returned to the surface, or a wellbore reaches its target depth. At times, the same or a new tubular string must be run back into the wellbore. Such a "tripping in" operation may, for example, put the drill string with new drill bit back into the well, lower a downhole tool such as a packer, or insert a casing string into the wellbore to complete the well.

[0006] Since modern wells may become extremely deep, tripping out or tripping in operations may require a large number of threaded pipe joints to be disconnected (broken out) or connected (made up). Traditionally, the same drawworks, roughneck, and slips are used to make or break each connection. As the operation of a drilling rig can be extremely expensive, the need to trip in or trip out a tubular string may be a very costly operation. Additionally, damage may be caused to the wellbore simply by removing the tubular string from or inserting the tubular string into the wellbore. For instance, wellbore pressure may, in some circumstances, be rapidly increased or decreased by a rapid movement of a downhole tool. Commonly referred to as "swabbing", these pressure fluctuations may cause, for example, reservoir fluids to flow into the wellbore or may cause instability in a formation surrounding a wellbore.

Summary

[0006A] According to various embodiments, a method of removing a tubular member from a tubular string being removed from a wellbore may be provided. The tubular string may be made up of a series of threadedly connected tubular members. The method may include: providing an automated pipe tripping apparatus, the automated pipe tripping apparatus including: an outer frame, the outer frame including one or more vertical supports; an inner frame, the inner frame slidingly coupled to the outer frame and positioned to be moved vertically by a lifting mechanism coupled between the inner and outer frames, the inner frame including: a tripping slips, the tripping slips positioned to receive the tubular string and selectively grip and support the tubular string; and an iron roughneck, the iron roughneck positioned above the tripping slips

and positioned to receive the tubular string and make up or break out a threaded joint between a first tubular member and a second tubular member of the tubular string, the iron roughneck selectively movable in a vertical direction between a lower and an upper position by a roughneck lifting mechanism; positioning the automated pipe tripping apparatus on a drilling floor of a drilling rig above the wellbore, the drilling rig including a drawworks, an elevator, an automated pipe handling device, and a drilling floor slips, the tubular string extending through the automated pipe tripping apparatus; lifting the tubular string with the elevator at a relatively constant speed defining a tripping speed; moving the inner frame downward; moving the iron roughneck into the upper position; moving the inner frame upwards at the tripping speed so that the iron roughneck is aligned with the threaded joint between the first tubular member and the second tubular member; actuating the tripping slips; transferring the weight of the tubular string to the tripping slips; breaking out the threaded joint with the iron roughneck; lifting the first tubular member away from the iron roughneck; removing the first tubular member from the elevator by the automated pipe handling system; moving the iron roughneck to the lower position; moving the elevator downward; moving the elevator upward at the tripping speed; attaching the elevator to the tubular string; transferring the weight of the tubular string to the elevator; and releasing the tripping slips.

[0006B] According to various embodiments, a method of adding a tubular member to a tubular string being inserted into a wellbore may be provided. The tubular string may be made up of a series of threadedly connected tubular members. The method may include: providing an automated pipe tripping apparatus, the automated pipe tripping apparatus including: an outer frame, the outer frame including one or more vertical supports; an inner frame, the inner frame slidingly coupled to the outer frame and positioned to be moved vertically by a lifting

mechanism coupled between the inner and outer frames, the inner frame including: a tripping slips, the tripping slips positioned to receive the tubular string and selectively grip and support the tubular string; and an iron roughneck, the iron roughneck positioned above the tripping slips and positioned to receive the tubular string and make up or break out a threaded joint between a first tubular member and a second tubular member of the tubular string, the iron roughneck selectively movable in a vertical direction between a lower and an upper position by a roughneck lifting mechanism; positioning the automated pipe tripping apparatus on a drilling floor of a drilling rig above the wellbore, the drilling rig including a drawworks, an elevator, an automated pipe handling device, and a drilling floor slips, the tubular string extending through the automated pipe tripping apparatus, the tubular string gripped by the tripping slips; moving the inner frame downwards at a relatively constant speed defining a tripping speed; moving the elevator upward; attaching a tubular member to the elevator by the automated pipe handling system, the tubular member having a lower threaded connector and an upper threaded connector; moving the iron roughneck into the upper position; moving the elevator downward at a speed higher than the tripping speed until the lower threaded connector of the tubular member aligns with an upper threaded connector of the tubular string, then moving the elevator downward generally at the tripping speed; making up the threaded joint between the tubular member and the tubular string with the iron roughneck; transferring the weight of the tubular string to the elevator; releasing the tripping slips; moving the inner frame upwards; moving the iron roughneck into the lower position; moving the inner frame downwards at the tripping speed so that the iron roughneck is aligned with the upper threaded joint of the tubular member; actuating the tripping slips; transferring the weight of the tubular string to the tripping slips; releasing the tubular member from the elevator.

