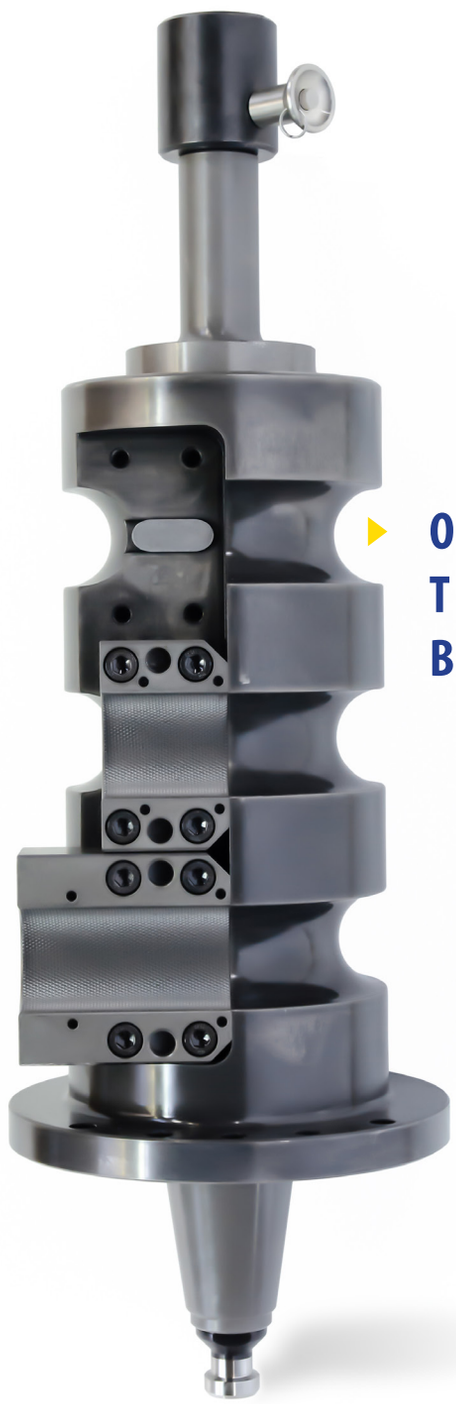
OMNI-X

WORLDWIDE LEADER IN TUBE BENDING TECHNOLOGY



OMNI-X GUIDE TO ROTARY DRAW BENDING

rotary draw bending ○ bending tools ○ mandrels ○ wiper dies ○ end forming tools

"We have set high expectations for ourselves and believe you should have high expectations of your tooling supplier. For almost 30 years we have met or exceeded these expectations and you have helped us become the largest manufacturer of tube bending tools and global leader in value, innovation, unbeatable lead times and superior customer service in our industry. Thank you for making us your global partner of choice."

CONTENT

HISTORY

Rotary draw tube bending has come a long way since the days of crude manual tube bending machines bending tube with tools and dies made from wood. Technological advancements in machines, tools and materials have enabled many companies to switch from expensive welding of tubular assemblies to the more cost efficient tube bending process.

In the past, the bending of tube on a center line radius of less than 2D (2 times the diameter of the tube) was very difficult at best, and thus discouraged many companies from bending their tubes and opting for welding. With today's technology, 1D (1 times the diameter of the tube) bends are common and even bends below 1D are possible. Another obstacle to bending was the inability to make tooling that was capable of making compound and complex compound bends. With today's CNC machining capabilities and CAD/CAM technology, simple and complex compound tooling can be accurately manufactured at a cost which is no longer prohibitive.

Standard mandrel <

OMNI-X

BASICS

OF ROTARY DRAW BENDING

When a tube is bent, basically two things happen. The outside wall of the tube collapses and thins out, and the inside of the tube compresses and wrinkles. The minimum tool requirements for rotary draw bending are the bend die (around which the tube is bent), clamp die and pressure die (which holds the tube in place as it bends around the bend die). Satisfactory bends can be achieved using this minimal tooling when bending pipe or tubing with a heavy wall or a large centerline radius. When bending light wall or thin wall tube the use of a mandrel and wiper die are necessary in making a nice bend. The mandrel minimizes the amount of collapse that will occur on the tube and the wiper die eliminates wrinkles on the inside radius of the tube.

It is important to keep in mind that the tooling is every bit as important as the actual bending machine. In most instances it is the tooling that will make or break a bend thus it is imperative to pay as much attention to detail when buying tooling as it is when buying a machine. Mixing and matching tooling or using inferior quality tooling will not pay off in the long run. Inferior tooling will wear out prematurely and may crack or break. Mixed and matched tooling also will not produce the quality bends that are expected from a set of tools built specifically as a set.

When buying tooling it is best to buy the bend die, clamp die, and pressure die at the same time to avoid any mismatching of the tube groove and ensuring that the dies fit into each other properly. When tools don't match up properly your bends will not be consistent and damage to the outside of the tube will occur.

Another important aspect to making good bends is lubrication. Lubrication comes in several different forms such as oil, grease, and paste. The kind of lubrication used will depend on the material of the tube to be bent. A generous amount of lubrication may be applied to the mandrel and the inside of the tube, however precautions should be taken to avoid getting any lubrication on the bend die and clamp die. The amount applied will determine whether or not a good bend is made."

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<<<< *1-ball mandrel*
<<< *3-ball mandrel*
<< *Plug mandrel*
< *Formed-end plug mandrel*

COMPONENTS OF ROTARY DRAW BENDING

BEND DIE

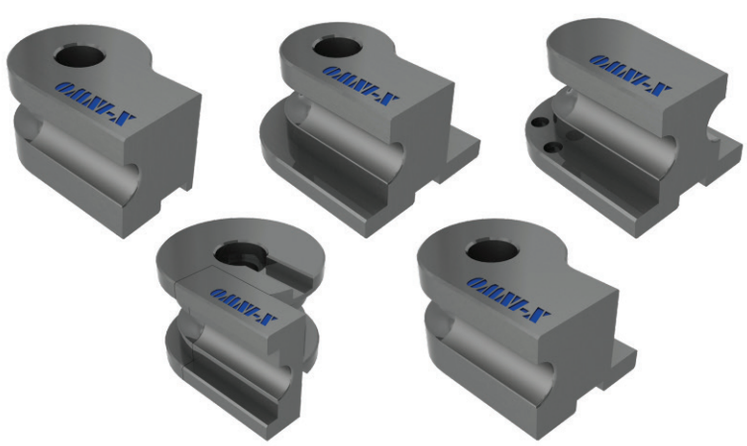
COMPONENTS

OF ROTARY DRAW BENDING

BEND DIE

When a tube is bent, basically two things happen. The outside wall of the tube collapses and thins out and the inside of the tube compresses and wrinkles. The minimum tool requirements for rotary draw bending are the bend die (around which the tube is bent), clamp die (which holds the tube in place as it bends around the bend die) and pressure die (second part of keeping the tube in place as it bends). Satisfactory bends can be achieved using this minimal tooling when bending pipe or tubing with a heavy wall or a large centerline radius. When bending light wall or thin wall tubes the use of a mandrel and wiper die are necessary to make a nice bend. The mandrel minimizes the amount of collapse that will occur on the tube and the wiper die eliminates wrinkles on the inside radius of the tube.

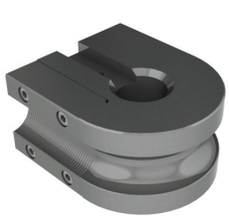
One Piece *Platform* *Flange*



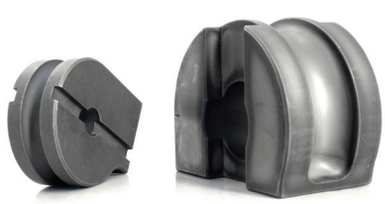
Spool *Partial Platform*

When choosing a bend die it is also important to consider whether the application will need precision tooling or standard to be consistent tooling. If you are bending standard to heavy walled pipe a standard, less costly set of tools will suffice. If on the other hand you are bending cosmetic, aerospace, thin walled tubing you may want to use a precision reverse interlock set of tools.

