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None

DESCRIPTION

FIELD OF THE INVENTION

[0001] The field of the invention is joining tubulars with friction welding and more particularly with an intermediate rotating or oscillating coupling with an optional induction unit for heating before, during or after the connection is made with compression applied to the fitting.

RACK GROUND OF THE INVENTION

[0002] Tubulars such as casing or liners are most frequently joined with threaded connections. These connections when used in a drilling environment are subject to fatigue from the dynamic loads encountered during such drilling procedures. There is a need to enhance the fatigue life of such connections.

[0003] Friction stir welding techniques have been used to join tubulars where the tubulars are butted together or alternatively with a shim introduced between them and the welding apparatus is rotated around the tubulars on its own axis while pushed into the junction of the tubulars as shown in US Publication 2010/0136369. In USP 3,779,446 the axis of the welding apparatus in FIGS. 3 and 4 is parallel to the tubulars being joined as the apparatus rotates on its axis and is brought to contact end flanges in the tubulars to be joined. Other similar references are USP 4,063,676; 5,071,053; 6,142,360; 3,848,793; 7,168,606.

[0004] EP 0 396 204 A2, which discloses the preamble of claim 1, describes a method for joining well tubulars by a friction welding technique that comprises positioning a welding ring on top of a first tubular element and hoisting a second tubular element above the welding ring. The method further comprises fixing the tubular elements in axial alignment with each other and rotating the welding ring relative to the tubular elements such that the ring is in contact with the tubular elements thereby generating sufficient frictional heat to create a friction weld between the welding ring and the tubular elements.

[0005] US 6 634 540 B1 describes a method for friction welding first and second elongated elements having weldable ends. The elongated elements are axially aligned with the weldable ends adjacent to one another. The described method comprises clamping the weldable ends together with a rotatable flat ring, rotating the ring relative to the two elongated elements to frictionally generate heat at the weldable ends to a suitable forging temperature, and pressing the elongated elements together at the weldable ends with forge welding pressure by at least one stroke (e.g. hammer stroke).

[0006] US 5 697 545 A describes a method of friction welding which comprises forcing together two components to be welded together and providing a relative oscillatory movement

between the two components to cause rubbing together of the two components to provide friction welding thereof. The oscillatory movement comprises linear, arcuate or orbital friction welding.

[0007] The common theme to many of these techniques is to insert a ring shaped member in a notch formed by ends of adjacent tubulars and apply radial force to the ring while it is rotated. The present invention applies axial force to a rotated or oscillating coupling through the tubular ends that are to be joined to opposing ends of the coupling. An induction heating device can be deployed at each connection to preheat the connection location before the friction welding begins during or/and after the connection is made. The use of the present invention enhances energy efficiency, weld quality, material selection choices and connection reliability; while enabling reduced equipment size and cost. These and other features of the present invention will be more readily apparent from a review of the detailed description and the associated drawing while recognizing that the full scope of the invention is to be determined from the appended claims.

SUMMARY OF THE INVENTION

[0008] Disclosed is a method of joining tubulars with friction welding for forming a tubular string to be delivered to a subterranean location as set forth in independent claim 1. Tubulars are joined to each other without rotation of the tubulars. A coupling is placed between the aligned tubulars and is supported for rotation about its longitudinal axis. The tubulars are clamped in a manner that allows a compressive force to be transmitted to the coupling as the coupling is rotated. An induction device can preheat each connection site before friction welding and/or provide heat as the connection is made and is allowed to cool down. The process can continuously create a string of casing or liner that can be run in or drilled into a wellbore.

BRIEF DESCRIPTION OF THE DRAWING

[0009] The FIG. illustrates two tubulars with a spaced coupling that can be rotated to make a connection at opposed ends using axial compression of the coupling provided by axial force through the tubulars that form the string being assembled.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0010] Referring to the FIG. an upper tubular **10** is to be joined to a lower tubular **12**. A coupling or short tubular segment **18** that has opposed ends **20** and **22** is gripped by a frame **14** that has a capability of rotating the segment **18**.

[0011] The lower end **24** of the upper tubular **10** is aligned with end **20** of the segment **18**.

These ends can be parallel or notched into a v-shape with the tapered gap enlarging toward the outside surfaces **26** and **28**. Similarly the upper end **30** of the lower tubular **12** is aligned with end **22** of the segment **18** with the ends being parallel or tapered with the gap enlarging toward outside surfaces **28** and **32**. Arrows **34** and **36** represent schematically a device that applies a compressive force onto segment **18** as it is gripped and rotated in either clockwise or counterclockwise directions by the gripping and rotating assembly **16**. There can be one or more than one gripping and rotating assembly **16**. Optionally the frame **14** can be split so that it can open to release the assembly of tubulars **10** and **12** joined to segment **18** by lateral movement. Alternatively in a one piece construction of the frame **14** the assembled string can be supported with slips on the rig floor so that the frame can be cleared of the top tubular **10** and reloaded with another segment **18** for the process to repeat.

[0012] One or more induction heaters **38** or **40** can be located at opposed ends or one end of the segment **18**. These can be used to preheat the friction welding locations either before the weld is made, during welding or for heat treatment after the weld is completed.

[0013] The frequency of the induction heating field can be changed in each heater and during each process step depending on material properties and process parameters to control the depth of the heating zone and temperature distribution within the weld and the parts to be connected. High frequency fields tend to concentrate the heat up zone on surface and low frequency fields (e.g. 50 Hz) allow the heat up zone to go deeper in to the parts to be treated.

