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Electrohydraulic drive for process line winders, unwinders and other equipment.

(57)

A hydraulic cylinder (106) controls linear traversing movement of a spooler (16) under the control of a high speed servo-valve (136) that in turn is controlled by electronic circuitry. Position, velocity and rotation speed transducers (106, 114 and 116) for the spooler and a position transducer (118) for a strand (18) being wound onto or unwound from the spool provide input signals to the circuitry.

EP 0 188 035 A2

ELECTROHYDRAULIC DRIVE AND CONTROL APPARATUS FOR LINEARLY
TRAVERSING A ROTATABLE SPOOL

5 This invention relates to an electrohydraulic drive and control apparatus for linearly traversing a rotatable spool (also known as a traverse winder or level winder) that both winds and pays out an indefinite length of metallic strand.

10 In the production of many materials, whether metal, paper, plastic films or otherwise, the product is in the form of a moving strand or web. In the case of a strand, it can be a solid wire, tubing, strip, or a variety of other forms. Processing of the material occurs "on the fly" as it moves
15 through the production equipment. Typically when the processing is complete, the material is wound onto a spool, core, reel or mandrel. In some applications, the material is wound and then later unwound for further processing.

20 An object of the invention is to provide an electrohydraulic drive and control system for traversing a spooler that maintains the strand being wound or payed out in a precisely predetermined lateral position.

25 According to the present invention there is provided an electrohydraulic drive and control apparatus for linearly traversing a rotatable spool that winds and unwinds an indefinite length of strand material with a constant
30 passline comprising:

an hydraulic cylinder that drives said spool linearly along its axis of rotation,

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first transducer means for sensing the position of said spool and generating an output signal indicative of said position,

5 second transducer means for sensing the linear velocity of said spool and generating an output signal indicative of said velocity,

10 third transducer means for measuring the speed of rotation of said spool and generating an output signal indicative of said rotational speed,

15 electronic controller means for generating a control signal in response to said position, velocity and rotation output signals, and preselected values for the limits of said traversing motion and the pitch of said traversing, and

20 a high speed servo-valve responsive to the output control signal of said electronic controller means that controls the operation of said hydraulic cylinder.

25 The present apparatus provides an electrohydraulic drive and control apparatus for process line equipment such as winders, unwinders (collectively "spoolers"), pinch rolls and bridles. The apparatus is intended to be incorporated in a related system which includes a bi-directional, variable displacement hydraulic motor that rotates a spool or other member that engages the product, whether a web or
30 strand. Hydraulic fluid is directed by a feed line from a constant pressure, variable flow rate supply to a directional valve connected to the motor. Fluid exiting the motor through the directional valve is directed back to the power supply by a return line.

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This related system further includes a pressure reducing valve controlled by a proportional electrical actuator is connected in the feed line. A sequence valve located in the return line maintains the pressure upstream of the valve at a predetermined and adjustable value. When the drive system is "motoring", typically in a winding or jogging mode, the entire output flow from the motor is directed via the sequence valve to the supply. When the motor is operating in a pay-out or braking mode, the motor acts as a pump. In this mode, the fluid exiting the motor flows through a regeneration circuit connected between the return line and the feed line. The regeneration circuit includes a flow divider that directs a significant portion of the flow from the return line back to the feed line to conserve the fluid. Cavitation is prevented under braking conditions by continuing to supply additional fluid from the feed line to maintain a positive pressure at the motor inlet at all times. A smaller portion is directed back to the power supply. The regeneration circuit includes a second adjustable sequence valve set at a pressure less than that of the first sequence valve and a check valve which prevents a flow of the fluid directly from the feed line to the return line. The directional valve is preferably a four-way, double solenoid directional valve with forward, reverse and neutral positions.

An electronic control circuit for the proportional actuator includes an integrating servo-amplifier, an analog multiplier, a diode, and a linear power amplifier. The integrating servo-amplifier receives the output signal from a tachometer which measures the actual speed of rotation of the motor and an electrical speed command signal from a controller. Unless these signals are the

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same, the integrating amplifier will change its output signal upwards or downwards, depending upon the sign of the error. The output signal of the integrating amplifier is applied to the analog multiplier which also receives a pressure limit command signal that is proportional to a preselected desired maximum pressure for the hydraulic feed line. The output of the multiplier, which will correspond to from 0 to 1.0 times the maximum pressure setting, is applied through a diode to a linear power amplifier which produces an output signal of suitable magnitude to operate the proportional actuator on the pressure reducing valve. The control system also includes a second proportional actuator that controls the displacement of the motor in response to a remote electrical control signal.

