PIPE BENDING MACHINE FOR INDUSTRIAL PIPING

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PIPE BENDING MACHINE FOR INDUSTRIAL PIPING

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This invention relates to a method of bending pipe, and to pipe bending machines for carrying out such method and more particularly to such pipe bending machines adapted to bend industrial pipe, such as pipe used in ships, plants, and refineries, and such invention particularly relates to pipe bending machines in which force is applied to a straight bending shoe to force a portion of the pipe to bend around to the curvature of the bend forming face portion of a curved bending die while the other end of the pipe is restrained in a rockably mounted holding shoe.

It is therefore an object of this invention to provide a method of bending pipe under space limitations, and also to provide machines for carrying out such bending.

It is also an object of this invention to provide pipe bending machines of this class which have a straight bending shoe to which force is applied to force a portion of the pipe to be bent around to the curvature of the bend forming face portion of a curved bending die while the other end of the pipe is restrained in a rockably mounted holding shoe.

It is another object of this invention to provide pipe bending machines of this class which have means to apply force to urge a part of the holding shoe directly toward the die to tightly embrace the pipe and also means to apply force beyond the die on the opposite side thereof from the holding shoe to roll the bending shoe along the die while it is held in such pipe embracing relation with the die.

It is a still further object to provide pipe bending machines of this class having actuating means for the two forces acting on the strong back to cause said forces to act conjointly on the bending shoe.

It is also a further object of this invention to provide pipe bending machines of this class in which the actuating means operates around a series of davits spaced to successively be employed to take the wrap of the actuating means as the bending of the pipe progresses.

It is yet a further object of this invention to provide pipe bending machines of this class which are inexpensively constructed, have few moving parts, and which can be installed in a pipe shop on a single slab.

It is yet a further object of this invention to provide a pipe bending machine of this class in which a bridle connects the pipe into an embraced position between bending shoe and bending die with the end portion of the bending shoe on the opposite side of the member from the holding shoe, such bridle passing through a bridle block interposed between its end connections.

It is also a still further object of this invention to provide a pipe bending machine of this class which may employ a multiplicity of reeved sheaves in the bridle block and davit members to multiply the bending force applied to the bridle.

It is yet another object of this invention to provide a pipe bending machine of this class having its bridle block connected by a line removably extending around a series of davits to a winch which supplies the pipe bending force.

It is still a further object of this invention to provide a pipe bending machine of this class which has a straight bending shoe which contacts the bending die as it moves therearound to bend the pipe embraced between the die and the shoe.

It is also an object of this invention to provide a pipe bending machine of this class which has a straight bending shoe which is spaced from the bending die as it moves around the pipe embraced between the die and the shoe to bend the pipe.

It is yet a further object of this invention to provide a pipe bending machine of this class which has a straight bending shoe spaced on either side of the central portion of a curved bending die; each bending shoe being operable responsive to the application of force thereto to bend a portion of a pipe into the bend forming face portion of the bending shoe so that the shoes operate together to bend the pipe to the curvature of the die.

It is also another object of this invention to provide a pipe bending machine of this class adapted to bend pipe in either a horizontal or vertical plane.

It is yet a further object of this invention to provide a method of bending pipe with a machine of this class by which method the line from bridle block to winch is successively removed from the davit nearest the bridle block as bending progresses.

It is still another object of this invention to provide a pipe bending machine of this class operable with two bending shoes, which provides means between the inner ends of the shoes to move in and grasp the central portion between the shoes to prevent this portion from wrinkling.

It is still another object of this invention to provide a rapid method of bending pipe by employing two force applying means outwardly and two forces inwardly thereof to contact the pipe with the curved bending die, the outward forces serving to bend the pipe from its center portion outwardly at each end into a curved die.

Other and further objects will be apparent when the specification is considered in connection with the drawings in which:

Fig. 1 is a plan view of the machine in initial position to begin bending pipe.

Fig. 1A is a fragmentary plan view of another modification of the machine which modification has special application in the bending of thick walled pipe.

Fig. 2 is a plan view of the machine as bending progresses.

Fig. 3 is a sectional elevation taken along line 3--3 of Fig. 2.

Fig. 4 is a perspective view of the pipe contacting elements and of the points of force application.

Fig. 5 is a plan view of a smaller size pipe bending machine showing a modification of the employment of the actuating means.

Fig. 6 is a view of a modification of a pipe bending machine of this class in which two straight bending shoes are employed, one on either side of the central portion of the bending die.

