Basic Principles Of Tube Expanding
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Determining Wall Reduction

Tube Expanding is the process of reducing a tube wall by compressing the outer diameter (OD) of the tube against a fixed container, such as rolling into tube sheets, drums, ferrules, or flanges. To assure a proper tube joint, the tube wall must be reduced by a predetermined percentage. The following chart can be used to calculate proper wall reduction.

### Calculating Wall Reduction

<table>
<thead>
<tr>
<th>Tube Test Number</th>
<th>Sample</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Tube Sheet Hole Inside Diameter (ID)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Tube Outside Diameter (OD)</td>
<td>0.750</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Clearance (A - B)</td>
<td>0.007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Tube Inside Diameter (ID)</td>
<td>0.620</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Tube ID When Metal-To-Metal Contact Is Reached (D + C)</td>
<td>0.627</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Tube ID After Rolling</td>
<td>0.636</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Wall Reduction (F - E)</td>
<td>0.009</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Actual % Wall Reduction (G / (B-D) *100)</td>
<td>7%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sample Tube Size 3/4” x 16 BWG
1. Measure the tube sheet hole ID.
2. Determine the tube OD.
3. Subtract the tube OD from the tube hole ID.
4. Using a tube hole gauge, determine the ID of the tube before rolling.
5. Add the “D” to the clearance (“C”) between the tube OD and the tube hole to determine the tube’s ID at metal-to-metal contact.
6. Roll the tube to what you estimate to be a good tube joint (by feel or an estimated torque setting) and check the ID of the tube with a tube gauge. Take caution not to over roll as it can cause damage.
7. Subtract “F” from the rolled diameter to determine the actual amount of expansion (tube wall reduction) on the inside diameter of your tube.
8. This can be converted to a % wall reduction by dividing the actual wall thickness (“B - “D”) into the amount of roll as shown in “G”.

Once metal to metal contact occurs (“E”) any additional increase of the inside diameter of the tube will result in actual wall reduction. Since the amount of wall reduction greatly determines the quality of the tube joint, you should know what percent of wall reduction is optimal for the application.

This technique is an excellent way to set torque rolling devices. Begin with the first sample tube and roll, measure rolled ID, calculate wall reduction, and determine if more or less wall reduction is required. Adjust torque as needed; roll the next tube, etc until proper torque is set. It is better to error on the side of under rolling. Once torque is set these tubes can then be re-rolled to achieve proper tube wall reduction.

**Lubrication**

Lubrication is critical in rolling a consistently tight tube joint. Tube expanding creates a great deal of heat and friction, so it is important to use the proper lubrication to obtain good tool life and consistent expansions.
Materials, Tube Leaks, & Pre-Expansion Steps

Tubing Material

Below are materials and percentages that can be used as a guideline when rolling tubes of like materials. In general, you want to roll to the lowest wall reduction possible where a tight tube to tube sheet joint can be achieved. The harder the material the less wall reduction required to obtain a tube joint. You should always consult the manufacturer of the heat transfer vessel for specific information before undertaking any maintenance procedures.

<table>
<thead>
<tr>
<th>Material</th>
<th>Target % Wall Reduction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TEMA Standard</td>
<td>API-660</td>
</tr>
<tr>
<td>Aluminum 3003 or 4004</td>
<td>4 - 6%</td>
<td>5 - 7%</td>
</tr>
<tr>
<td>Aluminum 6061-T</td>
<td>6 - 9%</td>
<td>8 - 10%</td>
</tr>
<tr>
<td>Carbon Steel and low-alloy steel (max 9% Chromium)</td>
<td>5 - 8%</td>
<td>8% max*</td>
</tr>
<tr>
<td>Stainless Steel and high-alloy steel</td>
<td>5 - 8%</td>
<td>6% max*</td>
</tr>
<tr>
<td>Duplex Stainless Steels</td>
<td>4 - 6%</td>
<td>Not specified**</td>
</tr>
<tr>
<td>Titanium (and other nonferrous, work hardening materials)</td>
<td>4 - 6%</td>
<td>5% max*</td>
</tr>
<tr>
<td>Admiralty Brass (and other nonferrous, non-work hardening materials)</td>
<td>4 - 9%</td>
<td>8%*</td>
</tr>
<tr>
<td>Copper &amp; Copper Alloys</td>
<td>7 - 10%</td>
<td>Not specified</td>
</tr>
</tbody>
</table>