[0014] According to the invention, the segment **18** is oscillated with combined movement patterns e.g. opposed rotational movements $\pm 0.5^\circ$ with 50 Hz and 0.2 mm radial movement with 100 Hz . Combined movement patterns support self cleaning and material unification of the weld and reduce required rotation speed of the segment.

[0015] The compressive force can be applied upon the start of the movement of the segment **18** or it can be applied thereafter. The local temperature can be monitored at the weld locations with an external sensor shown schematically as **S** to a desired value by control of the compressive force indicated by arrows **34** and **36**.

[0016] Those skilled in the art will now appreciate that tubulars can be joined without rotating them by using an intervening segment which is rotated and oscillated while being placed in a compressive loading situation to control the formation of the friction weld. The one of the tubulars can be axially advanced toward the other or both can be forced toward the segment as it rotates or oscillates for weld formation. The segment can be preheated before being placed into welding position with preferably an induction heating device or the heating can occur just before the welding with the segment in position to preheat the segment. After the weld is completed further heating can be applied in the same manner for stress relieving or other purposes.

[0017] As a non-claimed option the two tubulars can be abutted and relatively moved or rotated with axially applied compressive force to friction weld them to each other.

[0018] Cooling and gas shielding functionality can be added if needed.

[0019] The connection sleeve might be made out of a different material than the base material of the tubulars that it connects with the goal to improve weld performance parameters such as strength, expandability or quality. Some materials might be welded or expanded only with a connection sleeve made of a suitable material.

[0020] The above description is illustrative of the preferred embodiment and many modifications may be made by those skilled in the art without departing from the invention whose scope is to be determined from the literal and equivalent scope of the claims below:

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- [US3779446A](#) [0003]
- [US4063676A](#) [0003]
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PATENTKRAV

1. Fremgangsmåde til samling af rør med friktionssvejsning til dannelse af en rørformet streng, som skal afgives til en underjordisk lokalitet, hvilken fremgangsmåde omfatter:

5 justering af enderne af rør (10, 12), som skal svejses;

indføring af et rørformet segment (18) mellem rørene (10, 12);

sammenbringning af enderne (24, 30) mod modsatstillede ender (20, 22) af segmentet (18) med henblik på at sætte enderne under aksial trykspænding; og
kendetegnet ved:

10 forbindelse af enderne (24, 30) til segmentet (18) under anvendelse af kombinerede bevægelsesmønstre af det rørformede segment (18), hvor de kombinerede bevægelsesmønstre omfatter modsatte oscillerende rotationsbevægelser på $\pm 0,5^\circ$ med 50 Hz omkring en segmentlængdeakse og 0,2 mm radial bevægelse med 100 Hz i en retning vinkelret på en akse af de
15 justerede rør (10, 12).

2. Fremgangsmåde ifølge krav 1, der omfatter:

variation af aksial trykspænding.

3. Fremgangsmåde ifølge krav 2, der omfatter:

opretholdelse af en forudbestemt temperatur ved enderne (24, 30) af
20 rørene (10, 12) med den varierende trykspænding.

4. Fremgangsmåde ifølge krav 3, der omfatter:

registrering af temperaturen i den ene af enderne (24, 30) under samlingen.

5. Fremgangsmåde ifølge krav 1, der omfatter:

tilførsel eller fjernelse af varme til/fra det rørformede segment (18).

25 6. Fremgangsmåde ifølge krav 5, der omfatter:

tilførsel eller fjernelse af varme til/fra det rørformede segment (18) inden eller under samlingen.

7. Fremgangsmåde ifølge krav 6, der omfatter:

anvendelse af en induktionsopvarmningsindretning (38, 40) til tilførsel
5 af varme.

8. Fremgangsmåde ifølge krav 1, der omfatter:

montering af det rørformede segment (18) i en ramme (14).

9. Fremgangsmåde ifølge krav 8, der omfatter:

anvendelse af mindst én motor til rotation af det rørformede segment (18) i
10 mindst én retning.

10. Fremgangsmåde ifølge krav 8, der omfatter:

tilvejebringelse af en spalte i rammen (14) med henblik på at lette fjernelse af rammen (14) efter samlingen.

11. Fremgangsmåde ifølge krav 1, der omfatter:

15 formning af de rørformede ender (24, 30) og parring af enderne (20, 22) af det rørformede segment (18).

12. Fremgangsmåde ifølge krav 10, der omfatter:

variation af aksial trykspænding.

13. Fremgangsmåde ifølge krav 12, der omfatter:

20 opretholdelse af en forudbestemt temperatur ved enderne (24, 30) af rørene (10, 12) med den varierende trykspænding.

14. Fremgangsmåde ifølge krav 13, der omfatter:

registrering af temperaturen i den ene af enderne (24, 30) under samlingen.

15. Fremgangsmåde ifølge krav 14, der omfatter:

tilførsel af varme til det rørformede segment (18).

16. Fremgangsmåde ifølge krav 15, der omfatter:

tilførsel af varme til det rørformede segment (18) inden eller under samlingen.

17. Fremgangsmåde ifølge krav 16, der omfatter:

5 anvendelse af en induktionsopvarmningsindretning (38, 40) til tilførsel af varme.

DRAWINGS

