

# Automatic Serpentine Tube Bending Machine

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**Abstract**— The common method used to make a Condenser coil in India is by hand bending where the precision of the bend is dependent on the skill of the worker which is not always reliable as it leads to defects in bends like wrinkling, distortion on inner and outer side of the bends, wrong bend angle etc. We have worked very hard to provide a solution for this problem by designing an Automatic Tube Bending Machine which has negligible errors as compared to its manual counterparts. The machine is divided into 3 main systems which are bending system, feeding system and control system. The Bending system consists of 2 rollers mounted on two servo motors, the feeding system consists of two rollers powered by servo motor to feed the tube into the bending system and the Control System consists of Servo Drive and Programmable Logic Controller.

**Key words:** Bending, Defects, 3 Main Systems, Serpentine Tube, Automatic Bending

## I. INTRODUCTION

A Condenser is a device or unit used to condense a substance from its gaseous to its liquid state, by cooling it. In so doing, the latent heat is given up by the substance, and will transfer to the condenser coolant. [1]

Copper is the ultimate choice for most of the condensers as it is cheap, easy to cut, easy to bend and always offers resistance to oxidation thus it is used in Air Conditioning and Refrigeration systems which has given it the name of ACR (Air conditioning and Refrigeration) Tubing. The condenser tube is long thus needs a proper mechanism to fit due to the space constraints which is done by creating a coil of the tube. The coil can be made by various techniques such as by bending, soldered connections, compression rings. But in the case of a condenser mostly bending is done as minimum pressure drop takes place which in turn increases the efficiency of the condenser. When tubing is bent to a specific shape or geometry, force must be applied so as to exceed the material's 'yield point', which is the material's capability to resist permanent deformation, while staying below the material's 'ultimate tensile strength', which is the limit of the material's ability to resist tearing. As the tube is bent over a specific radius the outside wall will stretch in tension while the inside wall bends under compressive forces. [2]

## II. TYPES OF TUBE BENDING

- 1) Manual
- 2) Semi-automatic
- 3) Automatic

Manual bending involves minimum costs but is not reliable in regards to accuracy and repeatability. Manual bending is usually applied to tubing less than one inch in diameter or cross section. Semi-automatic bending uses machines with

either hydraulic or electric motors providing the bending force. Typically the tube must be manually repositioned before each subsequent bend. Thus repeatability and accuracy may still be an issue. In contrast, PLC or computer numerically controlled machines incorporating servo-drives can accurately control the degree of bend, distances between bends, as well as the plane of the bend. [3]

### A. Machine Is Divided Into Three System

#### 1) Bending System

The bending system should bend the pipe into a condenser coil which has constant curves so as to maintain a constant pressure in the flow of refrigerant through the condenser pipe. This can be only achieved if we design a machine that bends the pipe with precision. The bending system should bend the pipe into a condenser coil which has constant curves so as to maintain a constant pressure in the flow of refrigerant through the condenser pipe. The bending is done with the help of two rollers that are powered by two motors and pipe is feeded between the two rollers. One roller remains stationary whereas the other roller moves along the pipe to bend it in a U shape. This can be only achieved if we design a machine that bends the pipe with precision. We are using servomotor having torque 10Nm. The torque is calculated by considering roller weight, tube material, diameter, bend angle.

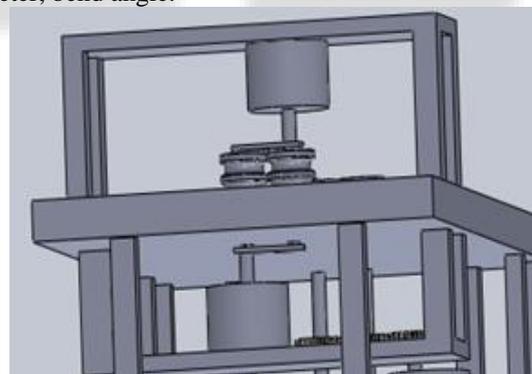


Fig. 1: Bending Mechanism

#### 2) Feeding System

The feeding system of the machine has the function to provide firm and constant feed of pipe to the bending machine. The machine should also have a proper guiding mechanism that guides the pipe accurately towards the bending system.

The feeding mechanism consists of the following parts,

- 1) Two rollers
- 2) Gear
- 3) Bearing
- 4) Servomotor

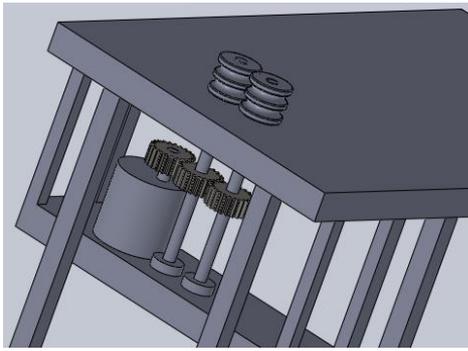


Fig. 2: Feeding Mechanism

### 3) Control System

The Control system should consist of devices that control the feeding and bending systems accurately. The power to the bending system and the feeding system is given by servo motors thus both the systems can be indirectly controlled if we control the servo motor. This is another advantage of servo motor that it can be controlled in various ways according to the function it performs for a particular operation.

