Design And Analysis Of Portable Rolling And Bending Machine Using CAD And FEA Tool

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Abstract

Portable Rolling and Bending machine is device which gives the less efforts of man and gives the required work properly of the construction and other metal fabricated areas. The large C-clamp mount attaches to work surfaces up to 2" thick; a rubber base pad protects the mounting surface. The orientation of the jaws is adjusted by a single clamping bar mechanism to provide quick repositioning of the work. Instrument makers will find many uses for this versatile vice. This machine work smoothly and gives proper dimension of the required jobs. Its one end having metal bending and rolling device & another end having Bench vice which is rotating about its Axis and hold work piece at any angle. The base plate is rotating of an angle 360 about its central Axis. This machine is used for heavy duty metals which are used in construction areas and multiple operations are performing on it. It is light in weight and portable attach to any work table in Industries, Workshop and Construction areas.

Keywords: *C-clamp attachment, Bending Device, Rolling Die, Rotating Vice.*

I. INTRODUCTION

Due to the globalization, it is very much essential for the manufacturer to produce a goods having highest possible reliability. Metal Bending and Rolling is extensively used in fabrication as an alternative method for casting or forging and as a replacement for a bolted and riveted joint. Since it is related to human being, it is necessary to design and analysis the joint with prior attention to safely of its user. Bending is a manufacturing process that produces a V-shape, U-shape, or channel shape along a straight axis in ductile materials, most commonly sheet metal.

In engineering mechanics, bending (also known as flexure) characterizes the behavior of a slender structural element subjected to an external load applied perpendicularly to a longitudinal axis of the element.

The structural element is assumed to be such that at least one of its dimensions is a small fraction, typically 1/10 or less, of the other two. When the length is considerably longer than the width and the thickness, the element is called a beam. For example, a closet rod sagging under the weight of clothes on clothes hangers is an example of a beam experiencing bending. On the other hand, a shell is a structure of any geometric form where the Length and the width are of the same order of magnitude but the thickness of the structure (known as the 'wall') is considerably smaller. A large diameter, but thin-walled, short tube supported at its ends and loaded laterally is an example of a shell experiencing bending. In the absence of a qualifier, the term bending is ambiguous because bending can occur locally in all objects. To make the usage of the term more precise, engineers refer to the bending of rods, the bending of beams, the bending of plates, the bending of shells and so on.

Fig.1 Bending of an I-beam

A better approach to the prediction of welding deformation is using the combined technologies of experiments with numerical calculation. With modern computing facilities, the Finite Element (FE) technique has become an effective method for prediction and assessment of Bending residual stress and distortions various factors, the quantitative prediction and the control of Bending deformation especially for a large and complex welded structure is extremely difficult.

II. BRIEF OVERVIEW OF SOME RESEARCH

As there are lot of work is done in Bending, very little work is done in relevant field of a bending and rolling of a metal rods and plate. A brief review of some selected references on the strength of bending stress, distortions of plate, strength of bending plates and rods.

A Joseph et. al. have suggested that dissimilar metal pieces between different materials are widely used in steam generator of power plant. Failure analysis carried out on a dissimilar bend joint, a residual stresses in the bend joints are one of the main factor which causes failure in dissimilar bend joint. Residual stress profiles across these bend joints were determined by X –ray diffraction technique. The failures are generally attributed to one or more of the following causes 1.Difference in mechanical properties across the bend joint and coefficient of thermal expansion of two materials. 2. Residual stresses present in the bend joint. 3. Service condition and others. A successful bend between dissimilar metal is one that is as strong as the weaker of the two metal being joined with sufficient tensile strength so that joint will not fail.

Chien-Yuan Hou has suggested that Fatigue analysis of bend joints usually assumes bend toes of _mathematically perfect‘geometry for the required bend toe stress state. However, the weld toe geometry certainly cannot be defined by simple mathematical functions. In that, the three-dimensional laser scanning technology used to preserve the real geometry of welded specimens. Finite element models of the specimens were then constructed with the scanned results. Linear elastic finite element analyses were then carried out to estimate the stress concentration factors along the weld direction of each specimen.

