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AUTOMATED BAR BENDER

FIELD OF THE INVENTION

The present invention relates to bending apparatus for shaping
5 bars. In particular, the present invention relates to automated bar
benders.

BACKGROUND OF THE INVENTION

Machines for bending bars, particularly metal bars are known in
the art. US Patent no. 4,555,924 discloses a bending machine that
10 includes a feed device that is advanced with a stepped feeding
movement. A continuous metal wire from a spool is driven past a
straightening device made of a number of rollers, and the bending
device then bends one bar at one time. US Patent 5,182,932 describes
a bar bending apparatus having at least one pair of operation-
15 controlled gripper tongs which can be swivelled from a first position, in
which they receive a plurality of bars from the bar feed device and
clamp the bars, into a second position, in which they insert the bars
into the gap between the bending members. These machines
however, are generally not fully automated. Others can handle only
20 small numbers of bars. There is therefore a need for an improved bar
benders.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides, in one aspect, an automated bar bending system with a bar bending unit for bending bars to a predetermined angle, an in-feeding system for receiving pre-cut bars for transferring one or more bars to the bar bending system, and an unloading system for unloading shaped bars from the bar bending system to a prescribed position at a prescribed location. The bending (also referred to as shaping), transferring and unloading functions are preferably performed concurrently for maximum efficiency.

10 In another aspect, an automated bar bending unit is provided. The unit contains a former assembly, a drive pin assembly and a backup clamp assembly. The automated bar bending unit is provided with a machine controller and actuating mechanisms such that different size bars may be automatically shaped to a prescribed angle
15 according to user specification.

In the preferred embodiment, the former assembly includes a series of concentric former rings mounted within a former housing. Each of the rings is provided with an actuating mechanism for moving it between a standby position and a forming position. A machine
20 controller is provided for controlling the actuating mechanism and to divide the rings into a first group and a second group, with each group containing zero or more rings. During operation, the first group of rings are actuated into the forming position, while the second group is

retracted into a standby position. As a result, the diameter and the bending curvature of the bar can be adjusted according to the user's specification.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of one embodiment of the present invention. Showing the in-feed system, bending system and unloading system

Figure 2 is a side view (view A as indicated in Fig.1) of the same
10 embodiment of the present invention. Some details are omitted intentionally for clarity of the illustration.

Figure 3A and 3B are side and perspective views respectively of the in-feed system showing the storage and loading section, the buffer and conveying section and the transfer section.

15 Figure 3C is a closed up view on the left side of Figure 3B.

Figure 4A is a perspective view of the bending system showing the two bending units, the intermediate support and X-axis rails.

Figure 4B is a perspective view of one of the bending units.

Figure 4C is the close up view on part of a bending unit showing the drive pin, former and backup clamp.

Figure 4D is the front view of the bending unit. Some details are omitted intentionally for clarity of the illustration.

5 Figure 4E is a cross-sectional view of the same bending unit.

Figure 4F is a perspective view of the bending unit showing the alternative preferred embodiment of the backup clamp assembly.

Figure 5A is the perspective view of unloading system showing the three unloading gripper assembly and support structure.

10 Figure 5B is a closed up perspective view of one of the unloading gripper assembly.

Figure 5C is a closed up view of the Figure 5B unloading gripper showing the Z-axis structure, Y-axis structure and gripper assembly.

Figure 5D is a closed up view of the Figure 5B unloading gripper
15 showing the X-axis assembly.

DESCRIPTION OF THE INVENTION

The automated bar bending and sorting machine **10** according to the preferred embodiment of the present invention is shown in Figures 1 and 2 comprising 4 sub-systems, a bar bending system **200** comprises two bar bending units **210** for bending the pre-cut bars, an elongated in-feed system **100** for receiving and aligning pre-cut bars, and also to deliver the bars to the bending system **200**, an unloading system **400** for transferring the shaped bars away from the bending system **200**, and a conveying system **500** for storage and transporting the shaped bars away from the entire system **10**.

Referring also to Figures 3A-C, the in-feed system **100** includes an elongated storage table **110** for receiving pre-cut bars, and an elongated and downward sloping buffer conveyor **120** aligned against one long side of the storage table **110**. A Turning device **130** is connected to the bottom of the buffer conveyor **120** and adapted to receive bars that are transferred from the buffer conveyor **120**. A transfer mechanism **140** is provided above the buffer conveyor **120** for transferring the bars from the turning device **130** to the bending units **210**.