*API-660 lists maximum tube wall thickness reduction values only. For some materials, API-660 allows the wall thickness reduction to be increased by an additional 2%, if approved by the purchaser.

**Maximum tubes wall thickness reduction to be agreed between the purchaser and vendor.

Tube Material Properties

Metals such as Titanium, Stainless Steel, and other exotics tend to work harden very quickly due to their elasticity. Elasticity refers to a material’s ability to stretch and return to its original state. Materials behave elastically until the force increases beyond the material’s elastic limit, meaning it cannot return to its original shape. During the expansion process, the tube material and tube sheet hole will expand until the tube reaches its plastic state and is contained by the tube sheet’s elastic properties.

Major Causes Of Tube Leaks

Tube leaks are usually caused by under-rolling, over-rolling, improper preparation of tube sheets, and differential thermal expansion. Improperly rolled tube joints can cause several challenges, such as necessary reworking and loss of vessel efficiency.

Under-Rolling Tubes

Under-rolling occurs when the proper amount of wall reduction is not reached. If left uncorrected, this will cause leaks between the tube OD and tube sheet hole ID. Under-rolled tubes can usually be fixed by rolling a second time to obtain the proper amount of wall reduction. Be sure to use a tube gauge to
periodically check the amount of wall reduction during rolling.

**Over-Rolling Tubes**

Over-rolling of tubes occurs when the expansion of the tube surpasses the expansion required for the proper wall reduction. Over-rolling can cause considerable damage to the tube sheet and adjacent tubes. Once a ligament is over rolled, it will deform the ligaments of the tube joints surrounding it. This deformation can cause adjacent tubes to leak.

In addition to impacting tubes, over-rolling can cause distortion in tube sheets or drums. Over-rolling can potentially cause a tube sheet to bow or warp to the point where the standard length tube could not be used in the vessel until the bowing is returned to normal. This can be corrected in some cases by placing stay rods in the vessel and pulling the tube sheets back to their original position.

Lastly, over-rolling can have a significant impact on expander tool life. It can cause the tube material to flake off, which can get trapped in between the rolls and mandrel. If this debris is not cleaned from the expander, it can reduce the life of the rolls and mandrel.

Over-rolling tubes is not something that can be easily corrected. Once ligaments become deformed, the entire tube sheet has an increased chance of leaks, higher maintenance costs, and decreased efficiency. As a result, it is important to avoid over-rolling by using an electronic or pneumatic torque control or an assisted rolling system. These systems will ensure you roll to an exact wall reduction every time.

**Improper Preparation Of Tube Sheet Holes**

The smoother the tube seat or tube hole, the easier it is to roll an optimum tube joint. If the tube sheet or drum is gouged, it is extremely hard to expand the tube to fill these gouges without over-rolling. It is important that light ligaments and thin tube walls are mated to a tube hole that has a low micro range finish. Many manufacturers today are drilling, reaming and sizing or burnishing to get the micro-finish desired for tube holes.

**Differential Thermal Expansion**

Expansion due to heat varies noticeably between a thinner tube and the tube sheet, a shift of the tube results. One of the most important steps for guaranteeing a safe and permanent tube joint is to
thoroughly clean the surfaces of the tube end and the tube hole wall. These two surfaces must be clean and free of all dust, mill scale and pits or scratches. Note: It is extremely important to eliminate any longitudinal scratches or cracks in the tube sheet hole wall. These longitudinal lines will cause leaky tubes.