Hyungyil Lee el.al. have presented that the mechanical behavior of a spot-welded specimen is generally approached in angles of overload and fatigue failures. Fatigue failure of spot-welded specimens can be dealt with a fracture parameter, since a spot-weld forms a singular geometry of external crack type. He expresses the limit loads in terms of base metal yield strength and specimen geometries. While spot-welding is generally used in the form of multi-spots, the fatigue strength of a multi spot-welded structure is eventually determined by the fatigue strength of each single spot-weld. Spot weld boundary is subjected to combined tension, bending and shear, therefore problem becomes an intrinsically there dimensional one. Wang and Ewing described the effect of material, shape, and radius of the nugget, width and thickness of the specimen.

M. Xiea,∗, J.C. Chapman have suggested that Friction-bend bar–plate connections are a basic structural component of Bi-Steel steel–concrete–steel sandwich construction. In Bi-Steel members, the bar–plate connections, embedded in concrete, are subject to tension, shear and bending. They describes experimental and numerical studies on the static and fatigue strength of the friction- bended connections with the bar loaded in tension. Finite element analysis is carried out to examine the effects of plate thickness, the collar (flash) formed after friction bending, and possible initial defects or fatigue induced cracks. It is found that except for 6 mm plate specimens, the static tensile capacity of the embedded connections is governed by the tensile strength of the bar connectors. In the fatigue tests, single fracture and double fracture mechanisms were observed.

III. QUASISTATIC BENDING OF BEAMS

A beam deforms and stresses develop inside it when a transverse load is applied on it. In the quasistatic case, the amount of bending deflection and the stresses that develop are assumed not to change over time. In a horizontal beam supported at the ends and loaded downwards in the middle, the material at the over-side of the beam is compressed while the material at the underside is stretched. There are two forms of internal stresses caused by lateral loads:

- Shear stress parallel to the lateral loading plus complementary shear stress on planes perpendicular to the load direction;
- Direct compressive stress in the upper region of the beam, and direct tensile stress in the lower region of the beam.

These last two forces form a couple or moment as they are equal in magnitude and opposite in direction. This bending moment resists the sagging deformation characteristic of a beam experiencing bending. The stress distribution in a beam can be predicted quite accurately even when some simplifying assumptions are used.

IV. EULER-BERNOULLI BENDING THEORY

In the Euler-Bernoulli theory of slender beams, a major assumption is that 'plane sections remain plane'. In other words, any deformation due to shear across the section is not accounted for (no shear deformation). Also, this linear distribution is only applicable if the maximum stress is less than the yield stress of the material. For stresses that exceed yield, refer to article plastic bending. At yield, the maximum stress experienced in the section (at the furthest points from the neutral axis of the beam) is defined as the flexural strength. Compressive and tensile forces develop in the direction of the beam axis under bending loads. These forces induce stresses on the beam. The maximum compressive stress is found at the uppermost edge of the beam while the maximum tensile stress is located at the lower edge of the beam.

Since the stresses between these two opposing maxima vary linearly, there therefore exists a point on the linear path between them where there is no bending stress. The locus of these points is the neutral axis. Because of this area with no stress and the adjacent areas with low stress, using uniform cross section beams in bending is not a particularly efficient means of supporting a load as it does not use the full capacity of the beam until it is on the brink of collapse. Wide-flange beams (I-beams) and truss girders effectively address this inefficiency as they minimize the amount of material in this under-stressed region.

The classic formula for determining the bending stress in a beam under simple bending is:

$$\sigma = \frac{My}{Ix}$$

Where,

- σ is the bending stress.
- M is the moment about the neutral axis .
- y is the perpendicular distance to the neutral axis .
- I_x is the moment of inertia about the neutral axis x.