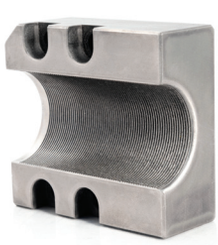
In addition to the different styles of bend dies, it is also important to choose the right grip length and grip surface of the die. The grip surface will depend on the application and is available with a sand-blasted, carbide sprayed, knurled or a serrated finish.



> One Piece



One Piece <



Gripping section with serration <

GRIPPING SECTION

COMPONENTS

OF ROTARY DRAW BENDING

GRIPPING SECTION

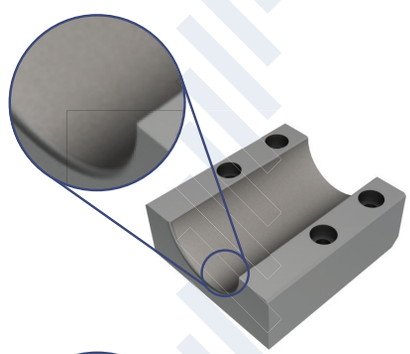
The length of the gripping part of the bend die is dependent on the parameters of the tube and usually has a special surface treatment to help in gripping the tube during the bend. This part is often made separately and attached to the bend die.
The surface of the clamp has a significant influence on the functioning of the tools.

SMOOTH SURFACE

The least useful, but sometimes necessary variant from a construction perspective, is a groove with no surface treatment. This variant is used in applications where it is necessary to take care of the visual quality of the surface of tube. The disadvantage of this is the need to use long clamps so that there are no markings on the pipe from gripping. This option is used in furniture making, for example.

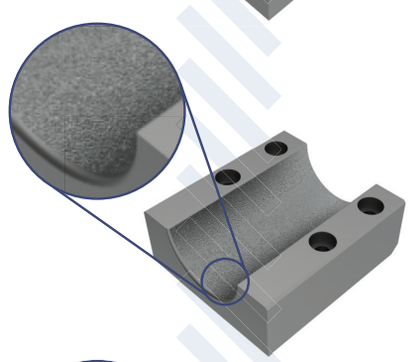
GRIT BLASTED

This treatment is a gentle roughing of the functional surface of the clamp. Compared to the smooth surface, this method doesn't particularly affect the length of the clamps. While we don't need to extend the clamps, we can't shorten them either. The advantage of grit blasted clamps are that they do not lower the quality of the outer surface of the tubes after gripping.



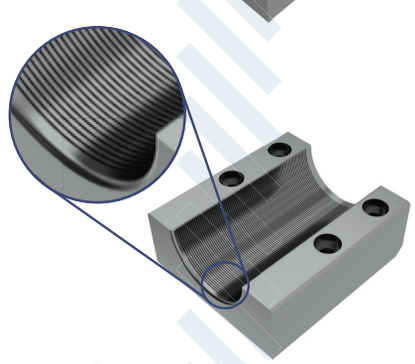
SURFALLOY

Another way we can treat the surface of the groove, with a carbide- based electric arc spray. This allows us to achieve a greater roughness and also to reduce the diameter of the clamp by 0.1 to 0.2 mm. That's why we recommend producing the diameter of the groove at the nominal diameter of the tube. This has a positive effect on the gripping surface of the and allows us to shorten the length of the clamp.



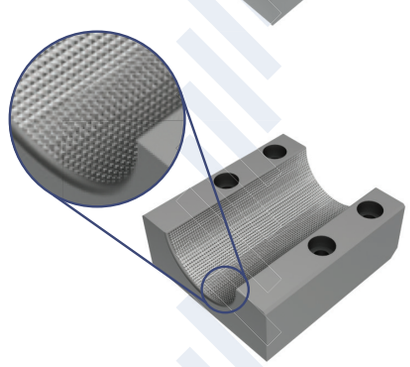
SERRATION

The surface treatment is a machined serrated surface of the groove. The main advantage of this surface treatment is that is allows us to significantly reduce the clamp length. The coarseness of the serration is chosen for the diameter of the tube. It is set by the number of teeth per inch. Typically we would have 12, 16, 20 or 25 teeth / inch.



KNURLING

This treatment is typically very coarse. It does leave small marks on the pipe, how this allows for the length of the clamp to be significantly reduced. We have 3 levels of coarseness, 12, 16 or 20-teeth/ inch depending on the diameter of the tubes, from 30 mm. The disadvantage of this solution is that it can only used for straight clamps or on straight parts of shaped clamps using insert.



CLAMP DIE | PRESSURE DIE

COMPONENTS

OF ROTARY DRAW BENDING

CLAMP DIE

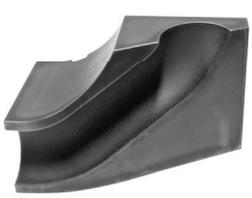
The clamp die is equal in length and has the same grip finish as the grip area of the bend die. The clamp die's primary function is to hold the tube securely to the bend die during bending. A solid grip on the tube is necessary for successful bending, any slippage of the tube will have a significant effect on the quality of the bend. There are many ways of fixing the Clamp Die to the machine and it depends on the equipment used. One frequent way is using a T-nut.

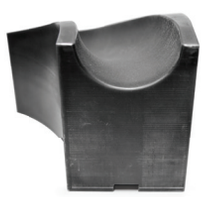
STRAIGHT DIE

Basic shapes of dies needed for all tools sets.

COMPOUND DIE

Shaped dies are used in tubes where there is a short distance between bends.

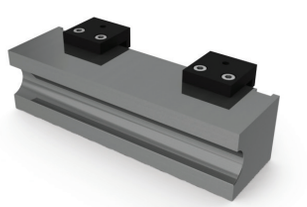




Compound dies are used in tubes where there is a short distance between bends <

PRESSURE DIE

The pressure die is used to maintain constant pressure on the tube at tangent where the bending is occurring and thus provides the reactionary force to make the bend. The size of the groove will depend upon the outside diameter (OD) and the center line radius (CLR) the maximum degree of bend (DOB). Most machines use a Pressure Die which moves with the tube in the direction of the bend and thus provides the best support. For older machines, you can still see stationary Pressure Dies, sometimes with several rotation rolls located in a row.



Pressure die <

WIPER DIE

COMPONENTS

OF ROTARY DRAW BENDING

WIPER DIE

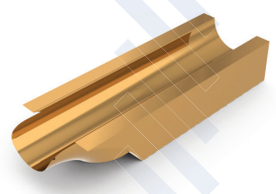
The wiper die mounts into the tube groove of the bend die with the tip positioned near the tangent point. Its primary function is to prevent wrinkling on the inside radius ot the tube. See appendix A.

The material of the wiper die is made from is also important. Steel is preferred for bending aluminum, copper or mild steel; Aluminum-bronze for bending stainless steel, inconel, titanium. The steel wiper dies can also be hard chrome plated to help reduce friction.

Like bend dies, there are several styles of wiper dies to choose from depending on application.

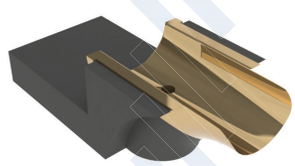
SQUARE BACK

This is a wiper die used for small series or one-off production and also for more complicated applications, where the important factor is the rigidity and stiffness of the wiper die.