The storage table **110** includes a bar storing area **111** and an adjacent rolling area **112**. Extending upwards and along one end of the rolling area is an alignment plate **113**. The buffer conveyor **120** contains a series of chain conveyors **121** driven by a common shaft

122 coupled to conveyor motor **123**. The chain conveyors **121** move in the downward sloping direction perpendicular to the long edge **112a** of the rolling area **112**. On each chain are attached stopper fingers **124** extending outwardly at equal intervals. The space between two stopper
5 fingers **124** define a buffer slot **125** and the distance between two fingers is the index spacing **126**.

The transfer mechanism **140** includes a row of transfer grippers **141** mounted on a transfer bar **142** that is aligned parallel to the long edge **112a** of rolling area **112**. Transfer bar **142** is in turn slidably
10 mounted on a set of transfer rails **143** that are provided perpendicular to the long edge **112a** of the rolling area. Each transfer gripper **141** contains a vertically aligned transfer arm **144** that is attached at the base to a pair of transfer jaws **145**. Pneumatic actuators **146** and **147** are provided to allow transfer arm **144** to move in the Y- and Z-directions respectively.
15 Actuator **148** is provided to allow transfer jaws **145** to open or close.

The turning device **130** includes a row of turning grippers **131** mounted on a rotatable shaft **132** that is positioned parallel to the edge **112a** of the rolling area, and between the transfer mechanism **140** and the buffer conveyor **120**. The turning grippers **131** overlap and
20 interpolate between the chain conveyors **121**. Actuators **133** are provided to rotating the turning grippers **131** between an inclined receiving position **131'** and a vertical transfer position **131''**. The inclination of the turning gripper **131** in receiving position

131 correspond to the inclination of the buffer conveyor **120** and is aligned with the lowest buffer slot of the buffer conveyor **120**. Each turning gripper **131** includes a pair of turning jaws **134** that can be actuated to open or close.

5 The bending system **200** is provided within and below the transfer mechanism **140** and the unloading system **400**. Referring to the embodiment shown in Figure 4A-4D, the bending system consists of 2 bending units **210**, 1 pair of bending rails **330** and a series of intermediate supports **350**. The 2 bending units **210** are essentially
10 mirror image of each other.

Each bending unit **210** contains a bending head **220** and a positioning structure **310**. The positioning structure **310** is to position the bender head **220** in X-direction (a direction parallel to the long edge **112a** of rolling area **112**) and Y-direction (a direction perpendicular to
15 the long edge **112a** of rolling area **112**).

The positioning structure **310** containing roller wheels **311** and drive unit **312** and enable the bending units **210** to slide independently along bender rails **330** for movement along X-axis. The roller wheels **311** are installed in such a way that some of them rotate about the
20 vertical (Z) axis and some about the horizontal (Y) axis so as to support the load of the bending unit **210** and to restrain lateral (Y-axis) movement. The drive unit **312** moves and positions the bending units

210 along the bender rail **330**. Drive unit **312** includes a positioning gear motor **313** mounted on positioning structure base plate **314**. Pinion gear **315** is installed on the gear motor **313** and match with the racks **316** that are mounted on bending rails **330**. As the drive unit **312**
 5 is actuated, the pinion gear **315** runs on rack **316** and moves the bending unit **210** along the X-co-ordinate and may be position in any pre-determined position.

The positioning structure **310** also containing guide shafts **321** and a second drive unit **322**. The bending head **220** is slidably
 10 mounted on the guide shafts **321** with guide bushes **327**. Guide bushes **327** support the load of the bending head **220** and restrain lateral movement in the X-axis. The drive unit **322** moves and positions the bending head **220** along the guide shafts **321**. Drive unit **322** includes a positioning gear motor **323**, lead screw shaft **324** and lead
 15 screw nut **325**. Lead crew shaft **324** is coupled to the gear motor **323**. the lead screw nuthousing fix the lead screw nut **325** on the base of the bending head **220**. As the drive unit **322** is actuated, the lead screw shaft **324** rotates and move the lead screw nut **325** together with the bending head **220** along the Y-direction and may be positioned in any
 20 pre-determined position.