In a preferred form of the related system, the speed limit, pressure limit, and displacement command signals, typically DC voltages, are generated by a digital computer acting through a multi-channel digital-to-analog converter. The rotational speed from the tachometer and an output signal from a transducer that measures the tension in the strand being processed are applied to the computer through a multi-channel analog-to-digital converter. The computer also receives command signals from conventional manually operated switches and a keyboard terminal. The computer can execute automatic controls such as a tapering of the tension in the strand as the diameter of a coil being wound on the spool increases and compensating for the inertia of the spooler during acceleration or deceleration.

The related system as described above, as well as the apparatus according to the present invention, is also shown and described in co-pending EP 0107959 A2, to which reference is accordingly directed.

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For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing, in which the single Figure is a schematic drawing of an electrohydraulic drive and control apparatus according to the invention for traversing a spooler in a highly controlled manner with the lateral position of the strand being wound or unwound being substantially constant.

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The Figure shows in a schematic form an electrohydraulic drive and control system 104 which controls the linear traverse of a spool 16 along its axis of rotation. The traverse mechanism produces a compact, even and level wound coil of a strand 18 on the spool 16 with a substantially constant passline (when viewed from above) for the strand entering or leaving the spool. The traverse drive is powered by a hydraulic cylinder 106 which is connected through a linkage 106a to main bearings 108 that support the spool 16. The cylinder 106 has a small orifice (not shown) through its piston to provide damping and facilitate air elimination.

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Input information to control the operation of the cylinder is provided by four transducers; a tachometer 110 (which may be one which produces an analog signal that measures the speed of rotation of the spool) coupled to the mandrel

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or shaft of the spool 16 through a linkage 112; a linear position transducer 114 that indicates the lateral position of the spool 16; a linear velocity transducer 116 that indicates the instantaneous linear velocity of the spool 16; and an optical sensor 118 that determines the lateral position of the strand 18 and generates an output voltage proportional to the sensed position.

The cylinder 106 is supplied with oil by a high quality servo valve 136, which in turn obtains its control signal from one of two servo-amplifiers 126 or 138 according to the state of a velocity relay 142. The output signal of the amplifier 126 is applied to the relay 142 over line 150 and the output signal of the amplifier 138 is applied to the relay 142 over line 152.

The amplifier 138 is the position control servo-amplifier, which is used (a) to hold the spool in a fixed traverse position for indefinite periods, (b) for manual traversing of the spool, and (c) for payoff operation under the control of the strip position sensor 118. Relay 144 is the payoff relay, which is energized to connect sensor 118 and de-energized to connect the spooler position sensor 114 (position signal on line 127). The output signal of the velocity sensor 116 is connected via line 124 to provide velocity compensation at high payoff speeds. A position command signal over line 154 from an external source such as a computer is used for manual traverse of the spooler. During position control operation, the amplifier 138 will adjust the valve 136 to minimise the position error of the strip or spool.

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For strip winding, the velocity servo-amplifier 126 is used. The velocity command is obtained by first scaling the spooler tachometer 110 signal by a pitch potentiometer 132, corresponding to the desired traverse per revolution. This signal over line 146, which is always positive, is fed into an inverter circuit 140 controlled by a comparator circuit 128. The comparator circuit compares the actual traverse position signal 127 with values set on traverse limits pots 130 (extend) and 134 (retract) and causes a control signal on line 148 to change from a logical "1" (extend) to a logical "0" (retract) at the end of each cycle and back again. The inverter 140 will then either invert the signal on the line 146 to an equal negative value or not, producing a velocity command signal on a line 149. A velocity feedback signal is on the line 124. For high speed operation, a velocity derivative (not shown) may be added to improve performance.

CLAIMS:

1. An electrohydraulic drive and control apparatus for linearly traversing a rotatable spool (16) that winds and
5 unwinds an indefinite length of strand material (18) with a constant passline comprising:

an hydraulic cylinder (106) that drives said spool linearly along its axis of rotation,

10 first transducer means (114) for sensing the position of said spool and generating an output signal indicative of said position,

15 second transducer means (116) for sensing the linear velocity of said spool and generating an output signal indicative of said velocity,

20 third transducer means (110) for measuring the speed of rotation of said spool and generating an output signal indicative of said rotational speed,

25 electronic controller means for generating a control signal in response to said position, velocity and rotation output signals, and preselected values for the limits of said traversing motion and the pitch of said traversing, and

30 a high speed servo-valve (136) responsive to the output control signal of said electronic controller means that controls the operation of said hydraulic cylinder.

2. A drive and control apparatus according to Claim 1,
characterised by means (118) for sensing the lateral
position of said strand being wound onto or unwound from
said spool and generating an electrical output signal
5 indicative of said strand position.

3. A drive and control apparatus according to Claim 2,
characterised by electronic means (126, 138) for
generating a control signal for said servo-valve
10 responsive to said strand position signal and said spool
velocity signal.

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