WIPER DIE HOLDER + INSERT

This type of wiper die is made in two parts, with a holder and insert. This is mostly used in large scale production. The disadvantage of this is a lower stiffness compared to the squareback wiper die.



Proper setup of the wiper die is essential to a good bend and the life of the die (see appendix A).

Insert wiper die <

Collection of wiper dies <

Square back wiper die <

MANDREL

COMPONENTS

OF ROTARY DRAW BENDING

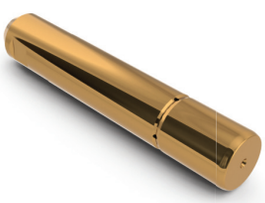
FLEXIBLE MANDRELS

Mandrels are generally made from the same materials as the wiper die, usually steel with hard chrome plating or aluminum bronze, depending on material being bent. The primary function of the mandrel is to prevent the outside diameter of the tube from collapsing.

There are five basic styles of mandrels to choose from:

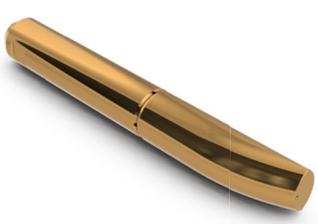
PLUG MANDREL

This type of mandrel is usually suitable for bending pipes or heavy duty walltubes and/or for bending applications with large centerline radius.



FORMED END PLUG

This is intended for similar applications as the simple plug, the shaped part of the mandrel provides better support for the tubes on the outer radius of the bend.



STANDARD MANDREL

This is most widely used because it covers the widest range of bending applications. Standard mandrels are made with one ball or can be made with any amount of balls. The standard mandrel is the most durable of the three flexible mandrel configurations because it uses the largest size links possible.

Thin wall mandrel balls <

Links of mandrels <

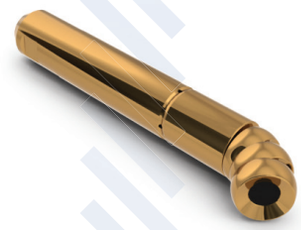
MANDREL
COMPONENTS
OF ROTARY DRAW BENDING

FLEXIBLE MANDRELS

THIN WALL MANDREL

CLOSE PITCH MANDREL

This mandrel is used in the bending of thin–walled tubes with smaller bend radii. The size of the links is one size smaller than in the standard mandrel, the ball segments are closer together and provide greater support needed during bending of thin walled tube. Strength is sacrificed for more support.

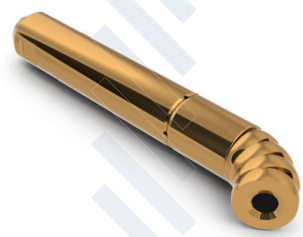


ULTRA THIN WALL MANDREL

ULTRA CLOSE PITCH MANDREL

These are suitable for tube bending of very thin walls and very small radius bends.

Just like thin-walled ball mandrel it has a smaller link size and specially designed balls. The effect being that the ball segments are now closer together and provide more support needed for thin walled tube bending. Strength is sacrificed for more support.



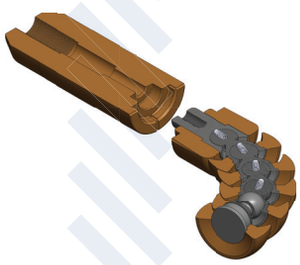
INSERTED MANDREL

Depending on specific bending application, in terms of feasibility, the Standard, Close or even Ultra Close Pitch style mandrels(built on H-style links) can be on request manufactured.

However, the most common is style called Inserted Close Pitch (ICP) - a mandrel that was designed with respect of needs of passenger car exhaust system producers. This quite new design combines advantages of two mandrel styles, the good tube support of close pitch style and price savings of inserted mandrel style.

The original close pitch style was often used to bend heavier walled tubes than recommended what repeatably causes links breakages. ICP mandrels are build on beefier ICP style("half close" pitch) links to cover range of 33mm – 90mm OD of tube.

Please be aware, these links are different therefore not compatible with the original in industry most used H-style links.



Choosing the right mandrel is very important in determining the quality of the bend.

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PROPER SETUP

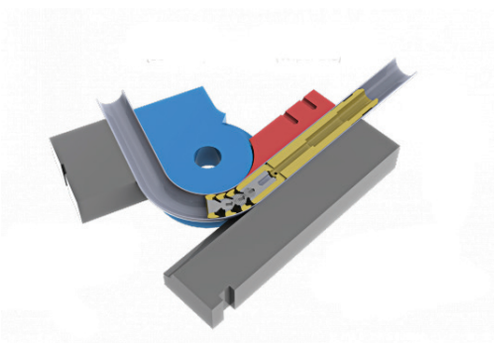
OF ROTARY DRAW BENDING TOOLS

INSTRUCTIONS

When it comes to making the perfect bend on a consistent basis, several factors come into play, any one of which may make or break the bend.

The first step to take before making any bends is to determine that the bender you will be using is operating properly. Make sure that the clamping and unclamping of dies, the rotation of the swing arm and the extracting of the mandrel are all occurring in the proper sequence.

Once you are sure your machine is operating properly make sure that the tubes you will be bending are clean, both on the outside and the inside. Debris on the outside of the tubes will scratch and deface the grooves in the tools and will make the tools wear prematurely, especially the wiper die. Also, debris on the inside of the of the tubes will prematurely wear out the mandrel and may gall the inside of the tube.



Finally, check the tooling to make sure it is clean, burr free and compatible with the tube to be bent.

After the preliminary inspection is completed you may proceed to setup the tools following these steps:

BEND DIE

Mount tools on the bending machine. Make sure the bend die is laying flat on the platform with the counterbore and key in place, not hanging up. If there is debris under the bend die or it does not fit properly it will not bend properly.

CLAMP DIE

Clamp the clamp die to the bend die. The grooves of the clamp die and the bend die should match up exactly. Adjust clamp die height as necessary. Also make sure the clamp die length is equal to the bend die length.

PRESSURE DIE

Mount the pressure die to the bending machine. The groove of the pressure die should match the groove of the bend die. Adjust the hangers as necessary. Be sure both the front and back of the pressure die are aligned with the bend die. Since the pressure die holds the tube against the bend die for the duration of the bend, make sure the pressure die is long enough to make the degree of bend you will be bending. Adjust the pressure die so that it applies medium pressure against the tube.

STEP BY STEP

INSTRUCTIONS

WHEN BENDING WITH TOOLS

WIPER DIE

The next component to check is the wiper die. The tip should have a feather edge and the groove should match the groove of the bend die. The centerline radius should match the centerline radius of the bend die. Then positioning the wiper die, do not go to or past the tangent of the bend die. The proper position for the wiper die is just behind the tangent (see appendix A). The best way to position the wiper die is to insert the tube over the mandrel and then close the clamp die to the bend die. Then advance the wiper die, by hand, as far forward in the bend die as it will go. Next, tap the back of the wiper die into the bend die until it cannot advance any further. The wiper die should now be in its proper position.

MANDREL

If using a mandrel, attach the mandrel to the mandrel rod. Advance the mandrel to the correct distance past the tangent point (see appendix B). Make sure that the mandrel is advancing and retracting in the proper sequence. The mandrel should advance to its preset position before the tube is inserted. After the bend is made the mandrel should retract. Further, make sure the mandrel is made from the material that is best suited for the material you are bending. For example, an aluminium-bronze mandrel should be used when bending stainless steel, inconel, titanium and other exotic materials. A hard chrome plated steel mandrel should be used when bending aluminum, steel, mild steel and copper. Do not forget to apply lubrication.

