When is a mandrel necessary?

When a tube is bent the outside wall collapses and thins out, and the inside compresses. When bending thin wall tube to tight radius a mandrel and wiper die are necessary. Use of a mandrel minimizes the amount of ovality occurring during bending.

Machine and tooling basics

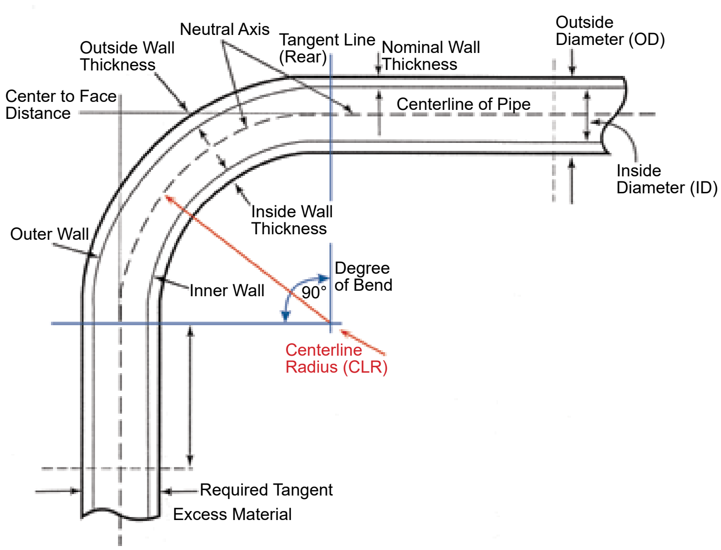
Machine capacity and features will vary based on application and production requirements. Ercolina produces both NC and CNC machines designed to accommodate job shop to moderate production applications. The correct selection of machine model, tooling and material will ensure success in bending, There are many factors to consider with selecting tooling. Generally parts with several bends or higher quantity may require a CNC machine. Parts with one centerline radius are the easiest to accommodate. Always encourage designer of the parts to use a single bend radius when possible. Most applications can modify the radius with little effect on the overall part design and make the bending process more productive. Using the largest possible radius will closely maintain shape of the material after the bend. Ideally mandrel bending to radius 2-3 times material diameter will yield the best results. Ercolina standard tooling sets are available in 2D and radius is base centerline radius (CLR).

Information required for mandrel tooling applications

- Size and wall thickness of material
- Material type and grade
- Number of bends on part
- Distance between bends
- Plane of bend relationship to one another
- Production rates
- Part tolerances
- Centerline radius of the bends. ***Note:*** bends with radius less than 2 times OD require greater attention, high grade bendable materials and heavier machine design.

Understanding material to be bent

Bending application success is dependent on several factors including and most importantly the proper material. Obtain a print of work to be done, review dimensions and tolerances. Review the mill certification for material from the mill and confirm the material is appropriate for bending. Use caliper to measure material and confirm dimensions are correct for tooling. Tube OD and wall thickness variations are far more common than you may realize. For some tube fabricating applications, this variation is of little concern, but in mandrel bending, ID dimension variation is a big issue. The tubing must fit the tooling and mandrel correctly and have the appropriate clearances. ***Note:*** tubing with no or minimal internal seam is preferred with mandrel bending. Material with heavy weld seam will interfere with mandrel and require tooling modification. Different types of material can be bent i.e., steel, aluminum, and stainless however the tooling composition and CLR may change to ensure material compatibility. Pay attention to material ordered and confirm it's received as ordered.



Terminology

Bend Specifications

OD is tube outside diameter, usually measured in inches or millimeters. Sometimes the tube outside diameter is expressed in nominal, such as IPS for pipe. Only rarely is a tube diameter specified as an inside diameter. This is non-standard, leads to confusion, and should be avoided. Whatever units are used, OD should be expressed in decimal, to three places in the case of inches.

WT is wall thickness. Inches and millimeters are common units, and again the precision of a decimal number to three places is warranted if inches are used; at least one place for millimeters. Frequently, the old Birmingham Wire Gage Standard is used to express WT; be sure to use the correct gage (there are several standards) when translating to decimal inches. When the Tube OD is expressed as an IPS nominal size, then the WT is expressed as a schedule number, which corresponds to a precise value in inches.

CLR is centerline radius and is the most common reference for bend radius. Again, inches and millimeters are the common units of measurement. Typically, fractional or two-place decimal inches are sufficiently precise. Sometimes the CLR is expressed as a multiple of the Tube OD, such as “1-D”, “2-D”, and so on. Note that if the Tube OD is expressed as an IPS nominal size and the CLR is expressed as a “D”, it is a multiple of the nominal, not the actual tube diameter. Inside radius, abbreviated “ISR”, is a common reference for specifying bend radius if the tubing is non-round. Outside radius is seldom used to define the bend radius.

DOB is degree of bend, often loosely referred to as the sweep of bend or depth of bend. This defines in decimal degrees (occasionally degrees and minutes) the arc of the bend. This is, of course, different from “plane of bend” or “orientation”, a specification for multi-bend parts which defines in degrees where the plane of the current bend is located relative to the plane of the first bend.

In defining multi-bend parts, XYZ rectangular coordinates are used, from which bend data are developed. Bend data consist of tangent length, plane of bend, and degree of bend and defines the motion of the tube during the bending process.

Geometry

All bent parts consist of arcs and tangents. The arc is simply the bent portion of the tube, and the tangent the unbent portion.

Inside radius (ISR) and outside radius (OSR) are nominal references defining the extreme inner and outer limits of the tube arc. The centerline radius (CLR) is, of course, the average of these two.

Plane of bend is the plane defined by the inside and outside radii.

Line of tangency is actually a plane, perpendicular to the plane of bend, passing through the origin of the bend and the beginning point of the bend (in other words, it separates the arc of the bend from the tangent section). Before the line of tangency, the tube is straight. Past the line of tangency, it is bent. In draw bending, the line of tangency is fixed in space, through which the tube is drawn around the bend die as it rotates.

Neutral axis vs. centerline radius. It happens that the neutral axis is physically close to the centerline radius, but these terms are not synonymous. The neutral axis is a narrow region, lying inside of the centerline radius, separating the zone of compression from the zone of stretching. At the neutral axis the tube wall neither compresses nor stretches.

Intrados vs. inside radius. The intrados is the zone of compression, bounded by the inside radius and the neutral axis.

Extrados vs. outside radius. The extrados is the zone of stretching, bounded by the outside radius and the neutral axis.