

DUAL FORCE RAM DRIVE FOR A SCREW PRESS

RELATED APPLICATION

This patent application is related to provisional patent application serial number 60/972,436 entitled "Setup System for a Fastener Press" filed on September 14, 2007 and
5 provisional patent application serial number 60/972,447 entitled "Dual Force Ram Drive for a Screw Press" filed on September 14, 2007, priority from which is hereby claimed.

FIELD OF THE INVENTION

This invention relates to a fastener press which utilizes electric servo motors for precise ram position control. More specifically, the present invention relates to a servo motor
10 driven ram having separate high-force and low-force drive motors using a clutch-type drive mechanism and regulated by a controller.

BACKGROUND OF THE INVENTION

The desirable characteristics of a fastener insertion press are high speed and high force. To achieve these characteristics a single drive unit is impractical as high cost, large
15 power requirements, and large physical size are restrictions. However, a press motion profile with a high speed approach to the pressing position and then an insertion press to a high force at slower speeds provides a solution.

To achieve this motion profile, presses utilize a two-motor servo system to control velocity, position, and force of the press ram to install fasteners to the proper force or
20 distance depending on the application. A high torque drive is engaged to drive the ram to the desired force or position. After insertion the high speed motor returns the ram to the home position.

There is therefore a need in the art for a ram drive in a press which provides both high speed and high force accurately and reliably. There is a further need for an accurate and
25 reliable ram drive and press which is economical to manufacture and does not require significant operator skill.

SUMMARY OF THE INVENTION

In order to meet the needs of the art described above, the present invention has been devised. A fastener press, for example a Pemserter Series 3000 manufactured and sold by
30 Penn Engineering and Manufacturing Corp., as shown in Figure 1, utilizes a bidirectional over-running clutch through which high force ram drive power passes. The clutch is controlled by relative motion of two separate motor drives as will be described in detail

below. Bidirectional over-running clutches are commercially available components that consist of a regular, polygon-shaped inner hub surrounded by rollers encased in an outer hub as shown in Figure 3. The inner and outer hubs are connected to separate shafts. The inner hub shaft can drive the outer hub shaft in either a clockwise or counterclockwise direction if the inner hub shaft speed of rotation is greater than the outer hub. If the outer hub speed is greater than the inner hub then the clutch is disengaged and the outer hub can rotate independently of the inner hub. The clutching action is therefore controlled only by the relative speed of its drive versus driven components. This provides an extremely smooth and responsive transition between high speed/low force and low speed/high force operation of the ram so that the pressing cycle can be as fast and efficient as possible. These structures may be used with the setup system for a fastener press disclosed in provisional patent application serial no. 60/972,436 of the same Applicant.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting.

As such, those skilled in the art will appreciate that the conception, upon which this disclosure is based, may readily be utilized as a basis for the designing of other structures, methods, and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a front left isometric view of a ram press utilizing the invention.

Figure 2 is a diagram showing the major components of the invention.

Figure 3 is a top front left isometric view of the bidirectional clutch of the invention.

Figure 4 is a elevation cross-sectional view of the bidirectional clutch of the invention.

Figure 5 is a graph showing the pressing profile of one embodiment of the invention depicting the speed of the ram over time.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Figure 1, a ram press 4 employing the invention is shown which includes a c-shaped frame 1 that supports an anvil 2 that is reciprocally impacted by ram 3.

Referring now to Figure 2, major components of the invention are disclosed which
5 comprise a frame that supports basic mechanical components of the invention that comprise a high-speed mechanical actuator and a high-torque motor. Also supported by the frame, is a screw drive which may be operated in either direction by either the high-speed or low-speed motor means. A bidirectional self-disengaging clutch is connected to the high torque motor
10 means which includes a motor/gear reducer combination. A programmable logic controller regulates operation of the two motors and thus movement of the ram by way of the screw drive. The bidirectional clutch is connected to the main shaft of the screw drive by way of a timing belt. The logic controller regulates the movement of the ram according to a pressing profile that will be described in more particularity with regard to Figure 5.