Fig. 7 is a sectional view taken along line 7--7 of Fig. 6.

Fig. 1 shows a machine 1 which includes a slab 2 on which it is generally mounted. Such machine has a base 3 which may be embedded in the slab or mounted rigidly thereon. Brackets 4 connect this base 3 to the support or body portion 5' of the bending die 5, and these brackets also support and space the die 5 from the slab 2.

The die is substantially semi-circular in shape, and the peripheral face 6 is formed to receive substantially the semi-peripheral surface of a pipe to be bent. The holding
shoe or strap 7 is pivotally or rockably mounted at 8 to the die 5 and is curved, as shown in Fig. 4 to extend around one end portion 9 of the pipe 10 which is to be bent.

The shackles 11 has the arms 12 and 13 thereof pivotally mounted to the pin 16 at the center of the die 5 and has the arms 12 and 13 with the roller shaft 15 journaled at either end in these arms. At the outer end 17 of the shackle, the bar 18 is connected to which may be connected one end 19 of the bridle 20.

The straight bending shoe 21 is of a cross-section to provide a bend forming face portion 22 to receive substantially the semi-periphery of the pipe 10 to be bent, and to complement the die 5 in embracing the pipe, and is of a wall thickness so that the shoe end 23 will be contacted by the roller 14. The bridle 20 may then be threaded through the sheave 24 of the bridle block 25 and the end 26 of the bridle 20 connected to the bar 27 on the outer end 28 of the bending shoe 21 into which the outer portion 29 of the pipe 10 extends.

A series of davits 30, 31, 32, and 33 are mounted on the slab 2 and the rotatable members 34 thereof on the upstanding studs 35 receive the line 36 thereagainst. This line has one end portion 37 connected at 38 into the bridle block 25. The other end portion 39 of the line 36 is wound around the drum 40 of the winch 41 and anchored thereto. Conventional power means, not shown, actuates the winch to wind up the line 36 thereon.

It can thus be seen that when the winch 41 is actuated to wind up the line 36 to draw the bridle block 25 toward the first davit, the holding shoe or strap 7 will initially pivot or rock about the pin 8, an indicated in Fig. 2. As this happens, the shackle 11, which is pulled by the portions 42 of the bridle 20, forces the roller 14 against the bending shoe portion 23. At the same time the portions 43 of the bridle pull upon the outer end 29 of the bending shoe 21 to apply the leverage to the shoe 21 which acts to bend the pipe 10.

As shown in Figs. 1 and 3, the sides 44 of the bending shoe and sides 45 of the bending die are in contact with each other at a point of contact which changes constantly as the bending shoe is rolled without slippage along the pipe and die to bend the pipe.

It can thus be considered that two force applying means act conjointly on the bending shoe to bend the pipe. One such force applying means acts at any point of time on the opposite side of the holding shoe 11 from the central point of the bend forming face of the bending shoe to urge a part of the bending shoe directly toward the die to tightly embrace the pipe held therebetween.

This force applying means has, in the form of the inner portions 47 of the shackle arms 12 and 13, spaced independent swinging connections to the support portion 5 of the bending forming face portion 6 of the die 5. Also, via the roller 14, the central portions 48 of these arms constitute spaced independent swinging connections to the bending shoe 21.

The other such force applying means acts beyond the die and on the opposite side thereof from the holding shoe to roll the bending shoe along the die while it is held in pipe embraced position. Such force applying means has, in the form of the bridle portions 43, the bridle block 25, the line 36, the davits, and via the winch 41, spaced independent swinging connections to the slab 2, which together with the base 3, brackets 4, and body portion 5 of the die, may be considered to form the support or rigid frame portion of the machine 1.

When the winch 41 is rotated by its driving means, not shown, such driving means, actuated by the bridle portions 43, which tie the two force applying means together to act conjointly serve as the actuating means operable to cause the two force applying means to act conjointly on the bending shoe to bend the pipe.

In general, the machine of this invention follows this type of machine in that this machine employs a comparatively long, straight bending shoe, and a curved bending die. A rockable holding shoe or anchor member holds one end of the pipe, and on the opposite side of this holding shoe from the central portion of the instantaneous active bending portion of the die, one force acts to hold, or force the shoe against the pipe and toward the die, and outwardly from the first force, and on the opposite side of the die from the holding shoe, a second force acts conjointly with the first force and toward the end of the shoe, to roll the shoe around the pipe as it bends the pipe into the curvature of the die.