**Pre-Expansion Steps**

**Preparation of Tube Sheet Holes – Heat Exchangers / Condensers**

1. Drill and ream tube sheet holes to TEMA or ASME codes.
2. Be certain the tube sheet material and ligaments are sufficient to guarantee a safe and permanent tube joint.
3. When conditions permit, utilize a sizing or burnishing tool to further assure a good finish in the tube hole. This will also slightly increase the tensile strength of the ligament.
4. The serrations or grooves to be used will determine the joint strength of the tube joint. It is extremely important when retubing that the grooves be cleared of all metals or any foreign material.

**Preparation of Tube Sheet Holes – Drums / Tube Sheets / Headers**

1. Tube holes are normally drilled and reamed to comply with API, ASME, or National Board Inspection Code.
2. It is extremely important during this operation that there are no longitudinal scratches or cracks left in the tube seat.
3. In cases where out-of-roundness is extreme, pre-rolling of the tube holes is advised.
4. Be certain that the tube hole walls and the grooves in the tube walls are cleaned down to bare metal before tubes are inserted. Be certain all foreign material such as oil, grease, rust, or just plain dirt are removed. Special attention during this cleaning will prevent serious trouble later.

After tube holes have been prepared they are usually coated with a rust preventative compound. Before inserting any tube it is important to remove all traces of this coating. It is extremely important that great care be taken in handling the tubes for insertion in all of the vessels discussed above. Be certain that the tube ends are clear of any foreign material. Be especially certain that there are no chips on the tubing which may gouge the tube sheet or tube seat when the tube is placed in the vessel.

In some cases it will be necessary to force a tube into a tube hole. This should be done with care. It is better to spring the tube than to try to force it with a hammer. If a tube end is kinked or damaged before rolling, the expanded end will be damaged and a leaky roll joint will result. Attention at this time to the tube ends and the tube alignment will prevent future troubles. It may be helpful to employ the use of a Tube End Setting Tool to properly set the tube in the sheet.

**Pre-Expansion Tools**

In order to create a better mechanical joint, it is important that the appropriate pre-expansion tools are used.

**Tube Hole Gauges**

Tube Hole Gauges make it easy to accurately measure tube IDs and tube sheet holes. Accurate
measuring of tube holes ensures that expansion requirements are being met resulting in a mechanical joint. Proper mechanical joints ensure that the vessel is built to applicable engineering standards and to maintain the efficiency and safety of the vessel.

**Tube Sheet Hole Brush**

Prior to rolling, it is important that tube hole surfaces are free of debris and minor scratches. A tube sheet hole brush can aid in the cleaning of these ID surfaces by removing dirt and deposits from tube sheets in surface condensers and heat exchangers. Clean tube sheet holes help to minimize the possibility of leak paths during expansion.

**Grooving / Serrating Tool**

Grooving tools, also known as serrating tools, can be used in milling or drilling equipment for OEM tube sheet hole preparation. These tools provide consistent diameter and depth of grooves in the production of the machined tube sheet holes.

**Tube Pilots / Guides**

Tube pilots, also known as tube guides, are used to pilot replacement tubes through tube sheets and tube sheet support plates that are commonly found in heat exchangers or surface condensers. The tube guide head is designed with a shoulder for the tube to rest against, eliminating the possibility of bending the tube end as the guide pushes through the support plates.
Water Tube Boilers

There are a number of important steps, which should be considered before the actual tube rolling is to take place. The sequence of rolling tubes into drums and water wall headers is as important as rolling the tube joints themselves. When rolling a tube joint, there is an elongation of the tube; the tube actually grows by a fraction of an inch. This growth causes pressure between tube sheets. When rolling water wall tubes, this will cause the tubes to push the upper or lower headers out of alignment. Therefore, it’s recommended that the sequence of rolling be obtained from the manufacturer of the boiler prior to rolling.

Determine Proper Tooling

1. What is the OD and BWG (or wall thickness) of the tube?
2. What is the tube sheet thickness, drum thickness, or length of the tube?
3. Do the tubes have a bend outside of the drum?
4. What type of mandrel is needed?