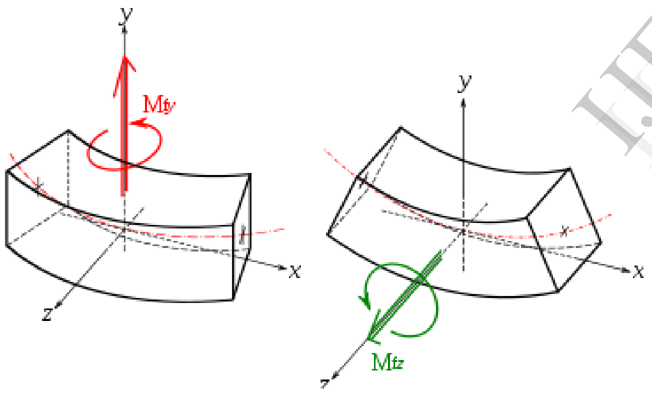
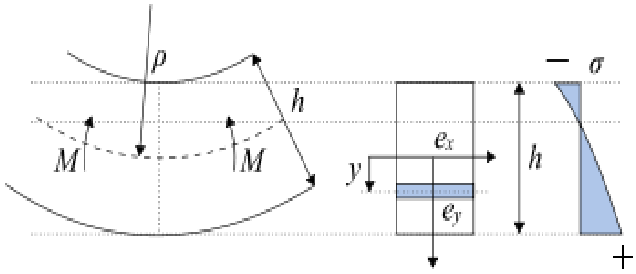


Fig. 2 Bending moments in a beam

V. LARGE BENDING DEFORMATION

For large deformations of the body, the stress in the cross-section is calculated using an extended version of this formula. First the following assumptions must be made:

1. Assumption of flat sections - before and after deformation the considered section of body remains flat (i.e., is not swirled).
2. Shear and normal stresses in this section that are perpendicular to the normal vector of cross section have no influence on normal stresses that are parallel to this section.



Large bending considerations should be implemented when the bending radius R is smaller than ten section heights h:

$$R < 10h$$

With those assumptions the stress in large bending is calculated as:

$$\sigma = \frac{F}{A} + \frac{M}{\rho A} + \frac{M}{I_x{}'} y \frac{\rho}{\rho + y}$$

VI. ROLL BENDING

Roll forming, roll bending or plate rolling is a continuous bending operation in which a long strip of metal (typically coiled steel) is passed through consecutive sets of rolls, or stands, each performing only an incremental part of the bend, until the desired cross-section profile is obtained. Roll forming is ideal for producing parts with long lengths or in large quantities. There are 3 main processes: 4 rollers, 3 rollers and 2 rollers, each of which has as different advantages according to the desired specifications of the output plate.

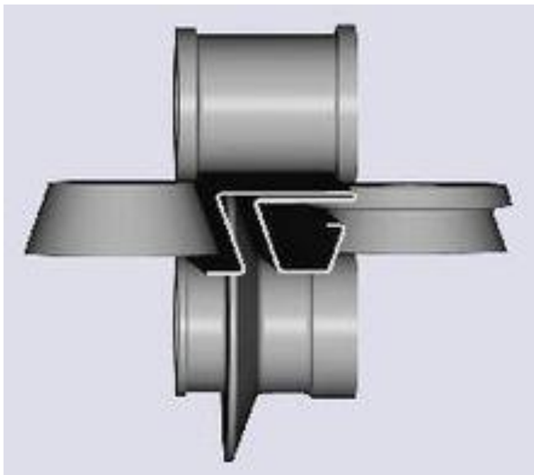


Fig. 3 Roll Bending

Flat rolling is the most basic form of rolling with the starting and ending material having a rectangular cross-section. The material is fed in between two rollers, called working rolls, that rotate in opposite directions. The gap between the two rolls is less than the thickness of the starting material, which causes it to deform. The decrease in material thickness causes the material to elongate. The friction at the interface between the material and the rolls causes the material to be pushed through.

VII. PROBLEM DEFINITION

- The present portable machines have taken only one operation on it.
- Machinery having multiple works is not portable for constructive areas.
- These machines are unable to slides over the work table.

As many constructive areas men are not using proper machine which give the uniformity in their work. They used the harming tool which will not give the proper stress on the work piece and their work is lose, fatigue occurs many thing which not seen they will impact on performance of tool equipments. Therefore portable machines have more advantages as compared to the other machines.

VIII. WORKING PRINCIPLE

The tools are safe and easy to use and they do not require any heat or electrical power. All functions are carried out by hand power and are designed for beginners and professionals alike to work with metal without having to heat it up. The Bending function is a useful tool for shaping all manner of components out of flat strip, square bar and round wire in a production environment. For the Bending operation, material is placed between the square or diamond shaped former and the side rollers. Operate the lever to gradually bend to required angle.