It is pointed out that the above described relationship, as compared with the presently employed "strongback" or straight bending shoe type pipe bending machine, holds even though the bridle portion 42 and the bridle portion 43 are constantly changing in length, and also the ratio of the lengths of the portions to each other is gradually changing.

It is also noticeable that, as bending progresses, the line 36 can be slackened and lifted successively from the davits 30, 31, and 32, so that bends of considerable arc can be accomplished.

It is also pointed out that whereas the bridle block 25 and line 20 are disclosed, such could be removed, and any two segments, one to the shackle and one to the end 28 of the shoe 21, and the theory of this invention could be employed by the co-ordination of such forces to bend the pipe.

As the winch 41 is of limited power delivery, and as the wall thickness and strength of various pipe varies widely, with a winch of rated capacity, it may be possible to bend thin walled pipe or relative weak pipe by using the form of invention shown in Figs. 1–4; the same winch might not be able to bend extra strong pipe, or comparatively thick walled pipe, as a fair part of the developed force is dissipated in the frictional contact between the die surfaces 45 and shoe surfaces 44.

However, if the modification of machine shown in Fig. 1A is employed, in which the peripheral length of the bend forming face portion of the die and the die are slightly less than the circumference of the pipe, so that the surfaces 44 and 45 do not come in contact, then the power dissipated in the modification of Figs. 1–4 in contact between the shoe and the die, is saved in this modification of Fig. 1A, so that substantially all of the bending power is employed to bend the pipe.

It is also possible to gain mechanical advantage in bending, as shown in Fig. 5, by reving the line 36 a plurality of times through the bridle block 25 and around the davit in use adjacent the bridle block. This can be done when required by disconnecting the end 37 of the line 36 from the bridle block at 38, making the extra desired turns through the sheaves 24 and around the davit, and then reconnecting the end of the line. In this regard it is obvious that the bridle block 25 must have a plurality of sheaves or grooves, as is conventional, and therefore no cross-sectional view is taken through the block to show this feature.

The modification of this invention employed in Figs. 6 and 7 shows a machine 50 having a frame 51 on which may be mounted the winches 52, 52', or optionally a single winch, not shown, may be geared or otherwise connected to drive two drums 53, 53', in the directions indicated. The central support beam or column 53 extends from the frame 51 to support the curved die 54 which is rigidly connected to the central portion of the machine 1.

This curved die has the bend forming face portion 55 to receive substantially the semi-periphery of the pipe to be bent.

The shackles 56 and 57 are pivotally connected to the pins 58 and 59 which extend from the column 53, and the rollers 60 and 61 thereof support the inner ends 62 and 63 of the straight bending shoes 64 and 65 having the bend forming face portions 55'. These shoes 64 and 65 have the sheave blocks 66 and 67 on their outer end 68 and 69.
A line 70 from the winch 52 is reeved through the block 66 and through the block 71 on the plate 72 which is rigidly connected to the frame 51 and column 53. The line 70 then may pass back through the block 66 and then through the sheave block 66, back again through the block 73, and back to a final dead end 75 at the block 66. The line 76 from the winch 52 is similarly reeved through the block 67 on the shoe 65, the block 77 on the plate 79, and the block 89 on the shackle 87.

In order to insure against the central portion of the pipe from writhing or the straight should or straights and against the straights a pipe of the pipe, the central die portion 81 is provided to move into grasping contact with the pipe as bending progresses. This may be accomplished by a number of structures, as a hydraulic ram, which moves the die into the space between the inner ends of the straights and against the central portion of the pipe. Another structure for this purpose may consist of sheave blocks or pulleys located on the die portion 81 and connected to a line passing through other blocks or pulleys on the frame 1 and finally connected with, and actuated by, the prime mover of the winches or drums 52, and 52'.

In this form of device for this purpose disclosed in the drawings linkages 82, 83 are pivotally connected at their inner ends to the pins 84 on each side of the die portion 81, and at their outer ends to the pivot pins 85 and 86 on either side of the straights or bending shoes 64 and 65. Guide sleeve 87 is provided on either side of the curved die 54 to receive the guide rods 88 connected on either side of the die portion 81.

This modification is designed to provide more rapid bending, by bending two portions of a pipe at once and is also designed to bend pipe to a greater degree of bend at a greater speed than can be accomplished with some of the other forms of machinery operable on the "strong-back" principle.

In this machine the anchor 7 is eliminated since the straights 64 and 65 act on either side of the central point of the bend forming face portion 55 so that the pipe sections between the inner ends thereof is restrained from motion.

