Manufacturing Process Of 30 × 1 Inches Pin and Box Premium Threaded Casing Connection for Deep Offshore Wells

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Abstract- ***Well casing is necessary after the drilling of the wellbore in order to consolidate the well, to protect the wellbore from falling, to protect the fresh water aquifers by preventing the drilling fluids used or oil to seep into the underground water reservoirs, and to facilitate the execution of drilling and completion operations. The main function of casing and tubing threads is to contain wellbore pressure and provide structural integrity to the well. For this purpose, pipe casing is used, consisting of casings assembled together by threaded casing connections. The emerging challenges in oil and gas exploration and production activities in deep and ultra deep waters in harsh environments necessitates the need to develop innovative threaded casing connections and design methodology capable of containing wellbore pressures and ensuring structural integrity to the well. Premium threaded casing connection has been a proven technology to ensure the integrity of drilled wells in deep offshore oil and gas drilling and completions. They are suitable for HTHP (high temperature, high pressure) wells, the connection has longer coupling, and provides better strength and stealing properties. This paper brings forward the detailed manufacturing processes of 30 X 1 inches PIN (male) and BOX (female) premium threaded casing connection for a typical West Africa deepwater offshore project that serves as conduit. A Computer Numerical Control (CNC) machine is used with a G-code programme to run the CNC machine to thread and insert the top and bottom seal of the casing connectors. A step by step detailed manufacturing process from the raw forged material to the machining of the finish casing connectors are elaborated in this paper to provide better understanding and for research purpose.***

Indexed Terms- ***Premium Threaded Casing Connection, Computer Numerical Control (CNC) Machine, G-Code Programme, Deep Offshore HTHP Wells, And Manufacturing Process.***

I. INTRODUCTION

In other to drill the wells of deep-water offshore projects and complete it, a series of pipe casings need to couple together to form different joints. These joints need to be connected by PIN and BOX connectors to form long connections that will get to the targeted depth of the well. Well casing is necessary after the drilling of the wellbore in order to consolidate the well, to protect the wellbore from falling, to protect the fresh water aquifers by preventing the drilling fluids used or oil to seep into the underground water reservoirs, and to facilitate the execution of work operations (drilling or exploitation) [8]. For this purpose, pipe casing is used, consisting of casings assembled together by threaded casing connections (Figure 1). The casings used for well casing are steel pipes. The casing manufacturer, according to reference standards, assembles in the factory coupling (box) at one casing threaded end (threaded casing connections-factory assembled), and during the well casing, the other threaded end of the casing is assembled in the operation field (threaded casing connections–borehole assembled), by makeup to the coupling (box) of another casing (Figure 2).

This current paper brings forward the detailed manufacture process of 30 X 1 Inches PIN (male) and BOX (female) premium casing connections for a deep-water offshore project in a typical West Africa Offshore that will serve as conduit, and for the structural integrity of the wells. A Computer Numerical Control (CNC) machine with G-code is used to manufacture a 30 X 1 Inches PIN and BOX Pipe Casing connections from the raw forge material

to finishing. Insert top and bottom seals, make weld prep and threads.

II. OVERVIEW OF THEADED CASING CONNECTIONS

Threads are used as mechanical means to hold the neighbouring joints together during axial tension or compression. The main function of casing and tubing threads is to contain wellbore pressure and provide structural integrity to the well. The following is a summary of the main features of casing threads:

- The thread sealing mechanism is one of the connection's most important features.
- In low pressure wells, gas integrity is not critical and API connections can be used.
- API connector uses a thread dope channel for a seal.
- The dope channel is a path formed by a gap between the root and crest of the trapezoidal thread or the stabbing flanks of the buttress type thread.
- The leak path is a continuous helical channel running the length of the connection.
- The API connectors depend on thread lubricant to block or plug this leak path.
- Viscosity of dope is highly dependent on temperature and pressure. The higher the temperature or pressure, the more quickly the lubricant is extruded through the helical path causing a leak.
- Therefore, API connectors are not suitable for wells with high temperatures, cyclic temperatures or high pressures.

TYPES OF CASING THREAD CONNECTIONS

Oilfield tubular may be equipped with plain ends (no threads), have API-specified threaded casing connections, or premium (non-API) threaded connections.

A. API CASING CONNECTION

Oilfield casing conforming to API standards may be obtained with plain ends, but ends are usually threaded and furnished with couplings such as:

- short thread and coupling (STC)
- long thread and coupling (LTC)
- buttress thread and coupling (BTC)
- Extreme-Line thread (X-line) for casing with 8 round threads per inch (8 RD)

B. PREMIUM CASING CONNECTIONS

Premium connections offer premium features not available on API connections. For this project specification, 30 X 1 Inches PIN and BOX premium connections were used.

