Western Instruments
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Producing a Testable Weld,

for the use of Ultrasonic Testing Equipment on Resistance Welded Tube and Pipe Mills.

Introduction

Producing a high quality weld is simply not done by just performing some type of Non-Destructive Test (Ultrasonics, Eddy Current, or Flux Leakage) on the weld area. Weld Quality starts on the coil, and must have attention from Breakdown through to Sizing. Non-Destructive Testing (NDT) only confirms weld quality, by not detecting defects. This article specifically discusses Ultrasonic Testing (UT), but many points are applicable to Eddy Current (ET) and Flux Leakage (EMI / MFL) as well.

Forming

The first consideration for an Ultrasonically Testable Weld is the roundness of the Weld Area (Weld Geometry). The Weld should to be as close as practical to the tube diameter when it exits the Pull Out Stand. Not only is a round weld beneficial for UT, but welder manufacturers also encourage 'round welding'. The Mill Operator can not depend only on the Weld Box to produce a round weld, as it starts at the first breakdown pass.

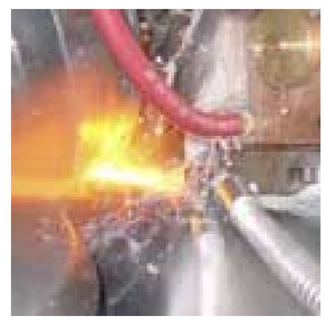
In the late 1970's many mills started to retrofit with 'W-Forming' Rolls on the first Breakdown pass. These type of rolls are an excellent first start to producing a Round Weld. W-Forming induces a slight 'break' into the edges before they become infinitely more stiff as the strip approaches the Weld Pressure Rolls. However, the roll design must ensure that the Breaking of the edges is not too severe, as it may cause the Edge to Stretch and cause weld buckling. The illustration, at the left, shows an early example of W-Forming for lighter wall thicknesses, however there is an excessive amount of 'Edge Breaking'.

The reader will note that this paper refers to ‘rolling’, and all too often poor roll design tends to bend the strip, which will result in excessive edge growth which causes weld buckling. There is a fine line between excessive rolling and simply bending the strip. Strip Width Growth, as measured after the Fine Passes, should not exceed 2%.

As the strip progresses through the breakdown passes and forming (or a Cage), the operator should recognize that the strip has been rolled into a basic round shape. The operator can not expect the Fin Passes to be used to form the strip much more. Many operators don’t seem to recognize that the Fins have two basic functions; to round out the weld area, but more importantly to prepare the edges for welding. Excessive work in the fins will result in damaging the Fin edge, which will result in damage to the strip edges.

Between the last Fin Pass and the Weld Pressure Rolls, mills are equipped with Seam Guides. This component, as the name states, is simply used to guide the edges into the Weld Pressure Rolls. There should only be a minimum pressure between the Seam Guide and the Rolled Edges exiting the Fins. The Fins represent the last point of ‘Rolling’ until the Weld Box.

Mill Coolant



The primary function of Mill Coolant is to lubricate the Roll/Strip interface. Secondly, as the name applies, it is used to cool the process, and this includes the cooling of the largest heat generator, Welding. The Weld Rolls are cooled to reduce heat build due to welding, and often we see coolant in the ‘Vee’ or impinging on the Weld. The effects of Coolant in the Vee is beyond the scope of this article, however, Welder Manufactures stress the use of Filtered Coolant.

Coolant carries away mill scales as it loosens due to the rolling if the strip surfaces. Furthermore, oils are also carried away, but the Water Soluble Oil used in coolant can also become separated. All of these impurities need to be removed from Coolant, as they will cause defects in the weld. When manufactures refer to Filtered Mill Coolant, we mean it should be passed through a Conditioning System that would include: Filtration, Magnetic Separation, and Oil Removal. Filtering isn’t simply allowing coolant to dwell in a settling tank or passing it though through a steel mesh, as there are companies who specialize in this type of ‘Conditioning’.

Edge Condition

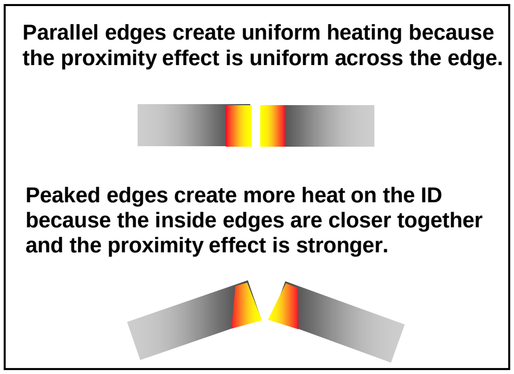
Many new mills are being equipped with Edge Millers, which are installed on the entry, after shearing knives. The edges, from the Rotary Shears, tend to be rough, however have been worked in the Fins for many years. While Edge milling will produce a very smooth edge, both edges tend to have a bevel created due to forming and do not mitigate the need for working the Strip Edges in the Fins.

The Edges coming out of the last Fin Pass should be very smooth. Furthermore, the edges should be as parallel as possible, so when they are squeezed in the Weld

Pressure Rolls they come together flat against one another. Seam Guides are often over used, and can cause damage to the abutting edges. The seam guide, and the Fins should be closely monitored for damage, and should be replaced and dressed often.

Weld Pressure Rolls

There are many different configurations of Weld Box, but in the authors experience, 5 Rolls tend to be optimum for OD sizes above 2" (50mm). The Bottom Roll is simply used to support the bottom of the tube, while the primary pressure is supplied by the Side Closure Rolls. Good tooling design has the rolls containing the section in a round state, however, the top 30° of the tube in unsupported by a full roll.



