

Design A System For Twist Angle of Multiple Bend

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I. INTRODUCTION

In the mechanical manufacturing industry, tube bending is very commonly used in processing and its products are widely applied in major industries, such as power plants, aviation, petrochemical industry, and the boiler industry. In bending of tube manufacturing industries they are normally using a Pines CNC machine to bend the tubes. In that machine the tubes with the larger length are not to easily bend in the Multi-plane direction so that we are tend to implement a technique to the bended.

1.1 BENDING

- Bending is a manufacturing process that produces a V-shape, U-shape, or channel shape along a straight axis in ductile materials.
- Tube bending is the umbrella term for metal forming processes used to permanently form pipes or tubing. One must differentiate between form-bound and freeform-bending procedures, as well as between heat supported and cold forming procedures.

1.2 BENDING GEOMETRY:

A tube can be bent in multiple directions and angles. Common simple bends consist of forming elbows, which are bends that range from 2 to 90°, and U-bends, which are 180° bends. More complex geometries include multiple two-dimensional (2D) bends and three-dimensional (3D) bends. A 2D tube has the openings on the same plane; a 3D has openings on different planes.

A two plane bend or compound bend is defined as a compound bend that has a bend in the plan view and a bend in the elevation. When calculating a two plane bend, one must know the bend angle and rotation (dihedral angle).

One side effect of bending the work piece is the wall thickness changes; the wall along the inner radius of the tube becomes thicker and the outer wall becomes thinner. To reduce this tube may be supported internally and or externally to preserve the cross section. Depending on the bend angle,

wall thickness, and bending process the inside of the wall may wrinkle.

1.2.1 BENDING PROCESS:

Tube bending as a process starts with loading a tube into a tube or pipe bender and clamping it into place between two dies, the clamping block and the forming die. The tube is also loosely held by two other dies, the wiper die and the pressure die.

The process of tube bending involves using mechanical force to push stock material pipe or tubing against a die, forcing the pipe or tube to conform to the shape of the die. Often, stock tubing is held firmly in place while the end is rotated and rolled around the die. Other forms of processing including pushing stock through rollers that bend it into a simple curve.^[2] For some tube bending processing, a mandrel is placed inside the tube to prevent collapsing. The tube is held in tension by a wiper die to prevent any creasing during stress. A wiper die is usually made of a softer alloy such as aluminium or brass to avoid scratching or damaging the material being bent.

Much of the tooling is made of hardened steel or tool steel to maintain and prolong the tool's life. However, when there is a concern of scratching or gouging the work piece, a softer material such as aluminium or bronze is utilized. For example, the clamping block, rotating form block and pressure die are often formed from hardened steel because the tubing is not moving past these parts of the machine. The pressure die and the wiping die are formed from aluminium or bronze to maintain the shape and surface of the work piece as it slides by. Pipe bending machines are typically human powered, pneumatic powered, hydraulic assisted, hydraulic driven or electric servomotor.

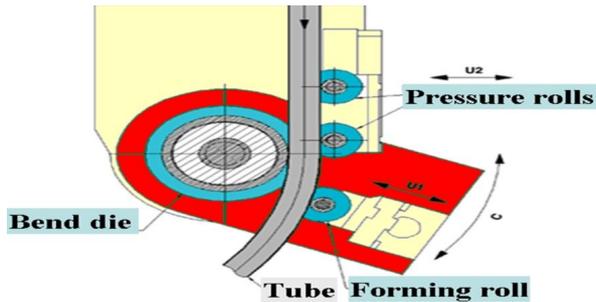


Fig 1.1 Bending process

1.2.2 BENDING TOOLS:

In the case of bending tools they are classified by the kind of generated bends. They can be constructed to adjust the bending angle by reference, stroke measurement or angle measurement.

CNC machines usually abstain from a reference part. They grant a high bending accuracy starting with the first work piece.

1.2.3 STANDARD BENDS:

All bends without an extraordinary geometry belong to standard bends. The distance between a bend and the material end is quite high providing an adequate bearing area. The same with one bend to the next.

Typical tools are a so-called bending former combined with a prisms with electronic angular measurement or an ordinary prism.

1.2.4 U-BENDING

For U-bends where tight and narrow bends are necessary, the bending former is replaced by a bending mandrel. A bending mandrel has a narrow geometry.