Types Of Mandrels

- Drum Mandrel - For drums that are 18” in diameter or larger.
- Short Mandrel - A set of short mandrels are used in curved boiler tubes to prevent the mandrel from damaging the tube.
- Header Mandrel - For extended reach if the tube is in direct line with the hand hole.

Generally, drums are thicker than the headers, so it’s important to select different expanders with the proper roll lengths for both headers and drums. Boiler expanders are designed with rolls sufficiently long to roll 1/4” to 3/8” beyond the sheet thickness. Boiler inspectors insist that tubes be rolled the full thickness plus a minimum of 3/16” beyond the sheet or drum thickness to a maximum 1/2”.

It’s very common to use four or five different tools when repairing watertube boilers. As a result, it is important to bring a variety of operating accessories, such as universal joints for rolling headers.

Step Rolling Process

The ASME boiler code states the projection of tube ends into boiler drums and headers shall not be less than 1/4” and not more than 1/2”. These are measured on the high side of the drum shell and before the tube end is flared. The code further specifies that the flare of the tube end must not be less than 1/8” greater than the diameter of the tube hole. It is important not to exceed these specifications, in order to prevent splitting.
Flaring The Tube End

When flaring tube ends it is extremely important that the flare roll does not travel into the drum. Otherwise, it will create a sharp edge on the ID of the tube and a surface crack on the OD of the tube. Choose the appropriate expander; tube hole tolerances should be considered (figure plus 1/32”), the roll length should allow you to expand a minimum of 3/16” to a maximum of 1/2” beyond the tube sheet or seat, as in a drum or counter-bored tube hole.

Using a flare roll tube expander, roll and flare the tube end in one pass, approximately three-fourths tight. Roll a suitable flare to meet the ASME specifications. When setting the tube expander in the tube, it’s important to determine how far into the tube the expanding portion of the rolls should be set. Set the rolls and tighten the mandrel so that the space between the end of the tube and the front of the flare roll will allow for rolling the tube three-fourths tight while producing a suitable flare. No rigid instruction can be prepared for this step since the rolling of boiler tubes is best performed through the experience and judgment of the operator.

If a condition exists where the tube hole tolerance is extremely large, it may be necessary to set the tube with the straight roll expander, flare the end with a flare roll expander, and then re-roll with the straight roll expander.

Expanding The Tube

To complete the tube rolling cycle and form a leak-proof joint, use a straight roll expander to re-roll each tube end. This will also smooth out any out-of-round holes in your tube sheet or any tube with an uneven wall thickness.

There are manufacturers who feel that rolling the tube with a flare roll expander only is the best procedure. They will take a flare roll expander and roll and flare the tubes to a tight tube joint. If the flaring roll starts to walk under the drum, they back the tool out and place the mandrel in the expander tightly and finish the roll. While this may work, it is not recommended.
Fire Tube Boilers

When the tube sheet is welded into the shell or, in some designs, when the main fire tube is welded to the sheet, the tube holes have a tendency to become oval shaped. Since it is practically impossible to prevent this, it is advisable to pre-roll tube holes with a pre-rolling tool. This tool must be equipped with four expanding rolls to round out the tube hole and improve the seat. This rolling action also has a tendency to strengthen the ligament between the tube holes. NOTE: The three Roll Tube Expander design is not recommended for this operation.

Tubes can be cut to length and inserted into the tube holes in smaller boilers. When cutting tubes to length for larger boilers it is usually best to cut all the tubes approximately 3/4” to 1” longer than required to allow for variance in the location of the tube sheet in the shell from one unit to the other, also to allow for a slight warpage in the tube sheet. Insert the tubes in the tube holes and set them uniformly at one end, preferably the back end of the boiler, so that the ends of the tubes project 3/16” to 1/4” beyond the face of the tube sheet for the beading operation. Each tube should then be held or pinned at one end while the other end (set to project 3/1 6" to 1/4") is rolled and flared. Excess tube projection can be removed by using an internal cutter or trimming tool.

