A flow-limiting device is placed in a hydraulic fluid circuit between a hydraulic pump of, for example, a power pack, and a motor of a coiled tubing injector. The flow-limiting device allows hydraulic fluid to flow through the circuit, but limits the rate of flow in order to avoid thermal damage to the motor.
COILED TUBING INJECTOR WITH FLOW LIMITER

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates generally to coiled tubing injectors.

BACKGROUND OF THE INVENTION

[0002] Continuous, reeled pipe is generally known as coiled tubing. It has been used for many years for a wide range of operations relating to oil and gas wells. It is much faster to run into and out of a well bore than conventional jointed, straight pipe. A coiled tubing injector mounted to a wellhead is used to run tubing in and out of well bore. It continuously grips a length of the tubing just before it enters the wellhead using a pair of continuous chain loops arranged on opposite sides of the tubing. The continuous chains carry a series of grippers that are pressed against opposite sides of the tubing and grip the tubing. Examples of coiled tubing injectors are described in U.S. Pat. Nos. 6,173,769, 6,216, 780 and 6,059,029, which are incorporated herein by reference.

[0003] Power to move the chains is delivered by one or more variable or fixed displacement hydraulic motors mounted on the injector. The outputs of the motors are typically connected to a gearbox on the injector. One or more outputs on the gearbox turn sprockets on which the chain loops are mounted. A separate “power pack,” mounted on a trailer or truck, supplies hydraulic fluid under pressure to the motor or motors on the coiled tubing injector. The power pack is also used to supply hydraulic fluid to other equipment that may be used in connection with the coiled tubing injector, such as masts that lift the injector onto the well head and reels on which the coiled tubing is spooled. The power pack typically includes a variable displacement, pressure-compensated hydraulic pump driven by, for example, an internal combustion engine. However, other types of hydraulic pumps are also used.

SUMMARY OF THE INVENTION

[0004] In order to provide finer control over the position of the end of the coiled tubing, especially heavier, larger diameter tubing, high-speed, low-torque hydraulic motors and gearboxes with higher gear ratios are being used on at least some injectors. Because these motors are rotating at comparatively higher rates for a given velocity of movement of the pipes, the motors have comparatively lower “top speed” ratings. This means that pipe cannot be moved into and out of the well bore as fast as other injectors might be able to move it, without running the motors at speeds that tend to cause the motors to overheat. Many power packs used in the field are capable of pumping hydraulic fluid at rates that drive the motors at higher than their rated top speeds. Given the natural tendency of those in the field to run pipe in and out of the well bore as quickly as possible, motors and gears are being over-speed, particularly but not limited to those that are “high speed.” Speeding of a motor can cause damage and lead to failure of the motor.

[0005] To address the problem of over-speeding, a flow-limiting device is placed in a hydraulic fluid circuit between a hydraulic pump of, for example, a power pack, and a motor of a coiled tubing injector. The flow-limiting device allows hydraulic fluid to flow through the circuit, but limits the rate of flow to a maximum permitted flow rate. Thus, it prevents flow rates that would run the motor at speeds which over heating may occur.

[0006] Described below, in reference to the appended drawings, are examples of coiled tubing injectors and power packs employing teachings of the invention in its preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a schematic diagram of a hydraulic circuit for a coiled tubing injector, including a power pack with a closed loop pump, a hydraulic motor of the coiled tubing injector, and flow limiting devices mounted on the coiled tubing injector.

[0008] FIG. 2 is a schematic diagram of a hydraulic circuit for a coiled tubing injector, including a power pack with a closed loop pump, a hydraulic motor of the coiled tubing injector, and flow limiting devices mounted on the power pack.

[0009] FIG. 3 is a schematic diagram of a hydraulic circuit for a coiled tubing injector, including a power pack with a open loop pump, a hydraulic motor of the coiled tubing injector, and flow limiting devices mounted on the coiled tubing injector.

[0010] FIG. 4 is a schematic diagram of a hydraulic circuit for a coiled tubing injector, including a power pack with a open loop pump, a hydraulic motor on a coiled tubing injector, and flow limiting devices mounted on the power pack.

DETAILED DESCRIPTION OF THE DRAWINGS

[0011] In the following description, like numbers refer to like elements.

[0012] Referring to all of the figures, coiled tubing injectors 2 and 4 each include a hydraulic motor 6 connected in a power supply circuit, in which hydraulic fluid pumped by a hydraulic pumping system in a power pack 8 or 10 circulates to supply power to the motor. Hydraulic lines generally designated 12, 14, and 18 represent this circuit. However, the hydraulic lines are intended only to be representative, and do not necessarily correspond to actual tubing used in the circuit. As the coiled tubing injector is mounted on a wellhead during operation, the power pack is located on a truck or other location in the vicinity of the wellhead. It supplies hydraulic fluid under pressuring through flexible hydraulic tubing extending between the power pack and coiled tubing injector. Connecting hydraulic lines 12 to 18 and 14 to 16 using connectors 20 represents the coupling in the field of the circuit using appropriate means.

[0013] In order to run the motor in either of two directions, hydraulic fluid flows in the illustrated example in either of two directions in the power supply circuit. Filters 22 and 24 are placed in the supply circuit, on opposite sides of the motor, for filtering hydraulic fluid prior to it entering motor 6. Each filter has a bypass circuit that allows fluid to bypass the filter when flowing in a direction out of the motor. In the example illustrated, each bypass system includes a hydraulic line 26 with a one-way valve 28.