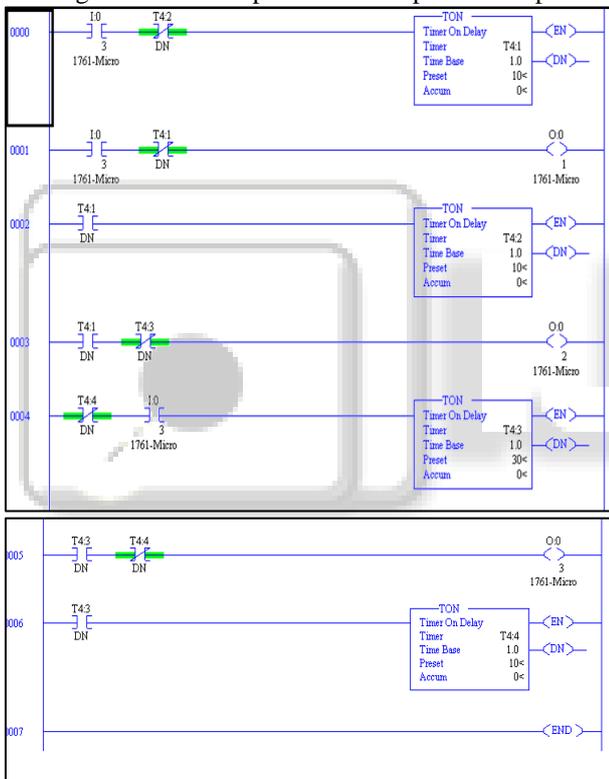


Fig. 3:

Above is the PLC programming ladder diagram that is used for graphical representation of Relay logic.

In both the systems we have to control the angle through which the motor rotates thus we need to control the angle of rotation of the servo motor. We have used Programmable Logic Controller for controlling the rotation of rollers. [4]

When input is given the feeding motor will start for 10 seconds and now when the T4:1 DN bit gets turned on the feeding motor stops.

Now, due to the T4:1 DN bit ON the bending motor starts to run and continues to do so for 10 seconds more.

Then after the completion of bending of the tube, the feeding motor again will be turned ON and continues to do so for 10 seconds more.

Now simultaneously the timer of bending motor (2) continues to count the 10 seconds of feeding motor and 10 seconds bending motor (1), 10 sec of feeding motor. Then after the completion 30 seconds in all the timers T4:3 DN bit gets turned ON and the motor starts.

Along with motor there is another timer T4:4 that is kept ON for 10 seconds more to control the bending motor (2). Now after the completion 10 seconds the motor will stop and it will reset.

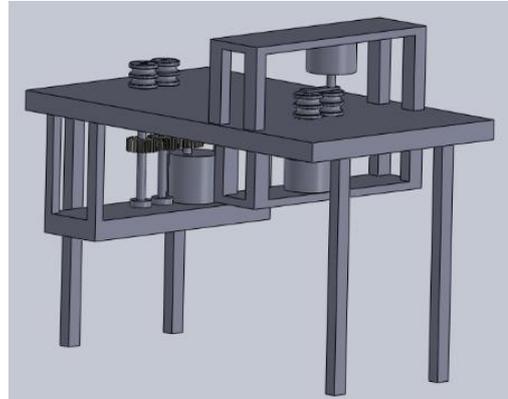


Fig. 5: Machine

### III. APPLICATIONS

The Automatic Tube bending machine can be used to make serpentine coils made of Copper thus it can be used wherever such kind of coils are required such as,

#### A. Air Conditioning and Refrigeration Systems

Copper piping systems are essential in making our built environment comfortable, safe and productive. Its high strength, excellent thermal performance (8 times better than aluminum), superior corrosion resistance and unmatched formability make it the ideal material for heating, ventilating, air-conditioning and refrigeration systems. Copper helps keep us warm in the winter, cool in the summer, keeps our food fresh and safe, and our computers and equipment from overheating year round.

#### B. Medical Gas and Vacuum Transportation

The Automatic and smart system ensures changes in the cycle on the press of the button making the machine more diverse than ever. When we're not feeling our best, or life hangs in the balance, copper piping delivers the necessary medical gases to aid in our treatment and recovery.

#### C. Serpentine Coil Thermal Fluid Heaters

As the heat is transferred by direct radiation only on the inside surface of the helical coil tubes, heat is transferred to the front, sides and back of the serpentine coil. As a result, the serpentine coil design allows for more even heat distribution, less oil degradation, longer tube life and higher operating oil temperature. If your serpentine coils are not bent properly, it is possible to experience too much or too little air flow. When this happens, the equipment that is using the coils could overheat, and the entire area might experience an influx of too much cold or hot air. To avoid this problem, it is imperative to utilize a professional bending machine.

#### D. Grid coil/Air sparger Units

The machine may be used to prepare Grid coils for Heating or cooling units. This level of diversity can only be achieved by smart and automated systems.

#### IV. FUTURE SCOPE

Our machine offers unmatched advantages such as improved precision, indefatigable performance, minimal maintenance, low reliance on skilled labor and reduction in labor costs which will act as a boon for the Industry Sector and thus makes it ideal to the Automatic future we are about to enter. The future scope for our machine is in its integration with an assembly line which will make the full product in minimum time. Assembly lines can be used in various Industries such as Boiler Manufacturing, Evaporative and Condenser tubes for reducing the logistics costs with manufacturing the full product under one roof.

#### V. CONCLUSION

The Paper gives information about condenser tube bending. Also different types of bending used. The components of Automatic tube bending system are explained in this paper. This machine can be used to replace manual bending machine.

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