1.2.5 OFFSET BENDING

Offset bending tools are used to assemble two bends with a small distance between in one step.

1.2.6 EDGEWISE BENDING

Edge bending tools are used if the bending axis is placed parallel to the tight side of the work piece. Tools for bending on edge may include electronic angular measurement allowing a high bending accuracy.

1.2.7 TORSION BENDING

Torsion tools are able to rotate the work piece on the longitudinal axis. Alternatives are complex assembly groups with standard bends.

1.3 PINES MACHINE:

To meet the demand of the modern tube bender, Pines has designed a new range of CNC tube benders. Pines is the leader in rugged and reliable machinery. The new designs continue these vital benchmarks such as power, precision, speed and improved the performance to provide users with enhanced capabilities to match the demands of the 21st century. Now, Pines has extended the choice specifications and options while improving precision and reliability.



Fig 1.2 CNC Machine

1.3.1 BENDING HEAD

The distance between the bending head's upper and lower bearings is increased by 33%. The change provides greater stability of the bend die when bending heavy wall pipe or exotic material used in aerospace.



Fig 1.3 bending head

1.3.3 HEAVY DUTY BENDING ARMS

Both the swing arm and stationary arms are built from one piece vertical members which are 200% thicker. This reduces the tendency of the arms to bend under heavy clamping pressure providing a stable platform for high clamping forces



Fig 1.4 Bending arms

1.3.4 WIDER ARMS

The stationary arm is 50% wider to provide a more stable platform for pressure die boosting.



Fig1.5 wider arms

1.3.5 RIGID TOOL MOUNT

Reduced the distance from the upper bearing to the center line of the tube by 33%. The change provides additional stability of the bend die when bending heavy wall pipe or exotic material used in aerospace



Fig 1.6 rigid tool mount

III. IDENTIFICATION OF PROBLEMS

In bending of tube manufacturing industries they are normally using a Pines CNC machine to bend the tubes. The major problems in the industries are listed as follows

- More cycle time and inferior quality while doing twist bend in manual mode.
- Manual marking has to be done.
- Bend is not forming at a correct ratio.

- The fitter has to keep on holding pipe during the operation.

IV. PROCESS FLOW DIAGRAM

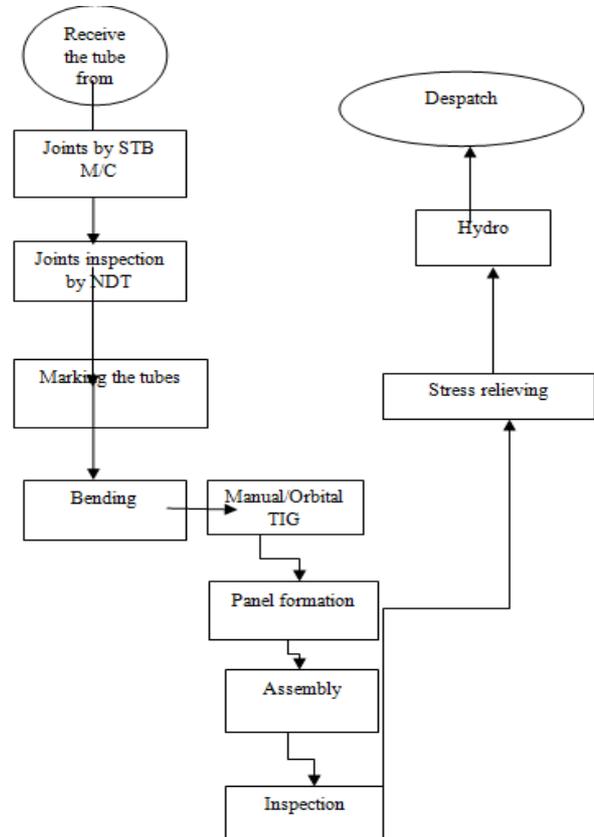


Fig 4.1 Process flow

V. PROBLEM SCENARIO

- In a boiler different types of panels are used which are among most vital requirements.
- For formation of panels among all others, bent tube are used for the panel door opening which are critical in nature from the operational point of view .
- Normally the bends specified are multi plane in nature.
- The execution of such bends with superior quality is a definite requirements as otherwise would involve maximum rework in bend correction & eventually lead to increase in overall cycle time