[0014] Two types of power packs are represented in the drawings. Power pack 8 in FIGS. 1 and 2 is an example of a power pack using a closed loop, pressure compensated, hydraulic pumping system 32. Power pack 10 in FIGS. 3 and 4 include an example of a pressure compensated, open loop, hydraulic pumping system 34. These are examples of well-known types of hydraulic pumping systems used in connection with coiled tubing injectors. Each power pack
pumps hydraulic fluid under substantially constant pressure, thus assuring that flow rate of the hydraulic fluid is proportional to motor speed over a range of expected loads. Each power pack will typically also supply hydraulic fluid to other equipment through other hydraulic circuits. These other circuits are not shown.

[0015] To prevent the hydraulic pumping system of a power pack from being operated to pump hydraulic fluid at flow rates exceeding recommended flow rates for motor 6 of the coiled tubing injector 2, a flow limiting device is placed in the hydraulic fluid supply loop. Flow limiting device 36 is an example of such a device. It is preferably placed between the output of the hydraulic pump, such as pumping systems 32 or 34, and input of the motor, such as motor 6, so that hydraulic fluid flows into the flow limiting device before reaching the motor. However, though it is not preferred, the flow limiting device could be placed in the hydraulic circuit between the motor and hydraulic pump, so that fluid flows into the flow limiting device from the motor, and then to the hydraulic pump. In a system with bi-directional flow, such as the one shown in the figures, a second flow-limiting device 20 is also placed in the circuit. However, it is preferable not to have both devices in the circuit at the same time. Therefore, each flow-limiting device 20 is provided with a bypass circuit that carries fluid flowing out of the motor, toward the pumping system, around the flow-limiting device. In the illustrated example, the bypass circuit includes a one-way flow valve. Though it is preferable for it to be part of the flow limiting device, the bypass line or circuit need not be.

[0016] The flow limiting device preferably functions substantially to either limit the flow to a predetermined maximum flow rate, or stops it, in response to the flow reaching the maximum flow rate. When the flow rate reaches the predetermined maximum flow rate, the flow limiting device partially or completely closes a valve, either stopping the flow of fluid or, if fitted with a feedback mechanism, limiting the flow rate to a maximum rate of flow. Thus, no matter how fast the hydraulic pumping system pumps the fluid, its flow rate will not substantially exceed, at least for other than a short period, a predetermined or set maximum rate.

[0017] Each flow limiting device is preferably mounted on, or otherwise incorporated with, the coiled tubing injector by, for example, mounting it to the injector’s case or frame as part of the injector’s hydraulic circuits. This configuration is illustrated in FIGS. 1 and 3. Incorporating it with the coiled tubing injector permits any power pack to be used in the field without risk of driving the injector’s motor beyond its maximum or recommended top speed rating. This arrangement avoids having to replace or modify power packs in the field, and permits the power packs to be used with other equipment, such as injectors that may have higher top speed ratings. It also allows the flow limiting device to be set according to the injector’s recommended operation ratings in the factory or before it goes into use in the field, rather than relying on the flow limiting device being properly set once it is connected to a coiled tubing injector.

[0018] However, as shown in FIGS. 2 and 4, the flow-limiting device may be placed on a power pack. Placement of the flow-limiting device on a power pack could allow use of a power pack with no flow limiting device with a coiled tubing injector and thus it is not preferred unless all of the power packs with which a coil tubing injector could be used are outfitted.

[0019] In an alternate, less preferable embodiment, the flow limiting device is not mounted to either the power pack or the coiled tubing injector. It is a separate unit connected into the hydraulic circuit between the power pack and injector when, for example, the circuit is completed at a well site. The separate unit could be placed onto a truck along with a power pack and an injector. Such a situation may include, for example, an oilfield service company’s fleet of power packs.

What is claimed is:

1. A coiled tubing injector system, comprising:
   a coiled tubing injector having a pair of opposing continuous chains rotated by power supplied from at least one hydraulic motor, the motor being connected to a hydraulic power circuit for receiving a flow of hydraulic fluid under pressure; and
   a flow limiting device coupled in the hydraulic circuit for preventing hydraulic fluid from flowing into the motor at rates in excess of a predetermined rate.

2. The coiled tubing injector system of claim 1, wherein the flow limiting device is mounted on the coiled tubing injector.

3. The coiled tubing injector system of claim 1, in combination with a power pack having a hydraulic pumping system for pumping hydraulic fluid in the hydraulic power circuit.

4. The coiled tubing injector system of claim 3, wherein the flow limiting device is mounted to the power pack.

5. The coiled tubing injector system of claim 1, wherein the hydraulic motor is a high speed, low torque motor, and wherein the motor and the chains are coupled through a speed reduction gear box.

6. A coiled tubing injector, comprising:
   a pair of opposing continuous chains rotated by power supplied from at least one hydraulic motor, the motor being connected to a hydraulic power circuit for receiving a flow of hydraulic fluid under pressure when coupled with a hydraulic pumping system; and
   a flow limiting device coupled in the hydraulic circuit for preventing hydraulic fluid from flowing into the motor at rates in excess of a predetermined rate.

7. The coiled tubing injector of claim 6, wherein the hydraulic motor is a high speed, low torque motor, and wherein the motor and the chains are coupled through a speed reduction gear box.

8. In a coiled tubing injector, the injector having opposing continuous chains rotated by power supplied from at least one hydraulic motor mounted on the injector, the motor being connected to a hydraulic power circuit for receiving a flow of hydraulic fluid under pressure, a method comprising:
   coupling a hydraulic pumping system to the hydraulic power circuit; and
   limiting the maximum flow rate of the hydraulic fluid delivered to the motor by a flow limiting device coupled in the hydraulic circuit.

9. The method of claim 9, wherein the flow limiting device is mounted on the coiled tubing injector.

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