Among the special features for premium connections are:

- clearance OD of coupling for slim hole completions
- metal-to-metal seals for improved high pressure seal integrity
- high bending strength for deviated holes
- multiple shoulders for high torque strength
- a streamlined connection OD for easy running in multiple completions.
- recess-free bores through the connection ID for improved flow characteristics
- higher tensile strength for deep holes
- an integral connection to reduce the number of potential leak paths
- resilient seal rings for continuous corrosion protection
- high compressive strength for compressive loading situations

See the figure below:

Figure 1: Premium Threaded PIN and BOX Casing Connections

Figure 2: Premium Threaded PIN and BOX Connection Assembling

DESIGN CONSIDERATION/CRITERIA

The casing joints are connected together using a threaded connection. These threaded connections are classified as: API, and gas-tight, metal to metal seal premium.

The design considerations for this project are those for the premium threaded connection for HTHP (High temperature, High pressure) wells, the connection has longer coupling and provides better strength and sealing properties. For casing design, there are three main loads which have to be considered: the yield strength, collapse pressure and burst pressure. However, the full detailed report for the design criteria is beyond the scope of this work. The design was done in Aberdeen, Scotland, UK and the drawings were passed down for manufacturing.

DESIGN SPECIFICATION FOR PIN AND BOX CASING CONNECTOR

The PIN casing connector is specified by the following parameters:

- Outside diameter and wall thickness, 30 X 1 Inches
- Weight per unit length, normally weight per foot or metre, 129.3 $Ib/_{ft}$
- Type of coupling, premium long threaded connection
- Length of joint, 30ft
- Grade of steel, e.g. L80
- Strength properties, yield, collapse and burst pressures.

CODES AND STANDARDS

The codes that are used for the design of flexible pipe are:

- API SPEC for Threaded Casings Connections
- PREMIUNM Threaded Casings Connections (Gas to tight, metal to metal seal)

Main programme code used for this project to run the computer numerical control (CNC) machine is G-codes programming.

Below is the schematic drawing and specification for the 30 × 1 inches PIN BOX threaded premium connector.

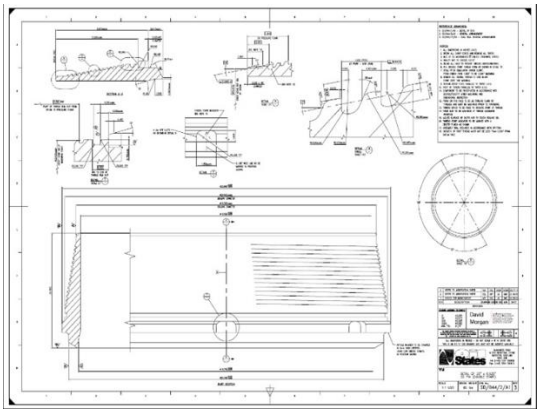

Fig 3: Schematic Drawing for 30'' × 1'' PIN Threaded Premium Connector. [1]

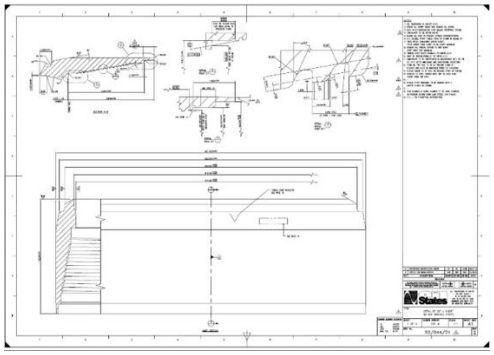

Fig 4: Schematic Drawing for 30'' × 1'' BOX Threaded Premium Connector. [1]

III. METHODOLOGY/MANUFACTURING PROCEDURE

The method used in executing the manufacturing of the 30 X 1inches PIN and BOX casing connection is itemized as follows:

Planning and Scheduling

After the award of the contract, project schedule was developed using MS – project professional to plan the project indicting the start and finish date of the project. This was baseline after approval by the client as a working document.

Procurement

Material-take-off (MTO) was generated from the approved for design drawings issued by the client. The material-take-off (MTO) was sent to vendors for procurement in line with the project requirements. The forge (raw) materials were procured from Germany, Europe and shipped to Federal Lighter Terminal (FLT), Onne, Rivers State, Nigeria.