Special shape tubes to bent <

1. MANDREL IN.
2. CLAMP DIE IN.
3. PRESSURE DIE IN.
4. ARM SWINGS FORWARD.
5. ARM STOPS.
6. MANDREL EXTRACTS.
7. CLAMP DIE AND PRESSURE DIE RETRACT.
8. ARM RETURNS TO ZERO POSITION.
9. MANDREL MOVES TO FORWARD POSITION.

BBLUBRICANTS

LUBRICATION

WHY LUBRICATE?

Lubrication is an essential part of the rotary draw bending operation. Products of BBLubricants are clean, non-oil alternatives to mineral, vegetable and animal oil for the demanding mandrel bending operations. Lubricants do not contain any harmful pollutants (no chlorines, nitrides, paraffins of formaldehydes). Products are gentle to skin and environmentally friendly. As it is washable with warm water this can result in a total cost reduction of up to 50%. A clean thin film provides excellent protection while keeping surface no resistant for welding (no washing is needed).
Lubrication in combination with right set of tools from OMNI-X can extend average tool life by 25%.

BBLUBRICANTS

100 % ecological biodegradable lubricants

BENEFITS

BIODEGRADABLE
EASY CLEAN UP WITH WATER

OIL-FREE
EXTEND TOOL LIFE

DILUTABLE WITH WATER
WELDING READY

CORE - 8 X

Heavy duty bending and metalforming liquid

Clear, pale-yellow appearance liquid. Core-8X lubricant for extreme bending and metalforming operations. Can be used also as a spray. Dilutable by water. Can be used on aluminium material.

- state: liquid
- material: steel, stainless steel, aluminium
- application: internal, external
- dilution possible (maximum ratio 1:1)

ALC

Heavy duty bending and metalforming liquid

ALC series products designed to work with various material range (stainless steel, aluminium, titanium, etc.). Liquid of high viscosity. Can be pumped through mandrel or applied manually.

- state: liquid
- material: steel, stainless steel, aluminium, aluminized tubes
- application: internal, external
- dilution possible (maximum ratio 1:1)

NIROL

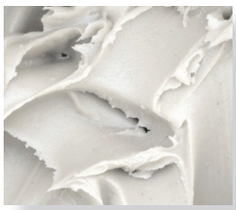
General purpose and heavy duty bending gel

Clear, yellowish gel. It does not drip or run from the components. Good for general and difficult bending. Can be used also for fabricating. Light to heavy duty bends. Application through mandrel, brush and roller.

- state: gel
- material: steel, stainless steel
- application: external
- dilution not possible

MEDELAN

General purpose and heavy duty bending paste



Dense, milky white non-pour paste. Light to heavy duty bends. Bending and also fabricating process. Applicable by brush.

- state: paste
- material: steel, stainless steel
- application: external
- dilution not possible

IN NUMBERS:

- 3X TIMES EASIER CLEANABILITY
- 2X COST REDUCTION
- 1.25X TOOL LIFE EXTENTION

END FORMING

// PROPER SETUP OF ROTARY DRAW BENDING TOOLS

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END FORMING TOOLS

There are many applications for shaping the tube ends. In most cases these shaping methods are used to connect tubes to other components (e.g. other tubes, hoses or flanges). In the automotive industry, end shaping is most often used in finishing the exhaust systems, connecting other parts and so on.

OMNI-X has primarily focused on shaping tube ends in the automotive industry and focuses on shaping tools, which we denote as either "I/O" or "C" for machines with a capacity up to 3 inches.

In other words we can say that the tools are suitable for expanding, reducing and calibrating the tube diameters. The required end forming result will determine the type of tooling needed.

TOOLS I/O

This is a two-function segmented shaping tool I/O. Suitable for reduction and expansion of tube diameters.

Complete assembly is composed of external collets, jaws, internal fingers, mandrel and barrel in which the individual parts are assembled. This type of tool is the only one which has fingers and jaws. This means that it is possible to re-inforce the shaped area from the inside or the outside, which gives much greater versatility in this type of tool. From the range of segmented shaping tools, the I/O gives the best quality from the point of view of tube shaping.

ARBOR

This component is inserted to the machine as an independent unit. The movement of the machine pushes the arbor into the fixed area of the expanding fingers. This leads to the expansion and calibration of the tubes.
From a production perspective this product comes in two variants depending on the outer diameter of the tubes, 6- or 8-segmented with different angles on the fixed area.

> Arbor <

I/O

END FORMING TOOLS

FINGERS

The movement of the mandrel cause the segments to be expanded to the required diameter of the tube. The mandrel is inserted through the correct fixed section on the individual segments of the inner fingers, which then apply a force to the inner side of the shaped area.

From a production perspective this product comes in two variants depending on the outer diameter of the tubes, 6 or 8 sided fingers.

> Fingers <

JAWS

To reduce the tube into required shape we use cone-shaped jaws inside and cone-shaped outer section. Using pistons we move the barrel into which the jaw is inserted or we move the front part of the shaping machine with the fixed cone.
The jaws are manufactured in three options 2.75 STD, HD, 3.125 (in inches). When changing the jaws type it is necessary to also change the fixed cone of the machine.

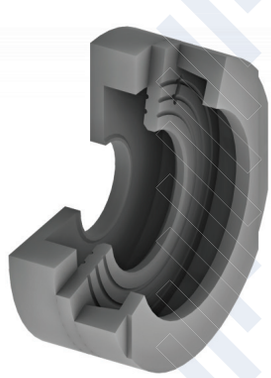
Jaws IO 8 - 3.125 <

Jaws IO 8 - HD <

Jaws IO 8 - 2.75 (STD) <

BARREL

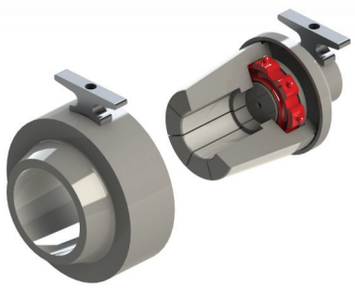
The barrel is made up of three parts, into which fingers and jaws are inserted. The barrel is fixed into the frame of the machine and using the pistons we can move the fixed cone towards the barrel. In this way the collet is closed to the required diameter.



Barrel <

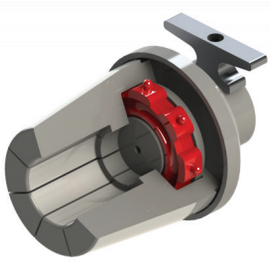
C - REDUCING

The single-purpose segmented shaping tool can be known as “C” or an “R” and is used for reducing the diameter of the tube.
The complete set contains an outer cone, jaws, a gripping adapter and a cone. This type of tool contains only external collets. This means that it is possible to apply pressure to the shaped area from the outside, which allows us to reduce the diameter of the tube.



JAWS WITH ACCESSORIES

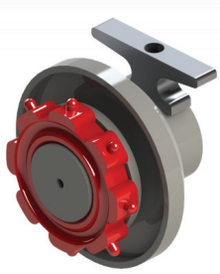
The collets are produced in two variants with 6 or 8 segments and with different angles of the fixed section. The cone-shaped section of the individual segments of the collet must be the same size as the cone shape of the fixed barrel. That’s why we recommend ordering both components together.



Jaws CR - 8 <

ARBOR WITH ATTACHMENTS

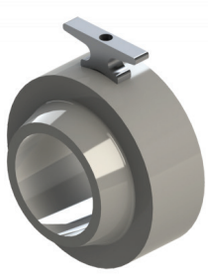
The clamping adapter is made up of several connected parts, which form an insert for the collet. The basic element is a rubber ring with 6 or 8 functional elements which serves to stretch the collet. Then using the machine piston the collet then moves into the shape of a cone. In this way the collet is closed to the required diameter.