[0007] In an example, an automated pipe tripping apparatus may be provided. The automated pipe tripping apparatus may include an outer frame, the outer frame including one or more vertical supports; an inner frame, the inner frame slidingly coupled to the outer frame and positioned to be moved vertically by a lifting mechanism coupled between the inner and outer frames. The inner frame may include a tripping slips, the tripping slips positioned to receive a tubular member and selectively grip and support the tubular member; and an iron roughneck, the iron roughneck positioned above the tripping slips and positioned to receive the tubular member and make up or break out a threaded joint between a first and a second segment of the tubular member.

[0008] In an example, a method of removing a tubular member from a tubular string being removed from a wellbore may be provided. The tubular string may be made up of a series of threadedly connected tubular members. The method may include providing an automated pipe tripping apparatus. The automated pipe tripping apparatus may include an outer frame, the outer frame including one or more vertical supports; an inner frame, the inner frame slidingly coupled to the outer frame and positioned to be moved vertically by a lifting mechanism coupled between the inner and outer frames. The inner frame may include a tripping slips, the tripping slips positioned to receive a tubular member and selectively grip and support the tubular member; and an iron roughneck, the iron roughneck positioned above the tripping slips and positioned to receive the tubular member and make up or break out a threaded joint between a first and a second segment of the tubular member. The iron roughneck may be selectively movable in a vertical direction between a lower and an upper position by a roughneck lifting mechanism. The method may further include positioning the automated pipe tripping apparatus on a drilling floor of a drilling rig above the wellbore, the drilling rig including a drawworks, an elevator, an automated pipe handling device, and a drilling floor slips, the tubular string extending through the automated pipe tripping apparatus; lifting the tubular string with the elevator at a relatively constant speed defining a tripping speed; moving the inner frame downward; moving the iron roughneck into the upper position; moving the inner frame upwards at the tripping speed so that the iron roughneck is aligned with the threaded joint

between the uppermost tubular member and the next tubular member; actuating the tripping slips; transferring the weight of the tubular string to the tripping slips; breaking out the threaded joint with the iron roughneck; lifting the uppermost tubular member away from the iron roughneck; removing the uppermost tubular member from the elevator by the automated pipe handling system; moving the iron roughneck to the lower position; moving the elevator downward; moving the elevator upward at the tripping speed so that the elevator may attach to the tubular string; transferring the weight of the tubular string to the elevator; and releasing the tripping slips.

[0009] In an example, a method of adding a tubular member to a tubular string being inserted into a wellbore may be provided. The tubular string may be made up of a series of threadedly connected tubular members. The method may include providing an automated pipe tripping

apparatus. The automated pipe tripping apparatus may include an outer frame, the outer frame including one or more vertical supports; an inner frame, the inner frame slidingly coupled to the outer frame and positioned to be moved vertically by a lifting mechanism coupled between the inner and outer frames. The inner frame may include a tripping slips, the tripping slips positioned to receive a tubular member and selectively grip and support the tubular member; and an iron roughneck, the iron roughneck positioned above the tripping slips and positioned to receive the tubular member and make up or break out a threaded joint between a first and a second segment of the tubular member. The iron roughneck may be selectively movable in a vertical direction between a lower and an upper position by a roughneck lifting mechanism. The method may further include positioning the automated pipe tripping apparatus on a drilling floor of a drilling rig above the wellbore, the drilling rig including a drawworks, an elevator, an automated pipe handling device, and a drilling floor slips, the tubular string extending through the automated pipe tripping apparatus, the tubular string gripped by the tripping slips; moving the inner frame downwards at a relatively constant speed defining a tripping speed; moving the elevator upward; attaching an additional tubular member to the elevator by the automated pipe handling system; moving the iron roughneck into the upper position; moving the elevator downward at a speed higher than the tripping speed until the lower threaded connector of the additional tubular member aligns with the upper threaded connector of the tubular string, then moving the elevator downward generally at the tripping speed; making up the threaded joint between the additional tubular member and the tubular string with the iron roughneck; transferring the weight of the tubular string to the elevator; releasing the tripping slips; moving the inner frame upwards; moving the iron roughneck into the lower position; moving the inner frame downwards at the tripping speed so that the iron roughneck is aligned with the upper threaded joint of the additional tubular member; actuating the tripping slips; transferring the weight of the tubular string to the tripping slips; and releasing the additional tubular from the elevator.