Fig 5.1 problem scenario

- The PINES tube bending machine used for bending the panel door opening are in general also used for bending of circuits while manufacturing coils in boilers.
- The collect & carriage assembly in the machine, responsible for holding & guiding the tube to the machine is removed to accommodate different length & types of bend like pre offset bends.
- In the absence of collect & carriage the tubes are marked, hold & fed to the machine manually.
- The panel door opening bends are of multi plane in nature, which are when done in manual mode does not yield accurate results.
- As the door opening bends are not accurate so these are made to fit on to the panel by doing HOT correction that consumes maximum time & increase the cycle time considerably in panel formation.

5.1 SEQUENCE OF OPERATIONS IN PINES BENDING MACHINE



Fig 5.2 sequence of operations

5.2 SEQUENCE OF OPERATION FOR MULTI PLANE BENDS



Fig 5.3 Multi plane bends

- All the tubes are marked manually for initial bends.
- After first bend is over, individually tubes are marked for reference line (zero position).
- Tubes are marked for twist (rotation) angle after converting the twist degree to perimeter of the tube into length.
- Takes considerably longer time to complete one full cycle of bending a single tube.
- Quality of bends (multi - plane) are comparatively inferior because of inaccuracy in marketing of twist angle

VI. ANALYSIS OF PROBLEM

The cycle time is increased due to the maximum rework of bent tubes. We are analysed the problem and find out the reason of the problem which are listed as follows

- Due to this problem the fitter has to hold the pipe for a long time.
- This affect the quality and the output of the bending pipes.
- Due to the above factor cycle time is increased and resulted in the rework.

6.1 OBJECTIVE

- Get better bend quality
- Minimise rework
- Improved out put
- Cycle time reduction in panel formation

VII. IDENTIFICATION OF CAUSES

7.1 FINDING THE CAUSE MAN

Table 7.1 cause man

CAUSES	VALIDATION	REASONS
Training	Invalid	Imparted with theory and practical training
Lack of skill	Invalid	Experienced wore force
Man power shortage	Invalid	Adequate man power
Fatigue	Valid	Marking manually each tube difficult
Carelessness	Invalid	Very responsible

7.2 FINDING THE CAUSE MACHINE

Table 7.2 the cause machine

CAUSES	VALIDATION	REASONS
No collet and carriage assembly	Valid	Manually marking the tubes for reference
Operating in manual mode	valid	Absence of collet and carriage assembly
No tube removal mechanism	invalid	Newly installed
Machine break down	invalid	Preventive maintenance done regularly

7.3 FINDING THE CAUSE METHOD

Table 7.3 the cause method

CAUSES	VALIDATION	REASONS
Tube removal	invalid	Tube removal mechanism installed
Tube handling	Invalid	Manual handling of more tubes are tiresome
Manual marking of tubes	Valid	Machine works in manual mode only
Excess remarking	Valid	For twist the dimension is calculated and marked

7.4 FINDING THE CAUSE MATERIAL.

Table 7.4 the cause material

CAUSES	VALIDATION	REASONS
Material segregation	Invalid	Tubes of different lengths mixed together
Bent tube	Invalid	Tubes are straightened and bent after
Higher tube wall thickness	Invalid	Handling becomes difficult
Excessive tube length	invalid	Handling becomes difficult for lengthy tubes

VIII. DEVELOPMENT OF SOLUTION

In house developments of fixture for holding the tube while doing twist bend

8.1 SELECTION OF ALTERNATIVES

Table 8.1 selection of alternatives

SN	ALTERNATE	OUTCOME
1	One extra man power can be added for marking only	No, that will be a wastage of man power
2	Can ask the maintenance to install the collect & carriage system once again	That will be time consuming & for doing other offset bend, the unit has to be removed again.
3	Can make one movable fixture with a dial to hold & rotate the tube doing twist bend	Oh! That's a better idea. We shall try this.