The Top Rolls are the operator's last point to round out the weld. Top Rolls are of course contoured to the diameter of the section, but are used to bring the edges down and evenly together. Top Rolls are all too often only adjustable in the vertical and horizontal plane, while the optimum designs have the Top Rolls with an angle adjustment as well. This Angular Adjustment permits the operator to adjust the contour of the rolls to an optimum angle to keep the weld area round. Welder Manufacturers stress the need for Parallel Edges, and a Round Weld, to optimize heating patterns. This is illustrated by the above 'tile' from Thermatool's PowerPoint *Welding Tutorial*.

If the Weld Area is reasonably round when it enters the Pull-Out Stand, typically located immediately after welding, the stand can be un-driven. The rolls on this stand are designed for the 'as welded' diameter of the section, but unfortunately High OD Flash is allowed to pass through this stand. More often than not, the top roll is neglected and tends to be galled and damaged by high OD Flash. With a severally worn top roll, the Outside profile of the weld can be changed.

The Weld Area is very 'dynamic', in that the geometry of the abutting edges are always slightly changing, due to mill set-up, dynamic strip conditions, etc. The Challenge to the operator is to make the Weld as consistent as possible, always aiming for a reasonably round Weld Area. The authors preference for Sliding Contacts is not at all the reduced power requirements, but the extra attention required by the operator. The extra time required to dress contacts to minimize Arc Burn, counters to reduced power requirements for welding. With a good crew, Induction Coils allow an operator the extra time and attention to constantly make mill adjustments, but all too often we see a lax crew when Induction welding is being done.

Flash Removal

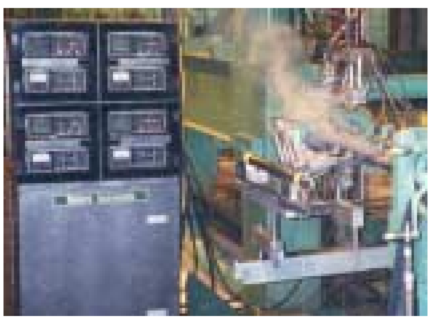
OD and ID Flash removal is performed immediately after welding, and before the Pull Out Stand. ID Bead Cutters represent one of the most difficult operations in Tube and Pipe production. For Ultrasonic Testability, a slight ID undercut is beneficial, as opposed to a slight amount of Inside Bead. With respect to OD Flash Removal, a slightly contoured (radiused) Tool is very beneficial, not only for testability, but to avoid excessive cold work to the weld in the sizing section, were a flat OD cut must be filled.

The desirable designs of ID Cutting Mandrels and OD Tool Holders allow for ‘on the fly’ adjustment of; rotational steering for alignment to the weld, Vertical Adjustment for the depth of the cut, and of course fast disengagement for end welds. These functions are especially useful when a Flash Gauge® type UT system is used, as they allow the operator to immediately see the results of any tool adjustments. All ID/OD Flash Monitors require a good OD profile for optimum performance.

When a Flash Gauge® displays an OD Profile, the operator can immediately see if the edges of the Strip have been welded at the same elevation. This ability to measure Edge Misalignment or High Low, allows the operator to make “on the fly’ adjustments to his top Weld Box Rolls.

Hot Ultrasonic Testing

Initial applications for Hot Mill-Line Ultrasonic Testing dates back to its infancy in the early 1960’s, after techniques were developed for Conveyer Line Testing. Hot Testing, immediately after welding has the great benefit of providing immediate feedback to the operator of not just Weld Defects, but defects that are aggravated by a poor mill set-up.



If Ultrasonic Testing is done, on the Hot Weld, both the OD and ID Flash Removal must be of reasonable quality. At this point, the profile is un-sized, so it is important that the Weld is reasonably round, to ensure proper wave propagation. At this point, if the weld is not round, and the OD Cut is not of a reasonable contour, a low level indication could result in the creation of a Rejectable Defect after excessive cold work in Sizing.

Seam Annealers

The benefit of Seam Annealers, on an API Mill, is that a second Pull-Out Stand can be incorporated, after the Annealers, to ‘Re-forge’ the weld, thus refining the grain structure and re-enforcing the weld with a slight build up on the ID. This Re-forging technique also reduces the diameter slightly, thus minimizing the cold work in the Sizing Section.

Many do not realize the importance of reducing the weld temperature to below the *Blue Brittle Range*. The weld could be of a higher temperature for Annealing, however Rapid Heating raises the Transformation Temperatures, and the grain structure does not increase in size as compared to standard furnace heating. Therefore, seam heating equipment (Annealers) are required to raise the weld to typically 1700°F to ensure grain structure refinement. Due to the skin effect and differential heating below the surface, the ID temperature is lower. Wherever the operator can ‘buy’ grain refinement, weld quality and properties will be increased.

Sizing

Performing any type of Non-Destructive Testing within the Sizing Section is simply easy. The Weld is cool, the first two stands have rounded up the weld, and there aren’t as many physical hazards as immediately after welding. However, the operator may have produced 10 or more lengths before defects are detected.

After reviewing the area’s above, we can see that the Sizing Section can aggravate small defects and they can be opened further. The point here, is that the operator wants the Weld to be as sound as possible before the cold work of sizing. Many times the author has found defects immediately after welding, and followed them down the mill to the sizing section, and hear that disheartening noise of Cracking as a defect breaks open.

Conclusion

The point of this article is to stress to operators, that weld quality, starts at the entry of the mill, and that no one area is more important than another. When the Welder Operator is able to produce a good weld geometry, chances are the weld will be good. It goes back to the old adage, ‘if it looks good, its got to be good’.

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