[0010] In an example, an automated control system may be provided. The automated control system may include first code instructions that vary the speed of a tubular member moving into or out of a

Claims

1. A method of removing a tubular member from a tubular string being removed from a wellbore, the tubular string made up of a series of threadedly connected tubular members, the method comprising:

providing an automated pipe tripping apparatus, the automated pipe tripping apparatus including:

an outer frame, the outer frame including one or more vertical supports;

an inner frame, the inner frame slidingly coupled to the outer frame and positioned to be moved vertically by a lifting mechanism coupled between the inner and outer frames, the inner frame including:

a tripping slips, the tripping slips positioned to receive the tubular string and selectively grip and support the tubular string; and

an iron roughneck, the iron roughneck positioned above the tripping slips and positioned to receive the tubular string and make up or break out a threaded joint between a first tubular member and a second tubular member of the tubular string, the iron roughneck selectively movable in a vertical direction between a lower and an upper position by a roughneck lifting mechanism;

positioning the automated pipe tripping apparatus on a drilling floor of a drilling rig above the wellbore, the drilling rig including a drawworks, an elevator, an automated pipe handling device, and a drilling floor slips, the tubular string extending through the automated pipe tripping apparatus;

lifting the tubular string with the elevator at a relatively constant speed defining a tripping speed;

moving the inner frame downward;

moving the iron roughneck into the upper position;

moving the inner frame upwards at the tripping speed so that the iron roughneck is aligned with the threaded joint between the first tubular member and the second tubular member;

actuating the tripping slips;

transferring the weight of the tubular string to the tripping slips;

breaking out the threaded joint with the iron roughneck;

lifting the first tubular member away from the iron roughneck;

removing the first tubular member from the elevator by the automated pipe handling system;

moving the iron roughneck to the lower position;

moving the elevator downward;

moving the elevator upward at the tripping speed;

attaching the elevator to the tubular string;
transferring the weight of the tubular string to the elevator; and
releasing the tripping slips.

2. The method of claim 1, wherein the lifting mechanism comprises one of one or more hydraulic pistons, jack screws, racks and pinions, cable and pulley, or travelling block.

3. The method of claim 1, wherein the iron roughneck further comprises:
fixed jaws, the fixed jaws positioned to grip and prevent rotation of the first tubular member;
makeup/breakout jaws, the makeup/breakout jaws positioned to grip the second tubular member and impart a high-torque, low-speed rotation on the second tubular member;
wherein the breaking out operation comprises:
engaging the first tubular member with the makeup/breakout jaws;
engaging second tubular member with the fixed jaws; and
rotating the first tubular member with the makeup/breakout jaws.

4. The method of claim 3, wherein the iron roughneck further comprises:
a pipe spinner, the pipe spinner positioned to impart a low-torque, high-speed rotation on the first tubular member;
wherein the breaking out operation further comprises rotating the first tubular member with the pipe spinner.

5. The method of claim 1, further comprising a control system, the control system positioned to control the lifting mechanism, the iron roughneck, and the tripping slips.

6. The method of claim 5, wherein the control system is positioned to further control at least one of a drawworks, top drive, elevator, elevator links, and automated pipe handling apparatus.

7. The method of claim 5, wherein the control system further comprises a closed-loop controller positioned to control the tripping speed.

8. The method of claim 7, wherein the closed-loop controller varies the tripping speed in response to variations in pressure within the wellbore measured by a pressure sensor at the end of the tubular string positioned within the wellbore.

9. The method of claim 1, wherein the iron roughneck further comprises a mud bucket, and the method further comprises confining, with the mud bucket, any drilling fluid contained within the first tubular member after the breaking operation.