8.2 EXISTING M/C LAY OUT



Fig 8.1 existing m/c lay out

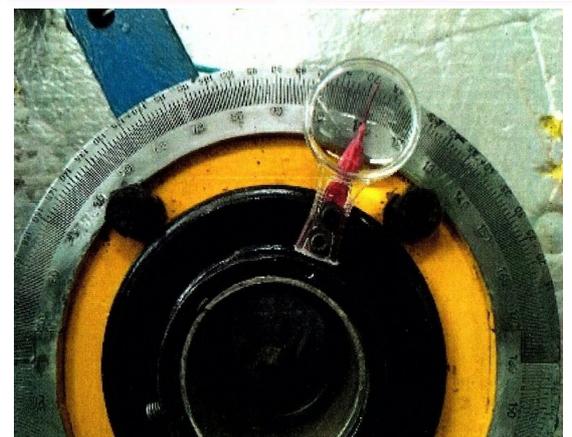
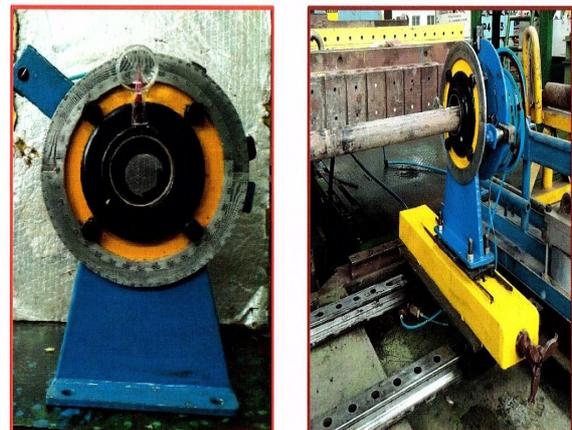
IX. FORESEEING PROBABLE RESISTANCE

9.1 FABRICATION UNDER PROGRESS



Fig 9.1 fabrication under progress

9.2 FABRICATION UNDER PROGRESS



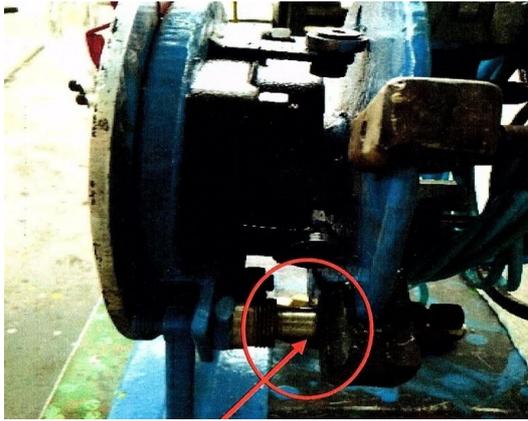


Fig 9.2 spring loaded & 360 degree graduated dial

9.3 INNOVATED MECHANISM IN ASSEMBLED POSITION



Fig 9.3 assembled position

X. 3D DIAGRAM

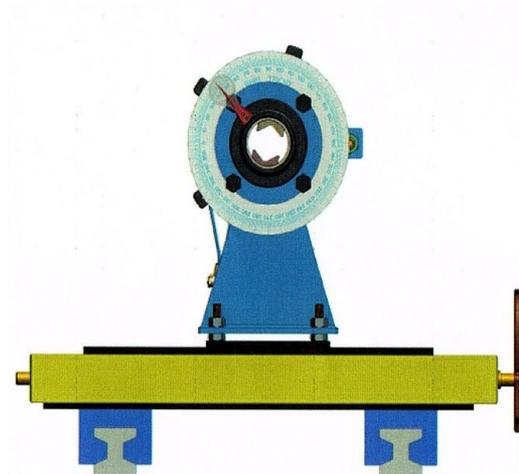
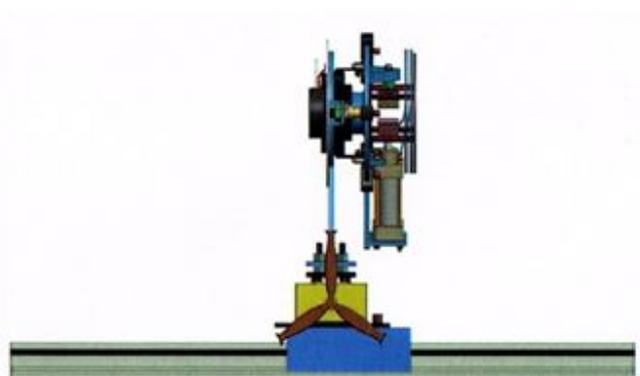
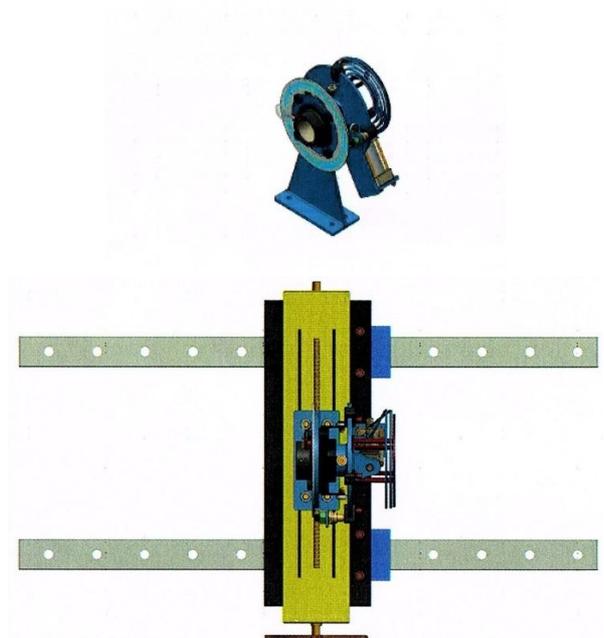


