Weatherford; lab tested and delivered to Indonesia within 12 months from the design kick-off meeting to final acceptance test, and successfully performed the first batch set of production risers.

When Weatherford was awarded the work, simultaneous design, manufacturing, training, and preparation occurred, including:

- The newly designed 21-300 tongs were, designed, manufactured, and lab tested in Langenhagen, Germany;
- The newly designed 13 3/8-in. and 14-in. Micro-Grip slips were manufactured and lab tested in Germany;
- The newly modified design of 24-80 tongs, the newly designed pneumatic/hydraulic pre-load assembly for non-marking tong jaws and joint compensators were manufactured and lab tested in Ventura, Calif;
- All crossover assemblies were made up in Houston at Weatherford's training rig and shipped to Indonesia;
- Personnel were sent to the US for training offshore on a spar for production riser running.

*Gulf of Mexico*. As a result of the success of the 21-300 in Indonesia, two follow-up projects were awarded in 2004 to install production riser in the Gulf of Mexico. These projects required four additional 21-300 tongs to be built.

Weatherford's 21-300 power tongs were also isntalled on Murphy's Front Runner spar in the Gulf of Mexico.

The Front Runner development project for **Murphy Exploration** also required a tong that could produce well over 200,000 ft/lbs. As with the Unocal West Seno project, this project also had a mixed string of production risers with weld-on and threaded and coupled connections.

With this project, only one tong was required to run all 13 3/8-in. outer risers and the 9 7/8-in. inner risers with no penetration into the pipe body wall. The 21-300 was used successfully for all applications.

The mechanized tongs and PowerScope were run remotely from a pneumatic/hydraulic control panel. The following additional equipment was used:

- StabMaster vertical alignment tool
- TripMaster single joint compensator
- 350 ton spider with low penetration inserts and hydraulic retracting base plate
- Special Delta Turn makeup software.

The second Gulf of Mexico project was **BP's** Mad Dog development, which required a fully mechanized 21-300 tong integrated into the rig's existing PowerFrame I. The entire production riser string consisted of weld-on connectors which potentially required greater than 200,000 ft/lbs. of torque. The following equipment was also manufactured and delivered with (12) months of receiving the order from BP:

- ServoFrame (required to assist the PowerFrame in moving the tong to and from well center);
- StabMaster vertical alignment tool with hydraulic retractable derrick mount;
- 350 ton Varco spider with 13.8-in. Micro Grip slips and hydraulic retracting base plate;
- TripMaster single joint compensator;
- Special Delta Torque makeup software.

The riser tongs were operated remotely from Weatherford's control panel which was integrated into the rig's existing zone management system. ■