10. The method of claim 9, wherein the mud bucket further comprises at least one of a lower seal and an upper seal, the lower and upper seals positioned to seal the interior of the mud bucket to the tubular member.

11. The method of claim 10 wherein the mud bucket further comprises a drain line positioned to permit drilling fluid to flow from the mud bucket to a drilling fluid reservoir.

12. A method of adding a tubular member to a tubular string being inserted into a wellbore, the tubular string made up of a series of threadedly connected tubular members, the method comprising:

providing an automated pipe tripping apparatus, the automated pipe tripping apparatus including:

an outer frame, the outer frame including one or more vertical supports;

an inner frame, the inner frame slidingly coupled to the outer frame and positioned to be moved vertically by a lifting mechanism coupled between the inner and outer frames, the inner frame including:

a tripping slips, the tripping slips positioned to receive the tubular string and selectively grip and support the tubular string; and

an iron roughneck, the iron roughneck positioned above the tripping slips and positioned to receive the tubular string and make up or break out a threaded joint between a first tubular member and a second tubular member of the tubular string, the iron roughneck selectively movable in a vertical direction between a lower and an upper position by a roughneck lifting mechanism;

positioning the automated pipe tripping apparatus on a drilling floor of a drilling rig above the wellbore, the drilling rig including a drawworks, an elevator, an automated pipe handling device, and a drilling floor slips, the tubular string extending through the automated pipe tripping apparatus, the tubular string gripped by the tripping slips;

moving the inner frame downwards at a relatively constant speed defining a tripping speed;

moving the elevator upward;

attaching a tubular member to the elevator by the automated pipe handling system, the tubular member having a lower threaded connector and an upper threaded connector;

moving the iron roughneck into the upper position;

moving the elevator downward at a speed higher than the tripping speed until the lower threaded connector of the tubular member aligns with an upper threaded connector of the tubular string, then

moving the elevator downward generally at the tripping speed;
making up the threaded joint between the tubular member and the tubular string with the iron roughneck;
transferring the weight of the tubular string to the elevator;
releasing the tripping slips;
moving the inner frame upwards;
moving the iron roughneck into the lower position;
moving the inner frame downwards at the tripping speed so that the iron roughneck is aligned with the upper threaded joint of the tubular member;
actuating the tripping slips;
transferring the weight of the tubular string to the tripping slips;
releasing the tubular member from the elevator.

13. The method of claim 12, wherein the iron roughneck further comprises:
fixed jaws, the fixed jaws positioned to grip and prevent rotation of the tubular string; and
makeup/breakout jaws, the makeup/breakout jaws positioned to grip the tubular member and impart a high-torque, low-speed rotation on the tubular member;
wherein the making up operation comprises:
engaging the tubular member with the makeup/breakout jaws;
engaging the tubular string with the fixed jaws; and
rotating the tubular member with the makeup/breakout jaws.

14. The method of claim 13, wherein the iron roughneck further comprises:
a pipe doping system, and the method further comprises applying lubricating fluid to threads of one or both of the upper threaded connector of the tubular string or the lower threaded connector of the tubular member before the makeup operation.

15. The method of claim 13, further comprising a tubular filling apparatus, and the method further comprises filling the tubular member with drilling fluid.

16. The method of claim 15, wherein the tubular filling apparatus is positioned on the top drive or iron roughneck.

17. The method of claim 15, wherein the tubular filling apparatus comprises a circulating packer.

18. The method of claim 13, wherein the iron roughneck further comprises:

a pipe spinner, the pipe spinner positioned to impart a low-torque, high-speed rotation on the tubular member;

wherein the making up operation further comprises rotating the tubular member with the pipe spinner.

19. The method of claim 12, wherein the lifting mechanism comprises one or more of hydraulic pistons, jack screws, racks and pinions, cable and pulley, or travelling block.

20. The method of claim 12, further comprising a control system, the control system positioned to control the lifting mechanism, the iron roughneck, and the tripping slips.

21. The method of claim 20, wherein the control system is positioned to further control at least one of a drawworks, top drive, elevator, elevator links, , and automated pipe handling apparatus.

22. The method of claim 20, wherein the control system further comprises a closed-loop controller positioned to control the tripping speed.

23. The method of claim 22, wherein the closed-loop controller varies the tripping speed in response to variations in pressure within the wellbore measured by a pressure sensor at the end of the tubular string positioned within the wellbore.