Using A Single Roll Beading Expander

Single roll-beading expanders simultaneously expand and bead the tube end in a single operation. The expander assures the creation of a joint, which is pressure tight and has a bead in contact with the tube sheet. The expander achieves this objective by utilizing the natural feed forces built into the expander. When expansion begins it forces the beading roll against the end of the tube forming it into a bead in one continuous operation.

Select The Right Expander

The guide roll and the beading roll must be the proper size for the tube wall. Guide rolls that are too large or too small will prevent proper bead formation. Beading rolls operate on a range of wall thicknesses, but the best results are obtained by using the beading roll specifically designed for that tube gauge.

Check Tube Projection

Tubes must have the correct amount of projection from the tube sheet before starting. Tube projection refers to the distance between a tube end and the tube sheet. The amount of projection can vary depending on the tube diameter, wall thickness, tube sheet thickness, and whether or not the tube is square or has a flare due to the use of an internal type tube cutter. The normal range of tube projection is 3/16” – 9/32”. If the tube sheet is bowed or warped and is not parallel to the end of the tube, the desired projection should be measured at the midpoint so that half of the tube will have greater than the desired projection and half will have less than the desired projection.
Apply Coolant

Coolant is necessary in order to reduce the heat created during the expansion process. If the expander overheats it may result in tube material flaking, premature tool failure, and poorly formed beads. In order to avoid these issues, it is recommended that you dip the roll end of the expander in a bucket of coolant between expansions. This will prevent the tool from overheating while also keeping it clean, extending the life of the rolls and mandrel.

Expanding

Retract the mandrel and insert the tool into the tube until the bead roll is in contact with the end of the tube. Push the mandrel forward until the rolls make contact with the ID of the tube and adjust the mandrel stop to reflect the previously calculated expansion requirement. Position the tube projection from the face of the tube sheet using the guide in the operating instructions for the specific tube OD being expanded. Start the expanding operation and continue until the mandrel stop nut is against the thrust bearing, then allow three additional revolutions of the mandrel to “iron out” the tube bead. Reverse the mandrel rotation and remove the expander from the tube. Verify the target ID and adjust the mandrel stop if needed. Inspect the bead and adjust the tube projection to achieve a “tight to the sheet” tube bead.

Trim Tubes

Upon completion of the expansion of one end of the boiler, the tube projection on the opposing end can be maintained by using a tube cutter to cut the excess tube from in front of the tube sheet.

Traditional Expanding & Percussion Beading

It’s recommended that you use a combination rolling and flaring expander for the first operation when the tubes are prepared for beading. The tube should be rolled sufficiently tight so it doesn’t move as a result of the beading operation. At this point, it’s preferred to have an under-rolled joint because the beading operation has a tendency to move the tube end by a few thousandths. This will prevent any ligament damage during the beading process.

Use a pneumatic hammer and beading tool to hand bead the tube. Once the beading has been completed, the tubes can be re-rolled with a straight expander. This final operation requires only a few seconds per tube, to ensure uniform leak-proof joints.
Heat Exchangers, Condensers, & Other Heat Transfer Units

**Selecting & Setting Up An Expander**

Before you can start rolling, you will need to select the right expander for the job. Tube OD, and Wall/BWG will determine the size of the expander. However, there are some other factors to consider, such as tube projection, roll length, reach requirements, space constraints, and whether it’s minimum or average wall tubing.

**Tube Projection**

It’s important to consider if the tube is going to be expanded flush to the tube sheet or if it will have a projection. The most common tube projection for shell and tube heat exchangers is 1/8” from the tube sheet. In situations where all tubes will be rolled to the same projection, an expander with a recess collar should be used. This will accommodate the projection and prevent the tube from being pulled into the expander. The outlet side of surface steam condensers can have varying projections, up to 1X’s the tube diameter in length. In this case a telescoping or full recess collar should be used. If no tube projection is specified, the tube expander will come with a flush collar to expand the tube flush to the tube sheet.