Broadly, this invention covers a pipe bending machine operable on the strong-back principle which is adapted to bend industrial pipe. In this regard it is pointed out that the relative positions of the elements in these machines can be reversed, that is, the machines of Figs. 1-5 can be shaped to operate in a vertical plane and the machine of Figs. 6 and 7 can operate in a horizontal plane. Also, each machine can operate with the straights rolling in contact with the curved die, or rolling about the pipe and spaced from the curved die.

What is claimed as new is:

1. A pipe bending machine comprising a support, a rigid die anchored on the support and having a working face with a bend forming portion shaped to conform to the curvature of the inside of the bend to be produced in a pipe, a rockably mounted holding shoe on the support opposed to the curved die adjacent one end thereof and movable toward and away from the curved die, a separate independently mounted rigid bending shoe shaped to conform to the shape of the pipe before bending and in initial position before bending of the pipe having a first part directly opposed to the bend forming portion of the working face of the curved die and extending past the central point of the face of the die toward the holding shoe and a second part located and extending a substantial distance beyond the bend forming portion of said face in a direction away from said holding shoe, shackle means pivotally connected inwardly to said support and including means thereon adapted to maintain rolling contact with the surface of said shoe first part opposite the bend forming face portion thereof, a line connected at a first end to said shoe at substantially the end of said second part, a bridle block, said line extending from said first end through said bridle block and connected at the other end thereof to said shackle outwardly of said rolling contact means, and power means connected to said bridle block and adapted to pull upon said bridle block as said bridle block slides along said line, the pull of said power means as transmitted through said bridle block to said other end causing said rolling contact means of said shackle to force said shoe into said part toward the die to cause the bending shoe and die to tightly embrace a pipe at the locus of bending during the bending operation while permitting the bending shoe to roll in contact with said die, said pull of said power means as transmitted through said bridle block to said first end acting transversely of said bending shoe in a direction to roll said bending shoe along said die to bend the pipe into said bend forming face portion of said die.

2. A pipe bending machine comprising a support, a rigid die anchored on the support and having a working face with a bend forming portion shaped to conform to the curvature of the inside of the bend to be produced in a pipe, a rockably mounted holding shoe on the support opposed to the curved die adjacent one end thereof and movable toward and away from the curved die, a separate independently mounted rigid bending shoe shaped to conform to the shape of the pipe before bending and in initial position before bending of the pipe having a first part directly opposed to the bend forming portion of the working face of the curved die and extending past the central point of the face of the die toward the holding shoe and a second part located and extending a substantial distance beyond the bend forming portion of said face in a direction away from said holding shoe, shackle means pivotally connected inwardly to said support and including means thereon adapted to maintain rolling contact with the surface of said shoe first part opposite the bend forming face portion thereof, a line connected at a first end to said shoe at substantially the end of said second part, a bridle block, said line extending from said first end through said bridle block and connected at the other end thereof to said shackle outwardly of said rolling contact means, and power means connected to said bridle block and adapted to pull upon said bridle block as said bridle block slides along said line, the pull of said power means as transmitted through said bridle block to said other end causing said rolling contact means of said shackle to force said shoe into said part toward the die to cause the bending shoe and die to tightly embrace a pipe at the locus of bending during the bending operation while permitting the bending shoe to roll in contact with said die, said pull of said power means as transmitted through said bridle block to said first end acting transversely of said bending shoe in a direction to roll said bending shoe along said die to bend the pipe into said bend forming face portion of said die.

3. A pipe bending machine comprising a support, a rigid die anchored on the support and having a working face with a bend forming portion shaped to conform to the curvature of the inside of the bend to be produced in a pipe, a rockably mounted holding shoe on the support opposed to the curved die adjacent one end thereof and movable toward and away from the curved die, a separate independently mounted rigid bending shoe shaped to conform to the shape of the pipe before bending and in initial position before bending of the pipe having a first part directly opposed to the bend forming portion of the working face of the curved die and extending past the central point of the face of the die toward the holding shoe and a second part located and extending a substantial distance beyond the bend forming portion of said die in a direction away from said holding shoe, shackle means pivotally connected inwardly to said support and including means thereon adapted to maintain rolling contact with the surface of said shoe first part opposite the bend forming face portion thereof, a line connected at a first end to said shoe at substantially the end of said second part, a bridle block, said line extend-
ing from said first end through said bridle block and connected at the other end thereof to said shackle outwardly of said rolling contact means, and power means connected to said bridle block and adapted to pull upon said bridle block as said briddle block slides along said line, the pull of said power means as transmitted through said bridle block to said other end causing said rolling contact means of said shackle to force said shoe first part toward the die to cause the bending shoe and die to tightly embrace a pipe at the locus of bending during the bending operation while permitting the bending shoe to roll around said die, said pull of said power means as transmitted through said bridle block to said first end acting transversely of said bending shoe in a direction to roll said bending shoe along said die to bend the pipe into said bend forming face portion of said die.

