A sheet metal bending machine is provided with a bending unit moved by hydraulic cylinders with sliding pistons. The cylinders are controlled by a closed loop control system comprising temperature measuring means for measuring the cylinder temperature, position detecting means for detecting the piston position and a control unit for varying the rate of hydraulic fluid fed to the cylinders according to the measured cylinder temperature and the detected piston position.
HIGH PERFORMANCE MACHINE WITH THERMAL COMPENSATION FOR PROGRAMMED SHEET BENDING WITH CONSTANT BENDING ANGLE

DESCRIPTION

[0001] This invention refers to a machine for programmed sheet bending of the general type known in the art as panel bender.

[0002] These panel benders are capable of automatically move a sheet metal blank on a horizontal surface placed in front of a bending press provided with a bending unit with one or two bending blades, which is able to perform a number of bends of variable size, angle and direction on each side of the blank. The bending press also comprises a fixed counter-blade and a blank-holder of variable size which cooperate with the counter-blade for clamping the blank near the edge to be bent. The bending unit and the blank-holder are activated by controlled hydraulic cylinders. An example of the present invention is given by the European patent EP-A-0293964.

[0003] The advantages of this machine reside in the constant production rate and the production and programming flexibility. A few drawbacks, however, are encountered.

[0004] In particular, a drawback consists in a slow and progressive variation of the programmed bending angles owing to the thermal expansion of the bending unit cylinders and pistons, which is caused by the progressive heating of the hydraulic oil, up to the work temperature is reached.

[0005] The object of the present invention is to eliminate this drawback so as to guarantee temperature compensated piston strokes and, consequently, desired constant bending angles.

[0006] According to this invention this object is obtained by a sheet metal bending machine with a bending unit moved by hydraulic cylinders with sliding pistons, characterised by a closed loop control system comprising temperature measuring means for measuring the cylinder temperature, position detecting means for detecting the piston position and a control unit for varying the rate of hydraulic fluid fed to the cylinders according to the measured cylinder temperature and the detected piston position.

[0007] In this way, by measuring the cylinder temperature at the beginning of each bending cycle of a type of panel and by the use of piston position detecting devices, which are substantially insensitive to the temperature changes, it is possible to guarantee piston strokes which are temperature compensated and cause a constant bending angle fully corresponding to the programmed angles.

[0008] An embodiment of the present invention is shown by way of a non-limiting example in the accompanying drawings, in which:

[0009] FIG. 1 shows the mechanical part of a bending press;

[0010] FIG. 2 shows a bent lateral edge of a sheet metal blank;

[0011] FIG. 3 shows a block scheme of a closed loop control system which causes the bending press to operate according to the invention;

[0012] FIG. 4 schematically shows the effect of the closed loop control system on the piston stroke of a hydraulic cylinder which controls the movement of the bending unit of the bending press.

[0013] The bending press shown in FIG. 1 comprises a fixed base 1, which supports a counter-blade 2 on which a lateral edge of a sheet metal blank 3 moved by a manipulator (not shown) rests.

[0014] A blank-holder 4 cooperates with the counter-blade 2 to clamp the sheet metal edge. The blank-holder is attached to the front end of a movable support 5, which has a rear end hinged at 6 on a rear part of the fixed base 1. The support 5 is moved up and down by a plurality of hydraulic cylinders 7 which react on the fixed base 1.

[0015] A bending unit 8 comprises a common support 9 for two bending blades 10 and 11 which cooperate with the counter-blade 2 to cause up and down bending of the clamped edge of the sheet metal. The bending unit is subjected to combined horizontal and vertical movements by hydraulic actuators formed by hydraulic cylinders 12 interposed between the rear part of the base 1 and a lever 13 having a fixed hinge 14 and a mobile hinge 100, and by further hydraulic cylinders 15 interposed between the blade support 9 and the fixed base 1.

[0016] FIG. 2 shows a side of the sheet metal 3, which has a bent edge 31 which forms an angle of 90° (for example) with the adjacent horizontal part 32 of the sheet metal.

[0017] The hydraulic cylinders 12 and 15, each provided with respective sliding pistons 20, 21, are controlled by a closed loop control system such as that shown in FIG. 3, comprising a hydraulic pump 16, a control unit 17 (in particular, a numerical control unit programmed according to a mathematical model of a panel as shown in FIG. 2) for controlling the fluid rate fed by the pump to the cylinders, a temperature measuring device 18 for measuring the temperature of the cylinders 12, 15 and a piston position detecting device 19 (in substance, an encoder) for detecting the position of the pistons 20, 21.

[0018] The mode of operation of the closed loop control system can be understood from the schematic drawing of FIG. 4, in which S is the programmed piston stroke, P is the piston position corresponding to the programmed piston stroke at a rest temperature, PL is the piston position corresponding to the programmed piston stroke at the work temperature and S1 is the temperature compensated piston stroke which allows the same piston position P at the work temperature.

[0019] The cylinder temperature is measured at the beginning of each bending cycle of a type of panel. In the traditional bending machines the lengthening of the body of the controlled cylinders causes a variation of the bending angle with respect to the programmed angle because the bending unit, for obvious reasons, feels the above mentioned thermal effect. According to the present invention the hydraulic cylinders 12, 15 are “controlled”, that is they are equipped with a device 18 for measuring the temperature of the cylinders and with a device 19 for detecting the position of the pistons included in a closed loop control system. The hydraulic cylinders 12, 15 and pistons 20, 21 suffer the effect of the thermal expansion caused by the heating of the oil whereas the devices for detecting the position of the pistons...
are substantially insensible to the variations of the temperature. The closed loop control system of the present invention determines a temperature compensated piston stroke which allows the piston position to remain constant when the temperature varies from the rest value to the work value at the beginning of the bending cycle.

1. Sheet metal bending machine with a bending unit moved by hydraulic cylinders with sliding pistons, characterised by a closed loop control system comprising temperature measuring means for measuring the cylinder temperature, position detecting means for detecting the piston position and a control unit for varying the rate of hydraulic fluid fed to the cylinders according to the measured cylinder temperature and the detected piston position.

2. Sheet metal bending machine according to claim 1, characterised in that said control unit is of numerical type.

3. Sheet metal bending machine according to claim 1, characterised in that said control unit is programmed according to a mathematical model of a panel.

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