Arbor CR <

GUIDING BARREL

This is an independent unit, which is connected to the shaping machine. The fixed barrel is produced with an inner cone-shape, which corresponds to the angle of the cone on the outer collet. We recommend ordering this component with the collet assembly and clamping adapter to ensure that all the components are compatible.

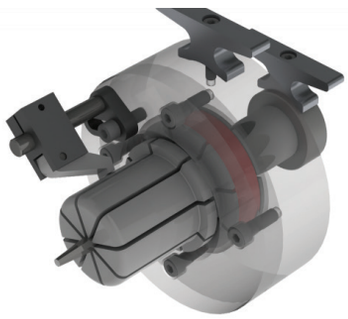


Cone CR - 8 <

C - EXPANDING

END FORMING TOOLS

C - EXPANDING



This is a single-purpose segmented shaped tool can be known as "C" or "E". It is suitable for expanding the tube diameter.

Complete assembly is composed of internal fingers, mandrel and barrel in which the individual parts are assembled. This type of tool contains only expanding fingers. This means that it is possible to apply pressure to the shaped area from the inside, which allows us to expand the diameter of the tube.

ARBOR

This component is inserted to the machine as an independent unit. Using the machine piston the mandrel is moved, this then causes the fingers to open up. This results in expansion or subsequent calibration of the tubes.
From a construction perspective this product is made in two variants depending on the inner diameter of the tube, 8 or 6 segment with differing angles.

Arbor <

FINGERS

The movement of the mandrel causes the segments to be expanded to the required diameter of the tube. The mandrel is inserted through the correct fixed section on the individual segments of the inner fingers, which then apply a force to the inner side of the shaped area.

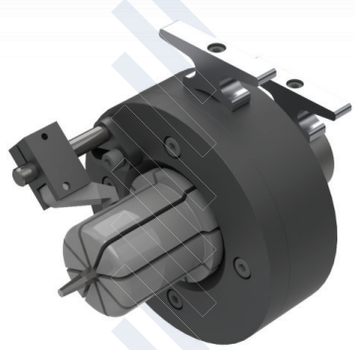
From a construction perspective this product is made in two variants depending on the inner diameter of the tube, 8 or 6 segment with differing angles.

Fingers CE - 8 <

BARREL

Barrel is produced from two flanges which create a space for the expanding fingers.

Optional extra equipment can be adjusted to the end of the tubes, which allows greater variability in the length of the shaped area. The finish of the tube is available at customer request only with the complete set of tools including the barrel.



C - Expanding <

TROUBLE-SHOOTING GUIDE

RECOMMENDED

TROUBLE-SHOOTING

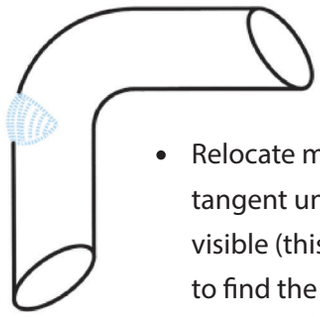
GUIDE

ROTARY DRAW MINDBENDERS AND THEIR SOLUTIONS

When it comes to making perfect bends, several factors come into play:

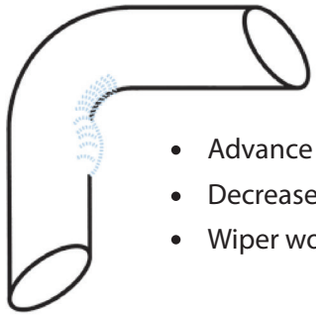
- Determine that the bender you will be using is operating properly.
- Make sure the clamping and unclamping of dies, rotation of swing arm and extracting of mandrel are all occurring in the proper sequence.
- Make sure the tube you will be using is clean, both inside and outside.
- Check the tooling, making sure it is clean, burr free, and compatible with the tube to be bent.
- Confirm that the mandrel is the required distance past the tangent.

1 Hump at end of bend



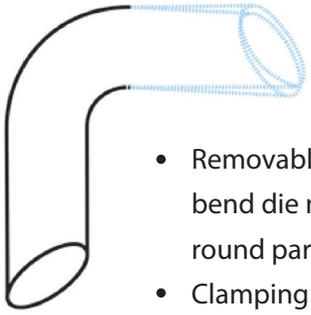
- Relocate mandrel back from tangent until bump is barely visible (this is a good system to find the best location for a mandrel.)

2 Wrinkling throughout bend and even extending into wiper die areas



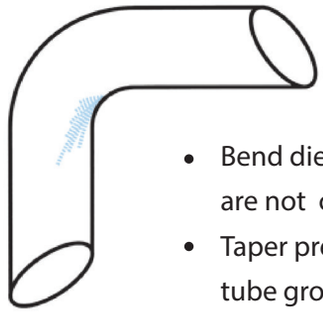
- Advance wiper die closer to tangent.
- Decrease rake of wiper die.
- Wiper worn out - have replaced.

3 Bad mark at start of bend and over bend for 90°



- Removable clamping portion of bend die not matched properly to round part of bend die.
- Clamping portion of bend die not parallel to the key way.

4 Wrinkling occuring for only a portion of the bend (45° out of 90°)



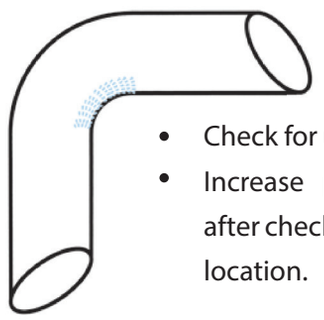
- Bend die groove and counter-bore are not concentric.
- Taper pressure die (from bottom of tube groove to back of die.)

RECOMMENDED

TROUBLE-SHOOTING

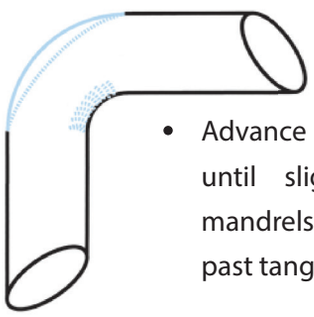
GUIDE

5 Wrinkling throughout bend area with wiper and mandrel in known proper position



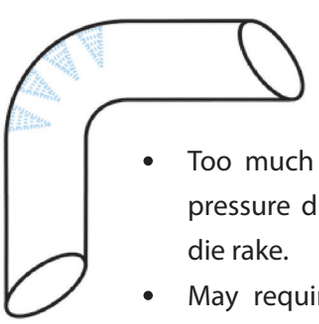
- Check for undersized mandrel.
- Increase pressure die force only after checking wiper fit and mandrel location.

6 Excessive collpase with or without wrinkling throughout entire bend



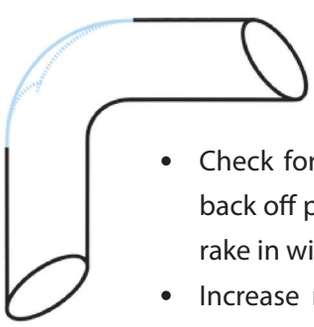
- Advance mandrel toward tangent until slight hump occurs (most mandrels must project somewaht past tangent.)

7 Mandrel ball humps



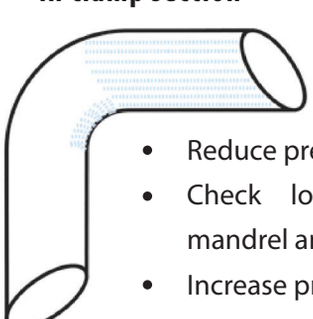
- Too much drag on tube; back off pressure die force - increase wiper die rake.
- May require closer pitch mandrel ball assembly.
- Tubing material too soft.