Fig. 4 Diagram of portable Rolling machine

This machine is attached to any work table or a flat surface. It is easy to handle and comfortable to work.

Fig. 5 Diagram of portable bending machine

IX. PROCESS OF PORTABLE MACHINE

The Bending function is a useful tool for shaping all manner of components out of flat strip, square bar and round wire in a production environment.

For the Bending operation, material is placed between the square or diamond shaped former and the side rollers. Operate the lever to gradually bend to required angle.

Fig. 6 Diagram of bending process

The Rolling facility enables circles and arcs of varying radii to be easily and consistently rolled without the need for pre-heating of the materials.

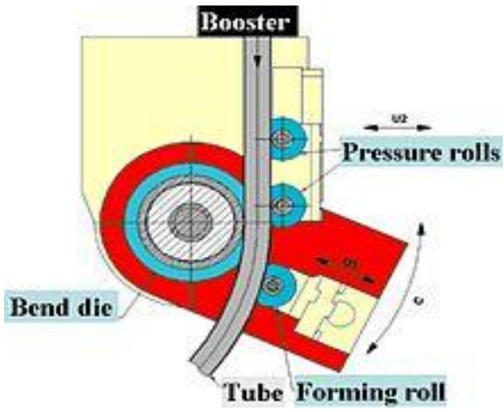
Rolling is achieved by using the winding handle to drive the bar forwards and backwards through the rollers. As this is done with each pass, the long lever is used to gradually increase pressure to roll and ever tighter curve.

Fig. 7 Rolling Process using portable machine

X. THREE-ROLL PUSH BENDING

The *Three-Roll Push Bending* (TRPB) is the most commonly used freeform-bending process to manufacture bending geometries consisting of several plane bending curves. Nevertheless, a 3D-shaping is possible. The profile is guided between bending-roll and supporting-roll(s), while being pushed through the tools. The position of the forming-roll defines the bending radius. The bending point is the tangent-point between tube and bending-roll. To change the bending plane, the pusher rotates the tube around its longitudinal axis. Generally, a TRPB tool kit can be applied on a conventional rotary draw bending machine.

The process is very flexible since with a unique tool set, several bending radii values Rm can be obtained, although the geometrical precision of the process is not comparable to rotary draw bending. Bending contours defined as spline- or polynomial-functions can be manufactured.



XI. CALCULATIONS

Many variations of these formulas exist and are readily available online. These variations may often seem to be at odds with one another, but they are invariably the same formulas simplified or combined. What is presented here are the unsimplified formulas. All formulas use the following keys:

- BA = bend allowance
- BD = bend deduction
- R = inside bend radius
- K = K-Factor, which is t / T
- T = material thickness
- t = distance from inside face to the neutral line.
- A = bend angle in degrees (the angle through which the material is bend)

The *neutral line* (also called the *neutral axis*) is an imaginary line that can be drawn through the cross-section of the work piece that represents the lack of any internal forces. Its location in the material is a function of the forces used to form the part and the material yield and tensile strengths. In the bend region, the material between the neutral line and the inside radius will be under compression during the bend. The material between the neutral line and the outside radius will be under tension during the bend.

Both bend deduction and bend allowance represent the difference between the neutral line or unbent *flat pattern* (the required length of the material prior to bending) and the formed bend. Subtracting them from the combined length of both flanges gives the flat pattern length. The question of which formula to use is determined by the dimensioning method used to define the flanges as shown in the two diagrams below.