Along the length of rails **330** , intermediate supports **350** are provided at predetermined positioned between the two bending units

210. Intermediate support 350 includes a clamp assembly 351, a retractable structure 352 and a fixed structure 353. The clamp assembly 351 contains a clamp 354 and an actuator 355. One jaw of clamp 354 is fixed and the other jaw is movable by actuator 355 to
5 open or close the clamp 354. Under operating conditions, clamp 354 is along the same reference Y-co-ordinates as the clamp jaw 273 of the backup clamp assembly 270. Retractable structure 352, when extended, positions the clamp 354 at the reference Y-co-ordinates; when it is retracted, the entire retractable structure 352 and clamp
10 assembly 351 is moved out of the X-axis path of the bending units 210.

The bending head 220 includes the former assembly 230, the drive pin assembly 250, backup clamp assembly 270 and motor gear drive assembly 290.

The former assembly 230 includes a former housing 231 and a
15 series of concentric cylindrical former ring 232. The former housing 231 is secured to the bending head table top 233. The former ring 232 are housed within former housing 231. Each former ring 232 have a key slot 234 at the low portion and is connected to a former actuator 235 at the bottom. When former actuator 235 is actuated, it raises the top portion of
20 the former ring 232 above the bending head table top 233. During retraction, the former actuator 235 retracts the entire former ring 232 such that it is flush with the table top 233. The key slots 234 of all former

rings **232** are aligned together and this alignment is maintained with a common key **236** inserted from the side of former housing **231**. The common key **236** prevents the rotation of the former ring **232** with respect to the former housing **231**. The key slot **234** is elongated such
5 that it is not impeding the extension and retraction of the former ring **232**.

The drive pin assembly **250** includes a drive pin **251**, a drive shaft **252**, a shaft housing **253** and a support housing **254**. The entire drive pin assembly **250** is installed on and rotates with the bending gear **293**
10 about the centre of the former ring **232**. The support housing **254** are secured on the bending gear **293**. The shaft housing **253** is slidably housed in the support housing **254**. Actuator **255** is mounted on the support housing **254** and, when actuated, raises the shaft housing **253** such that the bottom edge of the drive pin **251** is above the table top **233**
15 and when retracted, lowered the shaft housing **253** such that the entire drive pin assembly **250** is below the table top **233**. Keys **256** are provided on the contact surfaces of the support housing **254** and shaft housing **253** for guiding shaft housing **253** vertical movement and to withstand the load generated during bending.

20 The drive shaft **252** is slidably housed in the shaft housing **253** and can slide toward or away from the centre of the bending head **220** (i.e. centre of the former assembly **230**). The slide movement is guided

by key **261** installed between the contact surface of the shaft housing **253** and drive shaft **252**. A drive unit **257** consists of positioning gear motor **258** and lead screw are secured to the shaft housing **253**. When the drive unit **257** is actuated, the lead screw rotates and advance or retract a lead screw nut fitted on it. As the lead screw nut is secured on the drive shaft **252**, the drive shaft **252** will move forward or aft accordingly.

The backup clamp assembly **270** is provided on one side of the bending head table top **233** and includes a clamp unit **271** and a clamp adjustment unit **272**. The clamp unit **271** is slidably mounted on the clamp adjustment unit **272** and includes a pair of clamp jaws **273** and a hydraulic clamp jaw actuator **274** which open or close the clamp jaws **273**. The adjustment unit **272** is mounted to the table top **233**. It has drive unit **275** includes a positioning gear motor **276**, lead screw **277** and lead screw nut **279**. As the drive unit **275** is actuated, the lead screw **277** turn and move the clamp unit **271** toward or away from the centre of bending head **220**.

Before bending, the relative lateral position of the drive pin **251**, raised former ring **232** and backup clamp unit **271** have to be adjusted according to the diameter of the bar for which bending or forming is desired, former ring diameter and direction of bending i.e. forward or reverse bending(will be discussed in further detail later). This

adjustment is required such that the bars to be shaped can be placed in the gap **278** provided between drive pin **251** and raised former ring **232** and clamped by the clamp unit **271** substantially parallel to the X-direction.