8 Excessive collapse after tubing is pulled off mandrel balls



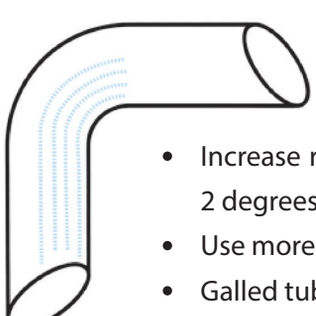
- Check for too much drag on tube; back off pressure die force, increase rake in wiper die, etc.
- Increase mandrel support, change from a plug to a one ball, from a 2 ball to a 3 ball mandrel, etc.

9 Heavy wrinkle through bend area only and linear scratches in grip area indicating slipage in clamp section



- Reduce pressure die force.
- Check location (and lube) of mandrel and wiper die.
- Increase pressure on clamp die.
- Use serration, knurling or carbide spray in clamp are.

10 Deep scratches throughout the bend and in wiper die area



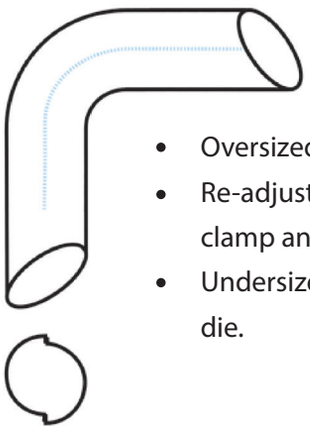
- Increase rake or relief in wiper die 1 to 2 degrees.
- Use more and/or better lubrication.
- Galled tube groove in wiper die. Recut wiper die.

RECOMMENDED

TROUBLE-SHOOTING

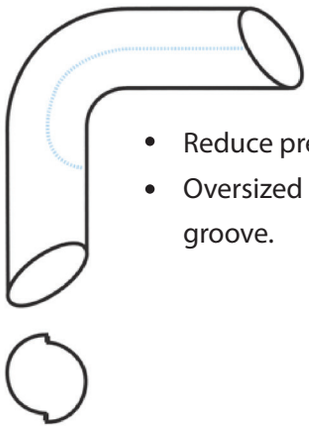
GUIDE

11 Tool marks on center of bend



- Oversized tube.
- Re-adjust vertical alignment of clamp and/on pressure die.
- Undersized tube groove in bend die.

12 Tool marks on center line of bend in clamp and presure die area



- Reduce pressure die force.
- Oversized tube or undersize tube groove.

TUBE BREAKAGE MAY BE CAUSED BY THE FOLLOWING:

1. Material does not have the proper ductility and elongation properties.
2. Tube slippage in the clamp die. Adjust pressure on the clamp die. Use different grip surface on the clamp and grip section of bend die.
3. Too much pressure on the pressure die causing excess drag. Reduce pressure on pressure die.
4. Material is wrinkling and becoming locked between the mandrel balls. Use as thin wall style mandrel. Clamp die pressing on the mandrel balls. Reduce pressure on clamp die.
5. Not enough lubrication is being applied, or the wrong type of lubrication is being used.
6. Mandrel is advanced too far forward past tangent. Move mandrel back.

TUBE WRINKLING MAY BE CAUSED BY THE FOLLOWING:

1. Tube slippage in clamp die. Add pressure to clamp die or use different grip in clamp die and the grip area of bend die.
2. Mandrel is not far enough forward. Advance mandrel past tangent.
3. Wiper die not far enough forward. See appendix A.
4. Wiper die is worn or not fitting properly. Make sure the centerline radius matches the centerline radius of bend die.
5. Too much clearance between mandrel and tube. Try larger size mandrel.
6. Not enough pressure on pressure die. Add pressure to pressure die.
7. Excessive lubrication being used.

OMNI-X

COMMONLY-USED TERMS

WHEN BENDING TOOLS

C.C.W.	Counter clock wise or left-hand rotation. On rotary draw tube bending machine the rotation of the arm swing.
C.W.	Clock wise or right-hand rotation. On rotary draw tube bending machine the rotation of the arm swing.
C.L.H.	Centerline height. On a bending machine, the height from the bottom of bend die to the center of the tube groove on the die.
C.L.R.	Radius along the centerline of the tube to be sent.
Captive lip	Tooling in which the groove in the bend die and wiper die is deeper than half the diameter of the tube. Used only with interlock tools in high precision aerospace applications. Minimizes tool marks from the bend die in ultra thin wall applications.
Carbide coating	Surface treatment to bend die grip sections and clamp dies to help prevent tube slippage.
Compound tooling	Tooling that has very short DBB (distance between bends) requires that the bend die grip section and the clamp die have the previous bend machine into them. Tooling is expensive but more practical than short grip sections in high production applications.
D.O.B.	Degree of bend. Number of degrees a tube is to be bent.
"D" of bend	The centerline radius divided by tube O.D.
D.B.B.	Distance between bends. The distance between the tangent of one bend and the tangent of another bend.
Easyway	Refers to the direction of bend for rectangular tubes. The tube stands vertically when placed into the bend die.
Galling	The transference of one material to another caused by high pressure and friction. Occurs when stainless steel is bent with a steel mandrel or wiper die; or when aluminum is bent with aluminum-bronze tools. Can be reduced by using better lubricants, alternative materials, or a slow arm rotation may help.
Hardway	Refers to the direction of bend for rectangular tubes. The tube lays horizontally when placed in the bend die.
Inserted grip	If a bend die has a removable grip section.
I.S.R.	Inside radius of bend. Typically used when specifying radius to bend on rectangular and square tube.
Knurling	Surface treatment to bend die grip section and clamp die to prevent slippage. Fine and coarse knurls are available. Does not deform the tube the way serration does.
Mandrel extractor	The hydraulic cylinder that removes the mandrel from the tube after bending. Necessary only when mandrel is being used.
P.O.B.	Plane of bend. Refers to the amount of rotation between two bends. Specified in degrees.
Pressure die assist	A hydraulic cylinder attached to the pressure die master bar. It forces the pressure die to push the tube during bending. This action reduces collapse and wall thinning and improves ovality of the tube by forcing more material to the areas of the tube where it is stretching and thinninh out during bending. Primarily used thin wall applications.