Material Inspection

The materials supplied by the vendors was inspected by the material officer, QA/QC Engineer and Project manager to ascertain that the materials meet the client requirements as specified in the material take-off list prepared and sent to the vendor. If the quality did not meet the client specification, it will be rejected and quarantine. Acceptance or rejection report will be prepared and sign off by the various people's concern. For this project, the materials were supplied as per required specification and standard.

Programming the CNC Machine

A sophisticated G-Code programme is written and test-run. Once it is confirm for use, the G-code programme is initiated in the computer numerical control (CNC) machine. The programme runs the machine and the CNC Machinist operates the machine. The Quality control/Quality Assurance Engineer verified the work by using precision measuring equipment and testing.

Stages for Manufacturing PIN Casing Connector

1. Blanking Process for Pin Connector:

- Facing of raw forge material
- Blanking of OD – outer diameter
- Finishing of OD
- Boring of ID
- Finishing of ID
- Measurement and inspection

2. Threading Process for Pin Connector:

- Facing
- ID bevel
- Blanking of OD
- Finishing of OD
- Measurement of Top and Bottom seals
- Roughing of O-Ring Groove
- Check Groove using CAST ON OVER-LAY
- Threading of connector
- Checking of Thread on Over-Lay using cast
- Clipping of Threading
- Inspection by a QAQC Inspector.

3. Blanking Process for Box Connector:

- Facing of raw forge material
- Blanking of OD – outer diameter
- Finishing of OD
- Boring of ID
- Finishing of ID
- Inspection

4. Threading Process for Box Connector:

- Facing
- OD Bevel
- Boring of ID
- Finishing of ID
- Measuring of Top, counter bore and bottom seals
- Roughing and finishing of Dove tail groove
- Checking groove on over lay using cast
- Threading
- Checking of thread on over lay using cast
- Clipping of thread
- Inspection by a QAQC Inspector.

The above stages are programme using G – Codes, then a Computer Numerical Control, CNC machine runs the G –code programme and manufactured the casing connections.

Phoshpating

The structure was properly cleaned of all spatters and grease. The manufactured threaded Pin (male) and Box (female) member of Casing connections is then coated with manganese phosphate for corrosion protection during storage. The coating allows the system to run without problems long after it is worn off. This is because of two mechanisms. Glaze layer formation on the coated surface and tribofilm formation on the uncoated counter-surface.

Welding

The PIN connector manufactured will be welded to the conductor pipe casing at one end, so also will the BOX connector welded to the end of another casing. The welded PIN and BOX casings will be couple together to form a joint. The welding was made uniform, smooth and cleaned from foreign materials such as moisture, slag, oil, grease, paint, scale or rust. Edge preparation was verified for proper groove angle and root face. Welding groove dimensions was inspected as per shop drawings under tack welded condition prior to welding. Compliance with all other variables as stated in the approved welding procedure was checked.

Non-Destructive Testing

All non-destructive testing was performed as per approved agency, as per the contract requirements. Magnetic particles inspection was carried out on the manufactured connections and casings structure. The NDT was carried out on visually approve welded joints. Repair was carried out on defective welded joints and re-tested by third party inspection agency approved by the client.

Load out

The painted casings with connectors after manufacturing were protected from further damage during transportation. After coating, the casings were transported to the client's designated area. The materials were loaded using timber supports, and separators and secured properly to prevent any damage to the material.

IV. ANALYSIS AND DETAIL MANUFACTURING PROCESS FOR PIN AND BOX PREMIUM CASING CONNECTION

This section present the detailed stage – by – stage manufacturing process for the 30 X 1 inches PIN and BOX conductor casing connection (premium thread), and the analysis of the G –Code programme used in running the CNC machine.

1. PRESENTATION OF THE FORGE (RAW) MATERIAL

The raw material is brought to the machine shop for machining after been inspected and certified for manufacturing. Below is a picture of the forged material.

Fig 5: Raw Casing connector Material for Machining

2. INCOMPLETE BLANKING PROGRAMME FOR 30 × 1 INCH PIN CONNECTOR (G - CODE)

The values in the programme are in millimeters.

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O0030 (30 INCH SD PIN OP1);
T1200 M06;
N10 G00 G21 G99 G40;
N20 G54;
N30 M51;
N40 M19;
N50 M41;
N60 G50 S170;
N62 G99 G96 M03 S155;
N64 T1212 (FACE);
N66 G00 X833.0 Z50.0 F0.4;
Z9.0;
G01 X645.0 F0.4;
G00 X833.0 Z11.0;
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Z6.0;
G01 X645.0; etc.