4. A pipe bending machine comprising a support, a rigid die anchored on the support and having a working face with a bend forming portion shaped to conform to the curvature of the inside of the bend to be produced in a pipe, a rockably mounted holding shoe on the support opposed to the curved die adjacent one end thereof and moveable toward and away from the curved die, a separate independently mounted rigid bending shoe shaped to conform to the shape of the pipe before bending and in initial position before bending of the pipe having a first part directly opposed to the bend forming portion of the working face of the curved die and extending past the central point of the face of the die toward the holding shoe and a second part located and extending a substantial distance beyond the bend forming portion of the face in a direction away from said holding shoe, shackle means pivotally connected inwardly to said support and including means thereon adapted to maintain rolling contact with the surface of said shoe first part opposite the bend forming face portion thereof, a line connected at a first end extending to substantially the end of said second part, a bridle block, said line extending from said first end through said bridle block and connected at the other end thereof to said shackle outwardly of said rolling contact means, and power means connected to said bridle block and adapted to pull upon said bridle block as said briddle block slides along said line, the pull of said power means as transmitted through said bridle block to said other end causing said rolling contact means of said shackle to force said shoe first part toward the die to cause the bending shoe and die to tightly embrace a pipe at the locus of bending during the bending operation while permitting the bending shoe to roll around said die, said pull of said power means as transmitted through said line to said second part acting transversely of said bending shoe in a direction to roll said bending shoe along said die to bend the pipe into said bend forming face portion of said die.

5. In a pipe bender, a stationarily mounted curved bending die having a bend forming face portion, means cooperating with said die to hold a portion of a pipe to be bent in fixed relation to said die, a rigid bending shoe shaped to conform to the shape of the pipe before bending with one end adjacent said pipe holding means in initial position before bending of the pipe and the other end extending along the portion thereof to be bent, a shackle mounted to swing about a fixed pivot at the center of curvature of said die and extending radially beyond said one end of said bending shoe and having means engaging said shackle to hold it against outward movement away from said die, and force applying means operatively connected to said shackle and to said shoe at a fixed position spaced from said one end thereof for con jointly swinging said shackle around said die to bend said pipe and said shackle means to hold said shackle against movement away from said die at the locus of bending.

6. In a pipe bender, a stationarily mounted curved bending die having a bend forming face portion, means cooperating with said die to hold a portion of a pipe to be bent in fixed relation to said die, a rigid bending shoe shaped to conform to the shape of the pipe before bending with one end adjacent said pipe holding means in initial position before bending of the pipe and the other end extending along the portion thereof to be bent, a shackle mounted to swing about a fixed pivot at the center of curvature of said die and extending radially beyond said one end of said bending shoe and having means engaging said shackle to hold it against outward movement away from said die, and force applying means operatively connected to said shackle and to said shoe at a fixed position spaced from said one end thereof for con jointly swinging said shackle around said die to bend said pipe and said shackle means to hold said shackle against movement away from said die at the locus of bending.

7. The invention, as set forth in claim 6, wherein means for connecting the force applying means to the shackle and shoe includes a line interconnected to the outer end of the shackle and the other end of the shoe, and means for maintaining said line under tension as said outer end of said shackle approaches said other end of said shoe while the bending operation is being performed.

8. In a pipe bender, a stationarily mounted curved bending die having a bend forming face portion, means cooperating with said die to hold a portion of a pipe to be bent in fixed relation to said die, a rigid bending shoe shaped to conform to the shape of the pipe before bending with one end adjacent said pipe holding means in initial position before bending of the pipe and the other end extending along the portion thereof to be bent, a shackle mounted to swing about a fixed pivot at the center of curvature of said die and extending radially beyond said one end of said bending shoe and having means engaging said shackle to hold it against outward movement away from said die, a line connected to said shackle and to said shoe at a position spaced from said one end thereof, means providing a sliding connection to said line, and force applying means connected to said sliding connection means for tensioning said line and con jointly swinging said shackle around said die to bend said pipe and said shackle means to hold said shackle against movement away from said die at the locus of bending.

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