OMNI-X

COMMONLY-USED TERMS

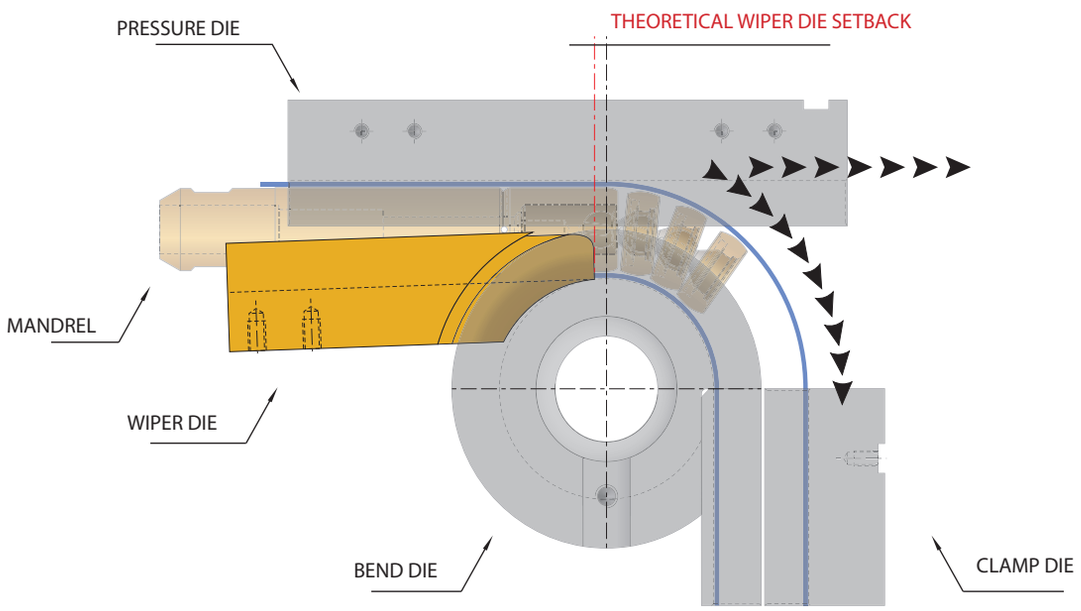
WHEN BENDING TOOLS

Radial Growth	After a tube is bent, it will springback and the radius of the tube will grow. It will be larger that the bend die CLR. Radial growth is greatest with CLRs greater that four times tube O.D. and when bending harder materials.
Reverse Interlock	Tooling that utilizes an interlocking design in which the wiper die, clamp die and the pressure die fit into the bend die. Used primarily for cosmetic or aerospace parts and high production bending. Helps in the alignment of the tube groove.
Serration	Surface treatment to bend die grip section and clamp due to prevent slippage. Usually used with grip section shorter that three times the tube O.D. Tube deformation should be expected.
Springback	When a material is bent it has a tendency to want to return back to its original position. The amount that it does actually return is called springback. The springback amount will differ depending on the material being bent and the CLR on which it is bent.
Thin wall mandrel	See page 11.
Tube I.D.	Inside diameter of the tube.
Tube O.D.	Outside diameter of the tube.
Ultra thin wall mandrel	See page 11.
Wall factor	Tube O.D. divided by by wall thickness.
Wall	Wall thickness or gage of tube or pipe.

APPENDIXES

APPENDIX A

PROPER SETUP OF A WIPER DIE



Never set the wiper die at tangent and begin bending. The result will be a broken tip.

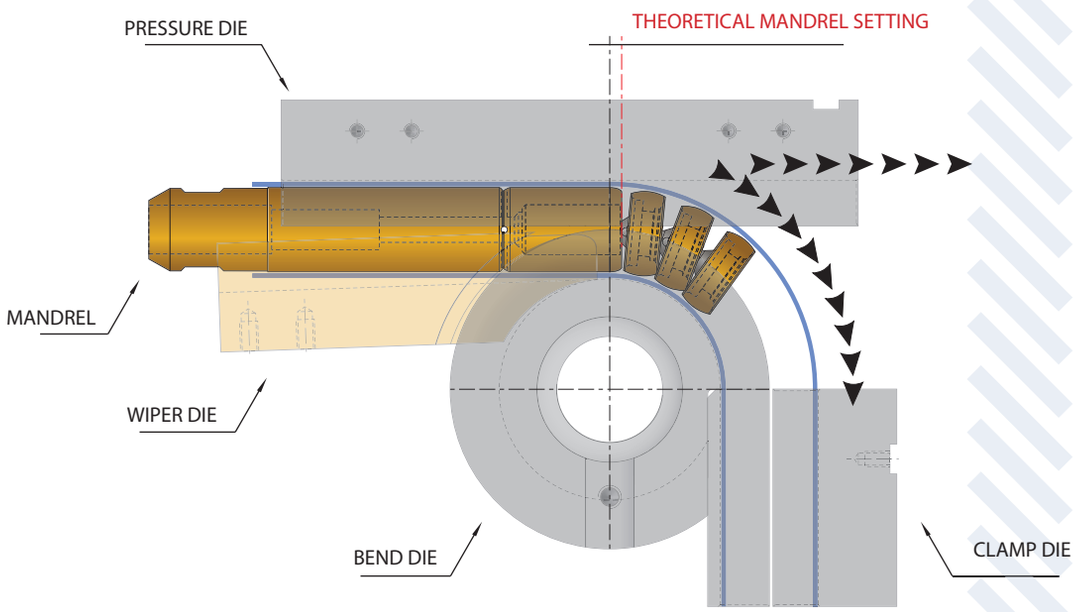
1. Always clamp a section of the tube to be bent in the bend die, clamp die, pressure die assembly.
2. Confirm that the pressure die and clamp die are in the fully forward locked and clamped position. The tube must be tight in the assembly.
3. Position wiper die onto the tube and begin sliding it toward the bend die. Then gently tap it forward to seat the tip.
4. Pull the heel of the wiper die away from the tube to give it about 1 degree of rake.
5. Secure the wiper die in position. Confirm that you will not have any clearance problems, especially if bending 180 degrees.
6. Unclamp the tube from tooling assembly. Measure the distance to tangent clearance and heel clearance. Compare with Table 1. Actual measurements may vary slightly with no loss of quality of bends produced.

ISR	Theoretical Tang. Setback
12.70	2.11 mm
25.40	3.00 mm
38.10	3.68 mm
50.80	4.24 mm
63.50	4.75 mm
76.20	5.21 mm
88.90	5.61 mm
101.60	6.02 mm
114.30	6.38 mm
127.00	6.71 mm
139.70	7.04 mm
152.40	7.37 mm
165.10	7.67 mm
177.80	7.95 mm
190.50	8.23 mm
203.20	8.51 mm
215.90	8.76 mm
228.60	9.02 mm

This procedure will work for all types of wiper dies including square back, round back or inserted. The important working part of the wiper is the tip, and the tip geometry will be the same for all types of wiper dies.

APPENDIX B

MANDREL TANGENT SETTINGS



Tip of mandrel shank should past the tangent. Location of mandrel settings is specified in chart below. These tangent settings are a starting point for proper mandrel setup. Fine adjustment should be done after analyzing your bent tube.

DO:

1. Set mandrel at tangent as recommended by chart below for initial setup.
2. Test balls to insure that have contact with bend die groove.
3. Occassionally rotate mandrel on mandrel rod to distribute wear.
4. Lubricate mandrel body and ball properly.

DO NOT:

1. Do not force mandrel into tube with mandrel extractor.
2. Do not over clamp onto ball during bending. Ball segment and links will break !!
3. Do not use more ball segments than are required.
4. Do not back up with mandrel during bending process !!!!

STANDARD PITCH MANDRELS

STANDARD PITCH MANDRELS	TUBE OD	mm	6.3 - 7.9	8.0 - 12.5	12.6 - 15.8	15.9 - 18.9	19.0 - 23.9	24.0 - 28.4	28.5 - 37.5
	TANGENT SETTING	mm	0.75	2	2.5	3	4.3	5.2	5.4

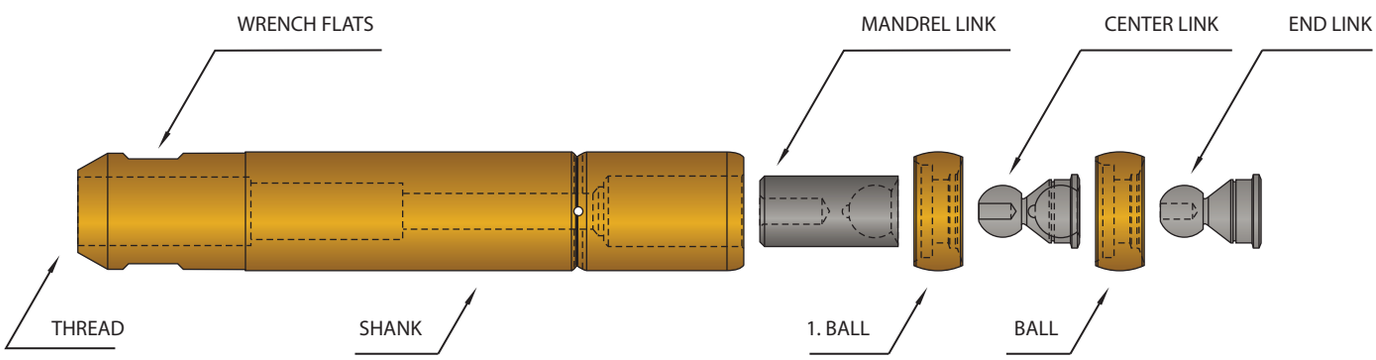
STANDARD PITCH MANDRELS	TUBE OD	mm	38 - 43.5	44 - 53	54 - 66	66.5 - 85	85.5 - 117	117 - 136	136.5 - 152
	TANGENT SETTING	mm	5.6	6.2	6.4	6.4	7.9	9.5	9.5

