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Development of a High-Fatigue-Life Spoolable Connector for Offshore Applications

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Abstract

As the offshore reserves are getting deeper and deeper, the coiled tubing (CT) string is getting longer and heavier. Since its introduction in the 1960s, coiled tubing has evolved from small diameters (used mostly in cleanouts) to larger diameters and heavier grades with higher flow rates, push-pull capacity, longer reach, and wider applications extending into CT drilling. Some limiting factors still exist however, especially at offshore platforms, where limited crane weight capability and poor weather conditions can severely limit the size of the reel that can be lifted.

With offshore crane capabilities as low as 8 tons on some platforms, coiled tubing reels are often transported in two or more sections and joined offshore. Two methods for joining CT reels include: (1) “butt welding,” which requires hot work permits and (2) the use of “spoolable connectors,” also called “cold connection.” Both methods reduce fatigue life significantly. Ideally, a spoolable connector should have the same fatigue life as the base pipe. This paper describes the development of a novel spoolable connector with fatigue life equivalent to that of base pipe. In addition, the pressure rating of the tool is as good as that of base pipe with no leaking on the shortest possible drums and tubing guides and up to the end of the fatigue life of the base tubing.

The connectors are made with material certified for sour wells and acid jobs. The spoolable connector assembles flush with the coiled tubing OD to help ensure continuous gripper engagement. The connector is designed using extensive nonlinear finite element analysis (FEA). Results from fatigue machine tests and full-scale yard tests will be discussed along with results from tensile, torque, pressure, and stripper packer testing.

Higher fatigue life and better pressure, tensile, torque and chemical compatibility should result in an increased utilization of existing CT strings with applications not deemed feasible previously. Higher fatigue life will enable the repair of damaged strings, and high-fatigue-life, large-sized CT will now be available for use on even older platforms.

Introduction

The history of coiled tubing (CT) for oilfield use dates back to the 1960s when a continuous conduit of pipe was developed to deploy in live wells. Since then, CT has found its major application in well intervention operations such as cleanouts, acidizing, and production stimulation. Since its introduction, CT applications have expanded; consequently, CT size and metallurgical composition have changed as well. For use in deepwater drilling, CT required higher flow rates and greater push-pull forces, leading to the development of larger diameter, heavier-grade coiled tubing (changes brought about mainly in the 1990s). Limitations of larger CT include insufficient platform space, insufficient weight-handling capability of cranes, and manageability problems in high seas and turbulent weather. These conditions severely limit the use of the larger sized coiled tubing required for deeper wells. The situation is even worse in deviated wells where smaller OD coiled tubing cannot provide sufficient push force and tractors or other methods may be needed to provide additional push.

There are very few new cranes offshore, most are close to 20 years old and have been downgraded over time. Quite a few of the older ones have as low as 8-ton capacity. The only way to work with these cranes is to lift the reel followed by the CT on wooden storage drums and spool onto the reel on the rig. The string can also be spooled directly from a boat, but this operation is very weather-dependent. Even if the crane weight capability is acceptable, its use requires calm weather and limited waves to be used to its full potential.

One solution to the problem has been to transport the CT reel in multiple sections according to the offshore crane limitations and later join the sections by butt welding. Field welding, such as manual butt welding, requires a qualified welder to perform the job and extra equipment to verify the integrity of the weld. A hot work permit is also required to perform the connection, and the well(s) has to