With continued reference to Figure 2, the press ram is moved by a screw actuator
15 whose shaft is coupled directly to the high speed motor means in this embodiment being the commercially available device generally referred to as an electromechanical actuator. The device incorporates a screw drive mechanism so that its internal shaft is reciprocated in a range of motion between extended and retracted positions. That drive shaft is also coupled to the output of the above-described clutch by way of a gear belt drive. The input shaft of the
20 clutch is coupled to the high torque motor. The clutch is operated by the relative speeds of separate brushless DC or AC servo motors that are regulated by a controller. Each motor has a feedback device such as an encoder or resolver and an additional encoder is attached to the main actuator shaft so that the relative position of the ram is known regardless of which motor is operating the ram. One motor provides a high-speed drive while the second motor is
25 a high-torque drive which is an integrated servo gear motor with a 10 to 1 ratio. The high-torque motor means has its own encoder for communication and control and its output shaft is coupled to the high-speed motor's drive shaft through the above-described high-torque clutch, transmitted there by a belt. The high-torque motor can rotate the screw actuator when the clutch is engaged. Engagement of the clutch is achieved by regulating the speeds of the
30 motors to switch ram operation from one motor to the other when the other is running faster.

Referring now to Figures 3 and 4, the bidirectional clutch of the invention is a commercially available device well known in the mechanical arts. Figure 4 is a cross-

sectional view of the bidirectional clutch describing greater details of its structure. The outer hub shaft carries the output of the clutch and is connected to the high speed motor shaft by way of a belt drive as depicted in Figure 2. The inner hub shaft is connected to a high torque output of the gear motor.

5 Operation

The required movements of the ram can be described by four stages:

1. High-speed down for set up or up for home position;
2. Upward high-speed movement after any move not requiring high-force;
3. High-force pressing; and
- 10 4. Upward movement after high force pressing

One embodiment of the invention may be described in detail as follows. The four stages of movement required of the ram described above are specifically carried out in the following steps for each movement, as follows:

1. Sequence to move high speed axis down for setup and up to home position
 - 15 a. Enable high speed servo drive, it will hold position
 - b. Enable high torque
 - c. Bump high torque axis $+0.015$ " to ensure clutch is free
 - d. $.050$ seconds into the move, enable high speed axis
 - e. Run high speed axis down while high torque is finishing its move
 - 20 f. Disable high torque
2. Sequence to move high speed axis up after any move not requiring the high torque axis for force:
 - a. High speed is enabled, since it just ran down
 - b. Enable high-torque
 - 25 c. Bump high torque axis -0.015 " to ensure clutch is free
 - d. $.050$ seconds in to the move, enable high speed axis
 - e. Run high speed axis up while high torque is finishing its move
 - f. Disable high torque
3. Sequence to engage the clutch for pressing with the high torque axis:
 - 30 a. Enable high speed servo drive – it will hold position
 - b. Enable high torque
 - c. Bump high torque axis $+0.015$ to ensure clutch is free

- d. High speed axis is moving down, two moves are compounded together (registration move and collapse move)
- e. Logical decisions are made on the fly to ensure the ram sensor tripped within a proper window and other conditions were satisfied
- 5 f. While high speed axis is moving, enable high torque
- g. Start high torque axis moving approximately .650" above workpiece -- it is running at a slower speed than the high speed axis, so ram is still being driven at 8 IPS by high speed axis while high torque is turning at a speed significantly less than this speed (.80 - 1.6 IPS)
- 10 h. High torque takes over ram movement as high speed axis is decelerating to zero
- i. High speed axis finishes its move and disables
- j. Run high torque axis down to complete pressing based on strain guage input
- 4. Sequence to disengage the clutch after pressing with the high torque axis:
- 15 a. After high torque axis completes all pressing and dwell, calculate disengage distance based on the force, to unload the force exerted on the clutch which would cause back driving of the ram.
- b. Move high torque axis -.XXX distance = $(\text{Force}/16000)*-0.150$
- c. Keep high torque enabled
- 20 d. Re-enable high speed axis

The above movements are regulated by a controller which determines the speeds of the high speed and high torque motors which, in combination with the clutch of Figure 2 interposed between the high torque motor and the screw actuator, follows a prescribed pressing profile that determines the motion of the ram.