**Roll Length**

Tube expanders come in two different roll lengths: short and long roll. In order to determine the correct roll length, you will need to know the tube sheet thickness. Choose the roll length that will expand the tube sheet area in the least amount of expansions. If expanding tubes in a double tube sheet, the inner primary tube sheet thickness must be specified so the expander’s rolls can be manufactured to allow for the proper effective expansion length. Whereas, the outer tube sheet would use standard rolls.
Reach Requirements

Generally, tube expanders come in 4”, 8”, 12”, and 18” reaches, but can be made longer to accommodate specific applications. For optimum tool life, use the shortest reach expander that will accommodate the application. Long reach expanders are used in heat exchangers with thick tube sheets or when reaching through water boxes, found in air coolers.

Space Constraints

Heat exchangers with channel boxes or division plates where the tubes are positioned too close to a wall for the expander’s collar to access perimeter tubes will require a friction collar. This collar is smaller in diameter than a standard collar, allowing more access to difficult areas. A friction collar should only be used as needed, as it’s not a replacement for a bearing collar.

Average Wall v Minimum Wall

When ordering tubes, it is very unlikely that each tube wall thickness will be exactly the same. Industry tolerances allow for ±10% thickness. That’s a total variation of up to 20% from the smallest to largest thickness, resulting in a wide range of sizes. For example, if you have .083” average wall tubes, the actual wall could be anywhere between .091” and .075”. If you were to buy a 14 BWG expander to fit .083, it would likely still work for either extreme due to the expansion range that the tool is capable of achieving.

A min wall tube offers the same total variation in wall thickness that an average wall tube does, but the variation is applied differently. It allows for -0% and +20%. So the wall will never be less than the specified thickness. For example, a .083” min wall tube will range from .083” to .100” wall thickness.

At the upper end of that range, a normally sized tube expander will not have enough clearance to enter the tube. If you have min wall tubing, it is recommended that you drop down one expander size. So instead of ordering a 14 BWG expander, you would drop down to a 13 BWG. This ensures that the expander will fit inside of the tubes and still achieve the proper range of expansion.
If you are unsure whether or not you have min wall or average wall tubing, it is important that you measure the inside diameter (ID) of your tubes prior to ordering tooling. If you do not take an average measurement, you may end up having to order additional sizes or spend time re-rolling tube joints later on.

**Setting Up A Condenser Expander**

Once the right tool has been selected, the tube expander’s collar will need to be set to the correct roll depth. Generally, you want to set the rolls 1/16” to 1/8” from the back of the tube sheet. This will ensure that the tool does not roll beyond the tube sheet. Simply, loosen the set screw on the collar, adjust the collar threads to the desired roll depth, and tighten the set screw on the expander’s cage flat. This will allow the expander to be adjusted to other depths if necessary.

**Expanding Tubes**

Once the collar has been selected and set, you can start expanding tubes. Using your predetermined wall reduction and calculated target ID, roll the first tube and check the finished tube ID. If the ID is over target, lower your torque value. If the ID is under target, increase the torque accordingly. Always expand an unexpanded tube when setting up. Once your target ID is achieved, go back and re-roll the initial setup tubes.

**Step Rolling**

In situations where the tube sheet is thicker than the length of the rolls, step rolling may be necessary. It is recommended to roll from the back of the tube sheet to the front of the tube sheet to allow tube growth to flow towards the operator or outside of the tube sheet. This will also help prevent the expander from putting stress on the tube and causing premature tube failure. Double radius rolls are recommended for step rolling. When rolling each step, you want to make sure the rolls overlap the previous step by 1/8” - ⅛” for a smooth transition.

**Keep Tube Expanders Clean And Cool**

In order to get the best results and improve tool life, it is important to keep the expander clean and free from debris. There are two common types of lubricants that can be used for tube expansion: paste lubricant and liquid lubricant. While some operators have personal preferences with what type of lubricant they use, there are a few industry recommendations and standards to consider.