5 In this preferred embodiment, the positioning structure **310** moves the bending head **220** in Y-direction, the backup clamp assembly **270** (and hence the clamp unit **271**) move together with it. The clamp adjustment unit **272** moves the clamp unit **271** in the reverse Y-direction by the same amount and in synchronisation with the y-
10 direction movement such that there is no change in the absolute clamp unit **271** Y-co-ordinates before, during and after the move. This is advantageous in this invention as a common lateral (Y-co-ordinates) position regardless of bar size or former size or during reverse bending simplified bending, feeding and unloading system design and
15 operation.

Another preferred embodiment of the backup clamp assembly **280** comprises a clamp unit **281** and a support structure **282**. The clamp unit **281** includes a pair of clamp jaws **283** and a hydraulic clamp jaw actuator **284** which open or close the clamp jaws **283**. The
20 clamp unit **281** is mounted on support structure **282** which in turn is mounted on the base plate **285** of the positioning structure.

The motor gear drive assembly **290** includes a driving gear motor **291** driving gear **292**, bending gear **293** and bearing assembly **294**. The driving gear motor **291** is coupled together with the driving gear **292**. The bending gear **293** is engaged with and driven by the driving gear **292**.
5 **292**. The bending gear **293** is mounted on the rotatable bearing housing **295** of the bearing assembly **294**. Bearings **296** are placed in between the rotatable bearing housing **295** and the fixed former housing **231**. As the driving gear motor **291** rotates, the drive pin assembly **250** mounted on the bending gear **293** will be rotated in either
10 forward or reverse direction. The rotation angle of drive pin **251** about the former ring **232** and hence the bending angle of the bar is controlled by the driving gear motor **291** turning angle. Various limit switches are mounted on the bending unit to prevent over-travel of drive pin in the forward and reverse direction.

15 Referring now to Figures **5A-5D**, the unloading system **400** contains 2 carriage rail **410** supported on 4 floor mounted columns **411**. Three essentially identical unloading carriages **420** are slidably mounted on the carriage rails **410**. Each unloading carriage **420** comprises a horizontal guide beam **430**, carriage roller assembly **440**,
20 a guide assembly **450**, a vertical pickup bar **460** and a unload gripper **470** attached on the lower end of the pickup bar **460**.

The two ends of the horizontal guide beam **430** are fastened to the 2 carriage roller assembly **440**. Each carriage roller assembly **440** has 2 support rollers **441** to support the weight of the unloading carriage **420** and 2 guide roller **442** to restraint the lateral movement (Y-axis movement) of horizontal guide beam **430**. A carriage motor **443** drive the unloading carriage **420** to travel on the carriage rails **410** by mean of rack **444** and pinion **445**.

The guide assembly **450** comprises a beam guide **451** and a bar guide **452**. The beam guide **451** is slidably mounted on the horizontal guide beam **430** with a series of guide and support rollers **453**. It have a drive motor **454** to drive the guide assembly **450** along the horizontal guide beam **430**. The bar guide **452** has a series of guide rollers **455** and allows the vertical pick up bar **460** to be slidably mounted on it. The bar guide **452** has a drive motor **456** mounted on it to drive the pick up bar **460** up and down in the vertical direction.

The unloading gripper assembly **470** comprises a rotational assembly **471** and a gripper **472**.

The rotational assembly **471** comprises a rotational motor **473** and a spring loaded self-adjustment mechanism **474**. The rotational motor **473** can rotates the gripper **472** about the Z-axis to any predetermined angle and the self-adjustment mechanism **474** allows the gripper **472** to adapt to the final bar shape during the gripping action.

The gripper **472** comprises a pair of actuator driven gripper jaws **475** mounted on spring loaded guide rods **476**. Gripper jaw **475** open or close depending on the action of the actuator **477**. Spring loaded guide rod **476** allows the gripper jaw **475** to self-adjust to accommodate any
5 error in the actuator direction. Depending on the shape of the bar and based on an intelligent picking logic, the three gripper **472** will automatically positioned itself to optimum pick up positions such that the shaped bar can be unloaded in a balanced and stable manner.