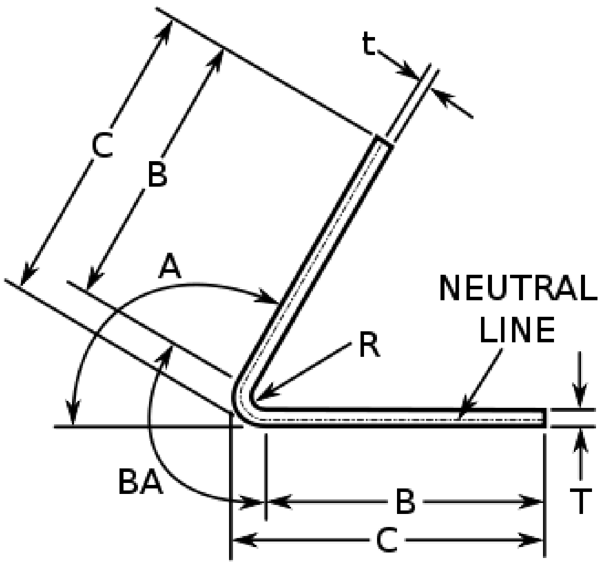


Fig. 8 Diagram showing standard dimensioning scheme when using Bend Allowance formulas. Note that when dimensions "C" are specified, dimension B = C - R – T

Where,

$$BA = A\left(\frac{\pi}{180}\right)(R + K \times T)$$

Example: Angle 90 , PI 3.142, Radius 1.5, K-Factor 0.33, Thickness 6, Therefore, Bend allowance 5.46708

XII. C-CLAMP ATTACHMENT

In C- Clamp Attachments, clamping beams hold the longer side of the sheet. The beam rises and folds the sheet around a bend profile. The bend beam can move the sheet up or down, permitting the fabricating of parts with positive and negative bend angles. The resulting bend angle is influenced by the folding angle of the beam, tool geometry, and material properties. Large sheets can be handled in this process, making the operation easily automated. There is little risk of surface damage to the sheet.

In wiping, the longest end of the sheet is clamped, then the tool moves up and down, bending the sheet around the bend profile. Though faster than folding, wiping has a higher risk of producing scratches or otherwise damaging the sheet, because the tool is moving over the sheet surface. The risk increases if sharp angles are being produced. Wiping on press brakes involves special tools.

XIII. CAD MODELING OF PORTABLE ROLLING AND BENDING MACHINE

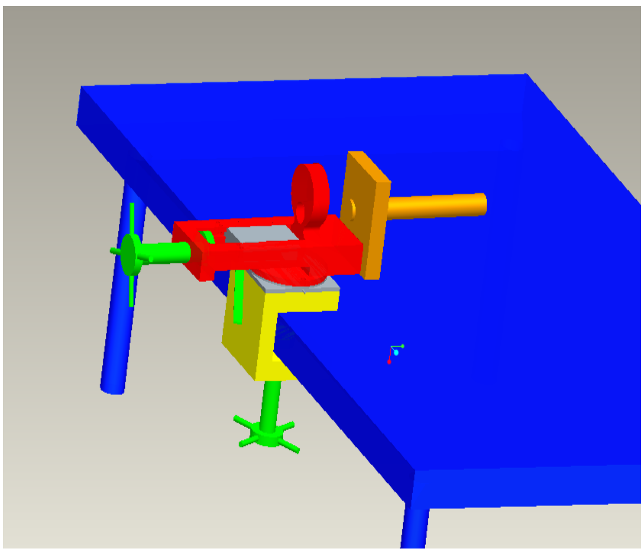


Fig. 9 Cad Model of portable machine

XIV. ROTATING VICE

The jaws are made of soft or hard metal. The vise is bolted onto the top surface of the bench with the face of the fixed jaws just forward of the front edge of the bench. The nut in which the screw turns may be split so that, by means of a lever, it can be removed from the screw and the screw and moveable jaw quickly slid into a suitable position at which point the nut is again closed onto the screw. This vice is attach at the another end of the portable machine therefore with the help of one machine we can do multiple operation on the metal pieces

Fig. 10 Diagram of Rotating Vice

XV. APPLICATION

1. As many constructive areas men are not using proper machine which give the uniformity in their work.

2. They used the harming tool which will not give the proper stress on the work piece and their work is lose, fatigue occurs many thing which not seen they will impact on performance of tool equipments.

3. Therefore portable machines have more advantages as compared to the other machines.

4. Material sheet thickness varies from 1/32 to ½ in with length from 6 in to 20 ft. Ductile materials are best suited for the pressing like aluminum, mild steel and new plastic materials.

5. Bending is a cost effective process when used for low to medium quantities, because it does not require significant amounts of tooling.

6. With the help of this one portable machine we can do multiple works on any type of the part or work pieces in the constructional areas.

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