Liquid lubricant is often used on stainless steel or titanium tubes due to its low sulfur content. It is also commonly used in the electronic and nuclear industries. Paste lubricant, on the other hand, is commonly used in air coolers or other applications where the operator is reaching through the header box, as it doesn’t drip into the vessel. When using paste lubricant for copper and brass tubing, it is recommended to dilute the paste. Paste lubricant is also used when the operator wants to put lubrication in the tube prior to rolling.

Both lubricants prolong tooling by keeping the tube expander cool and preventing debris from adhering to the expander’s mandrel and rolls. A cooler cleaner tool will extend tool life by as much as 2 times.
Watch For Wear

Replacement of damaged rolls and mandrels is necessary in order to eliminate tube leaks and damage to the tube or tube sheet. Proper maintenance of consumables also ensures no other parts of the expander become damaged.

Carefully inspect the length of the mandrel and rolls for scratches, pitting, galling, or spalling on the tapered surface and replace them if any irregularities are found. Since worn mandrels and rolls can damage other parts of the tool, it is important to replace worn or chipped parts immediately.

Parallel Pin Expansion

A traditional expander’s rolls are set at an angle to the mandrel, otherwise referred to as a feed angle. This feed angle causes a screw-like action that automatically feeds the mandrel into the tube as it rotates. With parallel pin expansion, the rolls are set parallel with the mandrel with zero feed angle. This means that the mandrel will not self-feed as a traditional expander would. Instead, the mandrel is pushed through the expander by force, in most cases hydraulic, causing the tube to expand.

There are two common reasons for choosing parallel pin expansion. The first is that it could reduce the stress on tube seal or strength welds. The second is that it is typically much faster than traditional tube expansion.

Some end customers are requiring manufacturers to use parallel pin expansion on seal welded tubes. They believe this process can better protect the integrity of the weld. In traditional expansion, the feeding of the mandrel introduces a pulling force on the tube, thus creating stress at the weld. With parallel pin expansion this force could be reduced or eliminated since the mandrel is being pushed into the tube and the rolls are being forced directly outward towards the tube wall.

Parallel pin expansion is significantly faster than traditional expansion due to the method in which the mandrel is pushed and pulled from the tube. In traditional expansion, the rotation of the mandrel combined with the feed angle determines how quickly a tube can be expanded; once the expansion is complete, the mandrel rotation must be reversed to remove the expander from the tube. Parallel pin expanders are constantly rotated in one direction while the mandrel is being pushed and pulled from the tube, independent to its rotational speed. This eliminates a portion of the time that a traditional expander needs to feed into and out of the tube, reducing the expansion cycle time by 50%.
Rolling Motors & Torque Control

There are two motor power sources that are used for expanding tubes mechanically: electric rolling motors and pneumatic rolling motors. Determining what motor to use for a job will depend on operator preference, availability of electricity or air, and the application.

Electricity offers better consistency when rolling tubes and is more readily available than air. Electric is the best option when you’re trying to roll to a very specific ID, because there’s less variation. Pneumatic motors offer faster speeds and more power; however, they can be susceptible to fluctuations in air supply. Pneumatic would be preferred in larger boiler applications because of the higher torque required to move a large amount of material.

Motor Torque Control

Torque controlled tube expanding is the most popular method for tube expansion because it compensates for variables which the operator/technician cannot control, such as sheet hole ID variance and tube wall thickness tolerances.

Electronic Torque Control

When using an electrical energy source for tube expansion, an Electronic Digital Torque Control monitors the power required by the electric rolling motor to properly expand the tube. This is done by constantly monitoring the amperage (amp) draw of the tube expansion motor.

As the rolling motor provides rotation during the rolling operation, the added resistance of reducing the tube wall requires additional electrical power. As this wall crush resistance increases, the motor’s amperage usage increases. Adjustable selections on the torque control allow the operator to establish a cut-off point which, when reached, will stop the electrical power to the motor. An LED readout on the control indicates the actual amperage usage of the rolling motor during all phases of the
operation. Since this process references motor power requirements after metal-to-metal contact (tube to sheet hole), any variances in tube or sheet hole dimensions are diminished.