The conveyor system **500** is positioned under the unloading
10 system **400**. It comprises a slat conveyor belt **510** driven by a conveyor gear motor (not shown). Conveyor system **500** simplify and speed up unloading system **400** operation. Before bending commences, unloading carriage **420** positions itself along carriage rail **410** according to the final bar shape. With conveyor system **500**, the unloading carriage
15 **420** do not need to move in X-direction along the carriage rail **410** during unloading. The unloading gripper assembly **470** will move in Y and Z direction to pick up the shaped bar from the bar bending system **200** and place it on the conveyor system **500**. After the unloading gripper assembly **470** unload all the bars at the first location on the conveyor
20 system **500**, the conveyor gear motor moves the slat conveyor belt **510** to bring an empty space on the slat conveyor belt **510** to the next unloading position. A computerised nesting program is incorporated in the machine controller to optimise the conveyor system **500** storage

capacity. When the conveyor system **500** is full and no location are available for unloading, all bars on the conveyor system **500** are conveyed away to a conventional bundling station for bundling. The empty conveyor system **500** will then be ready for the unloading system **400** again.

During operation. An operator receives pre-cut or cut-to-length bars in bundles and places them on storage area **111**. In this area, the bundles are cut open and the bars to be shaped are segregated and transferred to the rolling area **112**.

Before loading these bars into the buffer conveyor **120**, bar information such as shape and size of these bar are either download from a network system or input by operator keying in or scanning in bar code into the machine controller. Base on these information, the machine controller initiate the system to perform a set up operation. This set up operation involve setting up the in-feed system **100**, the bending system **200**, the unloading system **400** and the conveyor system **500** such that they are ready for bending operation. During set up operation, the bending heads **220** position themselves in the X and Y positions, the drive shaft **252** moves above the table top **233** and extend forward to a position predetermined by the machine controller. The predetermined number of former rings **232** will be pushed up and have their top half emerge above the table top **233**. The backup clamp

assembly **270** is aligned with the gap **278** in the reference position
Predetermined number of intermediate supports **350** will be extended to
the ready position. Those transfer grippers **141** that will be in used in
the bending operation will be activated and those transfer grippers **141**
5 not in use will be deactivated. The 3 unloading gripper assemblies **470**
position themselves in X, Y , Z and G direction. The conveyor system
500 moves the slat conveyor belt **510** such that an optimum empty
space on the conveyer system **500** is ready for the unloading system
400 to unload the shaped bars.

10 Once the set-up operation is completed, bending operation can
commence. The operator at the rolling area **112** aligns the bar end with
the alignment plate **113** before a prescribed number of bars are laterally
fed into the buffer conveyor **120**.

Rolling area **112** contains a series of rollers to facilitate
15 alignment of the bars to the alignment plate **113** and a declination angle
at the side next to the buffer conveyor **120** to facilitate the rolling of bars
from the rolling area **112** down to the buffer slot **125**. The prescribed
number of bars is thus laterally aligned in one row on the buffer
conveyor **120**. The set of bars is the buffer slot **125** from a downward
20 sloping array. The operator then indexes the buffer conveyor **120** forward
by one slot in the Y-direction. The next slot is then loaded by the operator
repeating the aligning and rolling action to load the next set of bars into
the next buffer slot **125**. The buffer conveyor **120** can also be multiple

indexed for fast-forwarding towards the turning device **130**. The turning device **130** is set to the receiving position **131'** such that the turning gripper **131** are aligned with the lowest buffer slot **125**. As the first set of bars is forwarded downwards from the buffer conveyor **120**, the bars are
5 inserted laterally into the turning gripper **131**, which then grips and rotates the array of bars to the transfer position **131"**. In the transfer position **131"**, the individual bar remains in a horizontal position, but if more than one bar is presented, the additional bars are stacked one directly above another in a vertical array due to the turning action of the
10 turning gripper **131**. The transfer grippers **141**, which interpolate between the turning grippers **131** have pre-set combination of "in", "out", "up" and "down" positions. In the "in-down" position, the transfer grippers **141** are moved downwards to align with the vertical array of horizontal bars held up by the turning gripper **131**. After gripping the
15 array of bars, the turning grippers **131** release their grip, and the transfer grippers **141** then move the bars upwards in the Z-direction, followed by movement in the Y-direction towards the bending units **210**. In the "out-down" position, the transfer grippers **141** are aligned (same Y-coordinate) with gap **278** of the bending unit **210**. Once the array of bars is
20 properly positioned within gap **278**, the clamp unit **271** close to grip the bars, the transfer grippers **141** open to release the bars and move back to the "in-down" position to retrieve the next set of bars. The clamp jaws **273** of backup clamp assembly **270** are also aligned to the gap **278**