CLOSE PITCH MANDRELS

CLOSE PITCH MANDRELS	TUBE OD	mm	32	38 - 41	44.5 - 50.8	54 - 63.5	66.5 - 82.5	85.5 - 114.3	117 - 133	136.5 - 152
	TANGENT SETTING	mm	2.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3

APPENDIX C

MANDREL COMPONENT DESCRIPTION AND MAINTENANCE



DISASSEMBLY

1. Remove socket head bolt from mandrel shank with allen wrench.
2. Remove split mandrel link from shank and split halves to release detent ball and detent spring.
3. Remove snap ring from link.
4. Slide ball segment off link.
5. Split halves of center link to release detent ball, detent spring, and locating key.
6. Repeat procedure #3 until desired dissaembly is reached.

ASSEMBLY

1. To assemble, reverse procedure above.
2. Always install solid end link on last ball for maximum strength.

APPENDIX D

BASIC MANDREL AND WIPER DIE SELECTION CHART

$$\text{Wall factor} = \frac{\text{Tube Outside Diameter}}{\text{Wall Thickness}}$$

$$\text{“D” of Bend} = \frac{\text{Bend Centerline Radius}}{\text{Tube Outside Diameter}}$$

P = Plug mandrel
F = Formed mandrel
M = Ball Mandrel
W = Wiper Die
 # = Number of balls

WALL FACTOR \ “D” OF BEND	1	1.25	1.5	2	2.5	3	4	5
10	M 1	M 1	M 1	M 1	P	P		
15	M 1 W	M 1 W	M 1	M 1	P	P		
20	M 2 W	M 1 W	M 1 W	M 1	M 1	M 1	P	
25	M 3 W	M 2 W	M 1 W	M 1 W	M 1	M 1	M 1	
30	M 3 W	M 3 W	M 2 W	M 2 W	M 1 W	M 1	M 1	M 1
35	M 3 W	M 3 W	M 3 W	M 2 W	M 2 W	M 2 W	M 2	M 1
40	M 4 W	M 3 W	M 3 W	M 3 W	M 3 W	M 3 W	M 2 W	M 2
45	M 4 W	M 3 W	M 3 W	M 3 W	M 3 W	M 3 W	M 2 W	M 2 W
50	M 4 W	M 3 W	M 3 W	M 3 W	M 3 W	M 3 W	M 2 W	M 2 W
60	M 4 W	M 4 W	M 3 W	M 3 W	M 3 W	M 3 W	M 2 W	M 2 W
70	TW 5 W	TW 5 W	TW 5 W	M 3 W	M 3 W	M 3 W	M 3 W	M 2 W
80	TW 5 W	TW 5 W	TW 5 W	TW 5 W	M 3 W	M 3 W	M 3 W	M 2 W
90	TW 5 W	TW 5 W	TW 5 W	TW 5 W	M 3 W	M 3 W	M 3 W	M 3 W
100	TW 5W	TW 5 W	TW 5 W	TW 5 W	TW 5 W	M 3 W	M 3 W	M 3 W
125	TW 5W	TW 5 W	TW 5 W	TW 5 W	TW 5 W	TW 5W	M 4 W	M 4 W
150	TW 6 W	TW 6 W	TW 6 W	TW 6W	TW 5 W	TW 5W	TW 4 W	TW 4 W
175	TW 7 W	TW 7 W	TW 7 W	TW 7W	TW 7 W	TW 6W	TW 6 W	TW 6 W
200	TW 10 W	TW 10 W	TW 10W	TW 10W	TW 9 W	TW 9W	TW 8 W	TW 8 W
225		UTW 10W	UTW 10W	UTW 10W	TW 10W	TW 10W	TW 10W	TW 10W
250			UTW 10W	UTW 10W	UTW 10W	UTW 10W	UTW 10W	UTW 10W
275			UTW 10W	UTW 10W	UTW 10W	UTW 10W	UTW 10W	UTW 10W

Example: M 3 W = Mandrel, 3 ball, Wiper die

Note:

- Grey area, use standard style flexible mandrel.
- Yellow area, use thin wall style flexible mandrel.
- Blue are, use ultra thin wall style flexible mandrel.

ORDERING GUIDELINES

When ordering tooling it is very important to provide as much information as possible about the tube that will be bent, the machine that will be used to make the bend and if known, the type of tooling you prefer to use. If you have made this bend in the past and are satisfied with the results you have been getting with your previous tools, we can make your new tooling to your specs. If on the other hand you are not familiar with tooling design and don't know what would work best and still be cost effective, we will use our expertise and many years of experience to provide you with such tools.

Below is checklist of information you should provide to get the best possible results from your tools and to avoid misunderstandings. If you are not sure of about what information to provide or how to measure your machine we can help by sending you drawings to fill in or by going to your facility to make the measurements for you. Once we have the information we will store it in our database for future tool orders so that you only need to provide the machine information once. If needed, we can also provide assistance in improving the quality of your bends and the efficiency of your bending process as well as offer solutions to reduce your inventory of tools by making the tools so that they fit all your benders if you have more than one bender model.

FOR QUOTE ON SET OF TOOLS

we need the following information:

- Tube Outside Diameter (OD)
- Wall thickness (WT)
- Centerline Radius (CLR)
- Material of tube
- Max. degree of bend (DOB)
- Machine make and model
- Application of bent tube

  (automotive exhaust, aircraft, heat exchanger, furniture)

FOR ENGINEERING AND MANUFACTURING OF TOOL SET

we may need more specific information about your bender:

- Mounting for the bend die, clamp die, pressure die, etc.
- Rotation of swing arm (C.W., C.C.W.)
- Grip length (If preferred) (L)
- Any special adapters needed

Please write this information to Quote / Order forms or call us to stop by your facility to discuss.

ORDERING GUIDELINES

FOR MANDREL

please specify:

NECESSARY	OPTIONAL
Tube Outside Diameter (OD)	Number of balls
Wall Thickness (WT)	Finish diameter of shank
Centerline Radius (CLR)	Weld seam
Material to bend	Material
Thread in mandrel (T)	Mandrel length (L)
DOB	Wrench size slots
Industry	Center Line Height (CLH)
	Rotation (C.W., C.C.W.)
	Material of mandrel and balls

FOR STANDARD SQUARE BACK WIPER DIES AND WIPER DIE INSERT HOLDERS:

please specify:

NECESSARY	OPTIONAL
Tube Outside Diameter (OD)	Dimension A
Centerline Radius (CLR)	Dimension B
Material to bend	Length (L)
Mounting hole size and location or machine make/model.	Any special relief or clearances

Please write this information to Quote / Order forms or call us to stop by your facility to discuss.

OMNI-X

WORLDWIDE LEADER IN BENDING TECHNOLOGY

OUR MISSION

OMNI-X will be honest and responsible in our dealings with customers, suppliers, and employees. We will provide products and service that meets or exceeds the expectations of our customers. We will relentlessly pursue continuous improvement and innovation in everything we do to create a significant competitive advantage compared to world standards.

OMNI-X GUIDE TO ROTARY DRAW BENDING

OUR PARTNERS

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