**Pneumatic Torque Control**

Pneumatic Torque Controlled Rolling motors are similar in practice to electronic tube expansion motors. As resistance is encountered during the wall reduction of tube expansion, the pneumatic torque control shifts a valve that stops the flow of compressed air to the motor. Power is reapplied as the motor is activated in reverse to release the tool from the tube.

**Dimensional Rolling**

Dimensional rolling is when an operator rolls a tube to a predetermined size, by stopping the forward travel of the mandrel. This can be done with either visual cues or by setting a mandrel stop. This restriction limits the diameter the rolls will expand, allowing for consistent and repetitive size control. For dimensional rolling to be accurate and repeatable, the tubes must have very controlled wall thicknesses and diameters, and the tube sheet hole diameters must be held to close tolerances. This process is usually used in roll beading applications and the generation bank of a water tube boiler.
Assisted Tube Rolling Systems

One of the most effective ways to prolong tool life and increase productivity is through the use of an assisted tube rolling system. Equipped with features such as torque control, an expander holder, and auto-lubrication, these systems can significantly increase expansion consistency and expander tool life.

Torque control systems accurately measure torque in order to roll to the target wall reduction each time, eliminating the amount of rework needed on a vessel. Additionally, an articulated arm and expander holder securely support the motor and expander to ensure proper tool alignment and eliminate premature breakage due to axial loads. Lastly, auto-lubrication provides automatic expander lubrication in order to increase tool life and reduce downtime spent re-lubricating tooling.

Consistency

Assisted tube rolling systems will be significantly more consistent than rolling by hand due to a built-in torque control system. While pneumatic motors are faster than electric, they tend to have challenges with consistency due to fluctuations in air volume or pressure. To overcome this, some systems will utilize an electronic torque control that can work with a motor regardless of its power source.

Productivity

There are several factors that can influence productivity, such as, the speed of the system, operator setup/cleanup, and downtime due to rework.

The time it takes to expand a tube, reach torque, reverse, and move to the next tube will determine system speed. Reducing the time spent in between expansions can greatly decrease job time. When comparing options, an electric system will be fast, a hybrid system will be faster, and a hydraulically powered motor will be the fastest. Auto cycling and auto-reverse features also boost productivity by further decreasing cycle time.

In addition to system speed, the amount of operator setup or cleanup required can also influence productivity. Depending upon the application it can take hours to lubricate tooling and cleanup excess lubricant after expansion. Thus, using a system with auto-lubrication can greatly reduce the amount of downtime between tube expansions.

Rolling to a consistent target wall ID is critical to avoid over-rolling or under-rolling tubes. If a specific wall ID is not reached it can result in costly re-work and postpone job deadlines. While most assisted rolling systems have torque control, some older systems may not be as precise. Depending upon the tolerances required, upgrading to a newer model can increase accuracy and consistency.
Auto-Lubrication System: Lubrication flows through the cage directly to the rolls and mandrel.

**Ergonomics**

Assisted rolling systems are equipped with features to reduce fatigue and stress when rolling. A counterbalance type system will reduce the weight of the motor for the operator when rolling. However, most counterbalance systems do not absorb the torque of the motor, causing the operator to take on that force. A system with an articulated arm will support the weight and absorb the torque of the rolling motor, allowing the operator to effortlessly roll and move the motor into position.

In addition to absorbing motor weight, rolling systems are also easier for operators to use. For example, an auto-reverse system will roll until it hits torque and automatically reverse out of the tube, speeding up cycle times. Further, some systems are equipped with auto-cycling. This allows the operator to simply turn the system on and it will start, stop, and reverse without any operator intervention.

Overall, assisted tube rolling systems are a great way to increase productivity and decrease cost.
Contact Us

Elliott Tool offers a complete line of precision tube tools to meet your needs. Contact us or your local support.

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