such that the array of bars is lowered into the clamp jaws **273** when the transfer grippers **141** move to the "out-down" position. The clamp **354** of the intermediate support **350** is also aligned to the same Y-coordinate as gap **278** such that the array of bars are lowered into clamp **354** in the same "out-down" position, and the bars are supported during the bending process. Meanwhile, the turning grippers **131** move back to the receiving position **131'** to receive and turn the next set of bars. Bending is achieved by the turning movement of the drive shaft **252** that is driven by the rotating movement of the bending gears **293**.

10 In this preferred embodiment, it is found to be advantages to have the bar fed onto the bending unit **210** at a fixed reference Y-Co-ordinates regardless of bar size and former rings **232** used. The infeed system **100** described above has transfer grippers **141** to load the bars onto bending unit **210** at this reference Y-co-ordinate.

15 The bending unit **210** in the preferred embodiment is an automated apparatus that can be easily adjusted to receive bar from the infeed system **100** and bend or shape bars of different diameters and to different degrees of curvature.

To achieve this, the bending unit adjust the gap **278** provided
20 between the drive pin **251** and the former rings **232**, the clamp jaw **273** of backup clamp assembly **270**, and the clamp **354** of the intermediate support **350** to be aligned with the reference Y-co-ordinate. These adjustments arise due to the different former ring **232** being used. As

different former rings **232** are used, the gap **278** change its Y co-ordinate. To compensate for the co-ordinate change, the bending units **210** moves in the Y-direction such that the gap **278** resume its reference Y-coordinates. As the bending units **210** move in Y-direction,
5 the backup clamp assembly **270** mounted on it moves with it and away from the reference Y-co-ordinate. A clamp adjustment unit **271** is provided to move the clamp unit **271** in the opposite direction by the same amount such that the clamp unit **271** is back to the original reference Y-co-ordinate.

10 To made the system easily adjustable for bending or shaping different diameters of bars and achieving different degrees of curvature, the bending unit **210** is provided with a series of concentric former rings **232** having former actuators **235** that allow them to be automatically raised or retracted below the bending unit table top **233**. During
15 operation, the former ring **232'** with the prescribed diameter will be raised for bending. For better strength, all other former rings smaller than the prescribed former ring **232'** are preferably raised during forming. In the preferred embodiment, a single anti-rotation common key **236** is provided to prevent the former rings **232** form rotation during
20 bending. To ensure that former rings **232** can slide easily over each other even after a long period of operation, former rings **232** are preferably made of hardened material to minimise wear, and the portion of the former rings **232** surface in contact with the bars is slightly

recessed so that even if there are some deformation or metal flare, the sliding movement is not hampered. The drive pin assembly **250** has a drive pin **251** at the front. Its movement towards and away from the centre of the bending head **220** is controlled by the positioning gear
5 motor **258**. The position of the drive pin **251** is dependent on the diameter of the prescribed former ring **232'** cylinders as well as the bar diameter. Once positioned, the prescribed former ring **232'** and drive pin **251** define a predetermined gap **278** between them where the bar is to be loaded. Other than turning in either direction for bending the bars
10 forwards and backwards, the drive pin **251** can also be retracted below the table top **233** by actuator **255**.

For reverse bending while the bar or set of bars are still in the bending table top **233**, all former ring **232** are retracted below the table top **233** and move over to the opposite side of the bar by moving the
15 bending head **220**. As bending head **220** are being move, the clamp adjustment unit **272** move the clamp unit **271** in the reverse direction such that the clamp unit **271** position is at all time at Y-reference coordinate. The drive pin **251** also fully retracted below the table top **233** by the combine action of positioning gear motor **258** and actuator **255**.
20 The entire drive pin assembly **250** is than rotated to the opposite side of the bar by the motor gear drive assembly **290**. Once over at the opposite side of the bar, former rings **232'** will be raised and drive pin **251** will

also be raised and move toward the centre of bending head **220** to the prescribed position.