Fig.6: 30 × 1 Inch Connector with Weld Prep after Blanking.

3. INCOMPLETE THREADING PROGRAMME FOR 30 X 1 INCH PIN CONNECTOR (G - CODE)

O0318 (30 INCH PIN OP2);
N10 G00 G21 G99 G40;
N20 G54;
N30 M51;
N40 M19;
N50 M41;
T1200 M06 (CNMG 08);
N60 G50;
N70 T1212 S140 (FACE);
N80 GOO G99 G96 X765.0 Z20.0 F0.4 M03;
Z12.0;
G01 X670.0 F0.4;
G00 X765.0 Z15.0;
Z9.0;
G01 X670.0;
G00 X765.0 Z12.0;
Z6.0;
G01 X670.0;
G00 X765.0 Z9.0;
Z3.0;
GO1 X670.0 F0.4;
G00 X765.0 Z4.0;
G01 Z0.4 F0.4;
G01 X670.0 F0.4;
G0 X925.0 Z2.0;
G00 X1000.0 Z200.0;
G28 U0. W0. M05;
M01;
;
N130 T0200 M06 (CNMG 08);
N132 G40;
N133 T0202 (ID BEVEL); etc..

Fig 7: Threaded 30 × 1 Inch PIN Casing Connector after the Threading Process.

4. INCOMPLETE BLANKING PROGRAMME FOR 30 X 1 INCH BOX CONNECTOR (G - CODE)

O0304(30 INCH OSUK BOX SD OP1);
N10 G00 G21 G99;
N20 G54;
N30 M51;
N40 M19;
N50 M41;
M05;
N56 G40;
T1200 M06;
N57 T1212 (FACE);
N60 G50 M03 S170;
N62 G99 G96 M03 S140;

N66 G00 X815.0 Z10.0 F0.4;
Z9.0;
G01 X650.0; etc...

Fig 8: Blanking of the 30 × 1 Inch Casing Connector

Fig 9: 30 × 1 Inch Connector Showing Top and Bottom Seal

5. INCOMPLETE THREADING PROGRAMME FOR 30 X 1 INCH BOX CONNECTOR (G - CODE)

(PLEASE THIS PROGREMM VALUES ARE IN MILI METERS)
N10 G21;
N20 G54;
N30 M51;
N40 M42;
N50 G40;
N60 G96;
T1200M06;
G50 M03 S200;
N80 T1212 (FACE);
N90 G99 G96 S140 M03 F0.4;
N100 G00 X840.0 Z50.0;
Z15.0;
G01 X745.0 F0.4;
G00 X840.0 Z22.0;
Z12.0;
G01 X745.0;
G0 X840.0 Z18.0;
Z9.0;
G01 X745.0;
G0 X840.0 Z14.0;
Z6.0;
G01 X745.0;
G0 X840.0 Z10.0;
Z3.0;
G01 X745.0;
G0 X840.0 Z6.0;
N110 G0 Z0.25;
N120 G01 X745.0;
N130 G00 Z250.0;
N300 T1200;
; etc...

Below is the picture of the casing connector after the threading process.

Fig 10: Threaded 30 × 1 Inch BOX Casing Connector after the Threading Process.

6. PHOSPHATING AND WELDING OF 30 X 1 INCH PIN AND BOX CONNECTOR

The manufactured threaded Pin (male) and Box (female) member of Casing connections is then coated with manganese phosphate for corrosion protection during storage. The presence of phosphate coatings is also known to give beneficial tribological performance.

The coating allows the system to run without problems long after it is worn off. This is because of two mechanisms. Glaze layer formation on the coated surface and tribofilm formation on the uncoated counter-surface. After phosphate, the casing connector is welded to the casing pipe as shown in figure 11.

Fig.11: Threaded PIN Connector Welded to Pipe Casing

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ABBREVIATION

API	American Petroleum Institute
BTC	Buttress Threaded Connections
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CC	Casing Connections
CNC	Computer Numerical Control
E & P	Exploration and Production
FLT	Federal Lighter Terminal
FT	Feet
FEM	Finite Element
FPSO	Floating Production, Storage and Offloading Unit
HTHP	High Temperature High Pressure
IB	Pounds
ID	Internal Diameter
ISO	International Standard of Organization
LTC	Long Threaded Connection
MTO	Material Take Off
NDT	Non Destructive Testing
OD	Outer Diameter
QA	Quality Assurance
QC	Quality Control
STC	Short Threaded Connections