Fig 10.1 3D diagram

10.1 EXPLODED VIEW



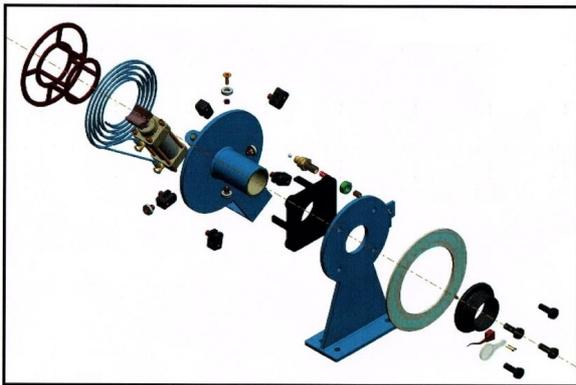
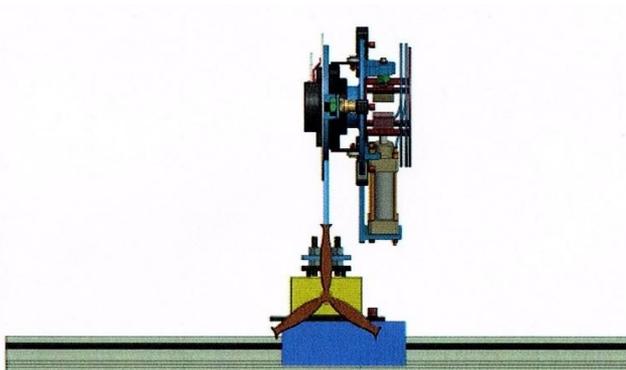


Fig 10.2 exploded view

Table 10.1 probable resistance & remedial action

S.NO	PROBABLE RESISTANCE	REMEDIAL ACTION
1	Safety may be a concern while modifying the existing arrangement of the machine	Safety is one of the main objective while designing the mechanism
2	May affect normal operation of the bending machine	The facility is made removable type so that can be removal as and when required
3	New facility may be of more complicated operation	Very simple operation is planned with help of available pneumatic system

XI. COMPARISON



11.1 IMPROVEMENTS IN BENDING MACHINE

BEFORE	AFTER
<ul style="list-style-type: none"> ▪ Tubes were remarked for reference ▪ Individually tubes were marked for twist angle ▪ Handled manually to the position ▪ No accuracy ▪ Low out put 	<ul style="list-style-type: none"> ▪ Reference marking %twist angle marking totally eliminated ▪ Tube is rotated directly to the required twist ▪ High value of accuracy ▪ Enhanced out put

Table 11.1 IMPROVEMENTS IN BENDING MACHINE

XII. RESULT

Due to the development of the new system for the twist angle bend by implementing the house development fixtures for holding the tube while doing twist bend. The cycle time has reduced by 61.27%. Due to reduce in the cycle time has increased the productivity in the unit.

The system developed for twist bend has reduced the rework and remarking on the tube so that work on the tube done properly without any damage.

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