For bending of single-bend bars and many kinds of double-bend bars, there is no need for adjustment of bending unit **210** during
5 bending once the initial set-up operation is completed. For single-bend bar, one bending unit performs the bending. For double-bend bar, each bending unit **210** performs one bend. However, for bars that have 3 or more bends, or double-bend bars that require bending to be performed by the same bending unit due to dimensional constraints, adjustment
10 of co-ordinates of bending unit may be required. During the adjustment, clamp unit **271** of the moving bending unit will open and all intermediate support **350** in the way of the bending unit movement will be retracted away.

When all the bending or shaping on a bar or a set of bars have
15 been performed, the unloading gripper assembly **470** will move in the Y direction to the reference Y-co-ordinates. The unloading grippers assembly **470** is then move down in Z direction to the same position as the "out-down" position of infeed system transfer grippers **141** to grip the bars. The clamp unit **271** of backup clamp assembly **270** and clamp
20 **354** of intermediate support then open and the unloading gripper assembly **470** moves the bar up in the Z direction and out in the Y-direction and places the bar down in the Z direction onto the conveyor system **500**. As more and more bars are unloaded, the unloaded bars

are stacked up to create a higher and higher stack. To ensure that the unloading gripper assembly **470** do not crash onto the stack of unloaded bars, detecting devices are installed on the unloading gripper assembly **470** such that the bars will be unloaded at a predetermined
5 distance from the top most bars on the stack.

The unloading grippers assembly **470** are pre-positioned to a ready position for picking up bars during the initial set up operation. The pick up positions are predetermined by the machine controller and is calculated based on the shape and CG of the bar. During set-up
10 operation, the machine controller determines the positions and rotating angles of gripper **472** on each unloading carriage **420**. After set up, grippers **471** only move in the Y and Z directions and do not move in the G and X-directions during unloading to simplify control and minimise unloading cycle time.

15 The conveyor system **500** act as an unloading storage area for shaped bars on which bars are unloaded and segregated. As the unloading system **500** positions itself only base on the bar information from the machine controller and do not alter its X position during unloading. The conveyor system **500** takes care of that by ensuring that
20 the location on which the unloading system **400** is going to unload is on an empty space. The slat conveyor belt **510** move in X direction to ensure that all bars on it will not interfere with the next bar to be unloaded.

An integrated system comprising the infeed system **100**, bending system **200**, unloading system **400** and conveying system **500** give rise to great benefit in bar bending operation. The fully automatic set-up operation greatly reduce operator set up time, skill level and human error. The fully automatic bending, unloading and conveying system reduces human resource requirements to a single operator at the infeed system side to just unbundling, aligning and loading bar into the buffer conveyor **120**. The greatest benefit of the system is realised through the parallel processing of the infeed, bending and unloading operations as compared to sequential processing as conventionally practice in the art.

While the present invention has been described particularly with references to the aforementioned figures, it should be understood that the figures are for illustration only and should not be taken as limitation on the invention. In addition, it is clear that the method and apparatus of the present invention has utility in many applications where automatic bar bending is required. It is contemplated that many changes and modifications may be made by one of ordinary skill in the art without departing from the spirit and the scope of the invention described.



CLAIMS

- 1 1 An automated bar bending and sorting system comprising :
 - 2 a bar bending system for bending bars to a predetermined
 - 3 angle;
 - 4 an in-feeding system for receiving pre-cut bars, said in-feeding
 - 5 system containing a transfer system for transferring one or more
 - 6 bars to said bar bending system; and
 - 7 an unloading system for unloading shaped bars from said bar
 - 8 bending system to a prescribed position at a prescribed
 - 9 location.
- 1 2 A system according to claim 1 wherein said transfer system
 - 2 comprises
 - 3 a conveyor system having an inclined conveyor with stopping
 - 4 elements mounted at predetermined intervals and defining slots
 - 5 therebetween;
 - 6 a transfer mechanism having a vertical array of transfer grippers
 - 7 slidably mounted on transfer bars; and
 - 8 a turning device provided with turning grippers, said turning
 - 9 grippers rotatable between an inclined receiving position and a
 - 10 vertical transfer position, said turning gripper in said receiving



11 position aligned with said conveyor for receiving one or more
12 pre-cut bars; said turning grippers in said transfer position
13 adapted to co-operate with said transfer gripper to transfer said
14 one or more pre-cut bars to said bar bending system.