- 25 Figure 5 represents a typical pressing profile. The X axis represents time in seconds and the Y axis represents speed (inches per second) The dotted lines **9** indicate the typical motion of the high torque motor and the solid lines **8** represent the motion of the high speed motor as it relates to ram movement. At the beginning of the process the first move is to start the high torque motor prior to starting the high speed motor. This move insures that the
- 30 clutch will disengage when the high speed motor overtakes the high torque motor. When the solid line crosses the dotted line (reading from left to right) the high speed motor overtakes the high torque motor and is then in control of the ram. The high torque motor then

decelerates and stops during the high speed move. At the mid point of the graph the high speed move (solid line) is approaching the pressing position. At this time the high torque motor starts accelerating while the high speed motor is decelerating. When the dotted line overtakes the solid line the high torque motor is in control and the pressing sequence begins.

5 Once pressing is complete the high torque motor decelerates. On the return stroke after pressing, the high torque motor is started in reverse and begins to accelerate. The high speed motor then starts and begins to accelerate at a faster rate. When the solid line crosses the dotted line the high speed motor overtakes the high torque motor and is in control. The high speed motor finishes the move and decelerates to a stop. The cycle is complete and ready for
10 the next cycle.

Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents
15 may be resorted to, falling within the scope of the invention.

CLAIMS

What is claimed is:

1. A drive for a ram press, comprising:

a frame;

5 screw drive means mounted to said frame, said drive means being selectively rotatable in opposite directions by first motor means;

a ram mounted to said screw drive reciprocal in a range of motion between extended and retracted positions;

second motor means connected to said screw drive means for rotation thereof;

10 a bidirectional, self-disengaging clutch having an input shaft connected to said second motor means and an output shaft connected to said screw drive means whereby the clutch disengages whenever said output shaft is driven at a speed greater than the speed of input shaft; and

15 a programmable logic control system for regulating the position of the ram by operation of said first motor means and said second motor means whereby said first motor means is signaled to rotate said screw drive at a higher rate of speed relative to said second motor means during a fast movement phase of moving said ram, said clutch being disengaged thereby.

2. The drive of claim 1 wherein said clutch is engaged when said control system signals said first motor to operate at a speed less than said second motor means whereupon said ram is moved by said second motor means during a high force phase of moving said ram..

20 3. The drive of claim 1 further including means for sensing the position of said ram electrically connected to said logic control system.

4. The drive of claim 1 wherein said first motor means is a high speed low torque motor and said second motor means comprises a gear reducer interposed between said second motor means and the input shaft of said clutch whereby said clutch input shaft is driven at a high torque and a low speed.

5. The drive of claim 1 wherein both first and second motor means always rotate said drive screw in the same direction when both motor means are simultaneously operative.

30 6. The method of operating the drive of the ram press according to claim 1 wherein the

logic controller regulates the motion of the ram following the pressing profile of Figure 5.

7. The method of operating a drive of a ram press comprising four stages:

a first stage for moving said ram at high speed, either downward for setup or upward for return to home position;

5 a second stage wherein the ram is moved upwardly at high speed after any ram motion not requiring high force;

a third stage in which the ram is moved at high force to accomplish pressing a workpiece; and

10 a fourth stage in which the ram is moved upwardly after the high force pressing of said third stage.

8. The method of claim 7 wherein the said fourth stage comprises the steps of:

calculating the clutch disengagement distance based on the pressing force to unload the back-force exerted on the clutch;

15 signaling the high torque motor means to move the ram upwardly said disengaged distance while simultaneously signaling the high speed motor means to move the ram upwardly.