1 3 A system according to claim 1 further comprising a conveying
2 system having said prescribed location for receiving shaped bars
3 and transferring said shaped bars therefrom.

1 4 A system according to claim 1 wherein said transfer system further
2 comprises

3 a conveyor system having an inclined conveyor with stopping
4 elements mounted at predetermined intervals and defining slots
5 therebetween;

6 a transfer mechanism having a vertical array of transfer grippers
7 slidably mounted on transfer bars; and

8 a turning device provided with turning grippers, said turning
9 grippers rotatable between an inclined receiving position and a
10 vertical transfer position, said turning gripper in said receiving
11 position aligned with said conveyor for receiving one or more
12 pre-cut bars; said turning grippers in said transfer position
13 adapted to co-operate with said transfer gripper to transfer said
14 one or more pre-cut bars to said bar bending system; and

15 said in-feeding system further comprises a preparation area including:



16 a storage area for receiving and holding said pre-cut bars; and
17 a rolling area having two opposing sides between two ends,
18 said rolling area further having an alignment plate mounted at
19 one end thereon, one side of said rolling area linked to said
20 storage area and the other side of said rolling area linked to the
21 top of said inclined conveyor.

1 5 A system according to claim 1 wherein said unloading system
2 comprises a plurality of unloading carriages slidably mounted on
3 carriage rails, said unloading unit further comprising an unloading
4 gripper for gripping and unloading bars from said bar bending
5 system at a prescribed location;
6 at least one horizontal guide beam for moving said gripper in the X-
7 direction;
8 at least one pickup bar to move said gripper in the Y-and Z-direction;
9 and
10 a rotational assembly to rotate said gripper about the Z-axis.

1 6 A system according to claim 5 further comprising:
2 a first spring loaded device coupled to said rotational assembly to
3 accommodate differences in lateral position between said
4 unloading gripper and said shaped bars; and



5 a second spring loaded device coupled to said unloading gripper to
6 accommodate differences in angle between said unloading gripper
7 and said bar.

1 7 A system according to claim 1 wherein said bar bending system
2 further comprises:

3 at least one bending unit for bending said pre-cut bars to a
4 predetermined shape; and

5 a plurality of bending rails for supporting said bending unit such that
6 said bending unit can move in the X-direction thereon.

1 8 A system according to claim 7 wherein said bar bending system
2 further comprises at least one intermediate support mechanism to
3 give additional support to said pre-cut bar during the bending
4 process.

1 9 A bar bending unit comprising a former assembly, a drive pin
2 assembly and a backup clamp assembly, said former assembly
3 comprising

4 a series of concentric former rings mounted within a former
5 housing, each said ring provided with an actuating mechanism
6 for moving said ring between a standby position and a forming
7 position;

8 a machine controller for controlling said actuating mechanism
9 and to divided said rings are into a first group and a second



10 group, each said group containing zero or more rings, said first
11 group of rings in said forming position co-operating with said
12 drive pin assembly and said backup clamp assembly to shape
13 bars placed thereon, said second group of rings in said standby
14 position withdrawn from the bending process.

1 10 A bar forming assembly comprising a series of concentric former
2 rings mounted within a former housing, each said former ring
3 provided with an former actuator for moving said former ring
4 between a standby position and a forming position; said assembly
5 further comprising a machine controller for controlling said former
6 actuator such that said former rings are divided into a first group
7 and a second group, each said group containing zero or more
8 former rings, said first second group selected to move into a
9 standby position while said second group is selected into the
10 bending position.

1 11 A method of bar bending using an automated bar bending unit
2 comprising :
3 entering information into the machine controller for said unit, said
4 information comprising the size of said bar and at least one
5 prescribed angle of bending;



6 moving a first group of former rings into a forming position using
7 said machine controller, said first group containing zero or more
8 former rings;

9 moving a second group of former rings into a standby position
10 using said machine controller, said second group containing zero
11 or more former rings; and

12 bending said bar into said prescribed angle.

1 12 A method of bar bending using an integrated bending system
2 comprising:

3 feeding said bar into said bending unit;

4 bending said bar into a predetermined shape; and

5 transferring said formed bar to a prescribed location;

6 said method characterised in that said feeding, bending and
7 transferring steps are performed concurrently.