SCARFING TUBE AND PIPE— CUT TO THE QUICK

PART I: DRAWING A BEAD ON SCARFING CONDITIONS

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Editor's Note: This is the first article in a three-part series on cutting, removing, and disposing of weld beads. Part I discusses the reasons to remove the weld bead and equipment parameters that affect the scarfing process. Part II, which will appear in the September issue, will discuss manual and automated removal processes. Part III, which will appear in the October/November issue, will discuss strategies for improving ID weld bead removal and disposal.

MANY commonly used methods of welded tube and pipe production create an upset, or weld bead, on both the OD and ID. This is true for any variation of electric resistance welding (ERW), whether it uses high-frequency (HF) or direct current (DC), and regardless of the current transfer method, such as contact wheels, shoes, or induction coils. Fusion welding methods, such as gas tungsten arc welding (GTAW), plasma, and laser, can produce thickness variations but normally do not produce weld bead upset zones unless hot forging is used.

The weld upset zone is rough, sharp, and undesirable in the majority of finished goods. Therefore, the weld bead must be removed or reduced to make the product marketable. Consequences of not removing the weld bead include personnel injury, lost-time accidents, and product rejection. Accidents involving weld bead scarfing are a leading cause of lost-time accidents in the tube and pipe industry.

Bear in mind that weld beads on the outside of the tube are the easiest to remove. If the removal process goes poorly, the OD can be repaired or reworked. The ID weld bead is far more difficult to remove, and after the tube is manufactured, the ID scarf flaw is almost impossible to repair.

SAFETY IS THE FIRST CONCERN

The top four strategies for reducing accidents are training, training, training, and strict enforcement of safety policies. Be sure that every employee understands the principles of the manufacturing processes so the hazards are clear. Guarding goes only so far in protecting people. Knowledge is the best line of defense.

Equip every tube mill operator and all personnel working near the tube mill with hardhats, face shields, hearing protection, flame-resistant clothing, and hand and forearm guards made from NOMEX[1] or a similar material to protect against cuts and burns.

The next line of defense is plant cleanness. Keep floors clean and dry, and maintain clutter-free work areas.

Finally, use your tube mill equipment the way it was designed to be used. Do not eliminate guards, defeat interlocks, misuse tools, overload the mill, or ignore the maintenance schedule.

TIPS TO IMPROVE WELD BEAD TRIM OPERATIONS

To improve the weld bead scarfing process, concentrate on the factors that affect the weld bead. The main factors are the strip edges and mill parameters.

Strip edge condition affects tooling life, weld fit-up, and the weld bead. Edge condition systems can increase setup reliability and reduce the weld upset.

Pay particular attention to setup charts so strip edges are properly set in the fin passes and you have the right weld approach angle. The setup must follow material requirement guidelines, and the strip width must be appropriate for the yield strength and thickness. A careful setup reduces variations in weld bead upset conditions and contributes to longer scarf tool life.

Work coils and impeder location affect the heat coupling to the skelp edge and thereby affect weld bead scarfing. Scarfing while the bead is as hot as possible is accomplished by balancing forge conditions against OD and ID scarfing needs. The scarfing location should be as close as possible to the weld forge point.

Equally important as scarfing location is coolant control. Do not quench the weld bead any more than necessary—this helps maintain the forge roll life. Rolls and bearings experience heating because of their proximity to the induction coils. New carbide and ceramic scarfing tools are designed to run hot and require

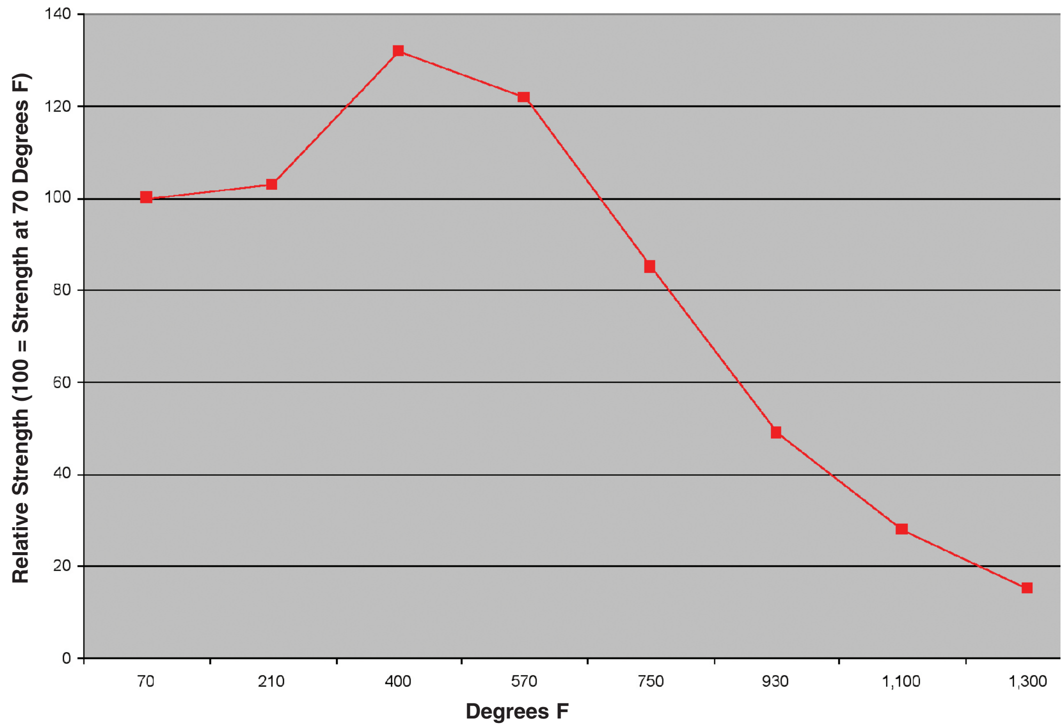


Figure 1
The relative strength of steel changes with temperature, as does its resistance to scarfing. Scarfing the weld bead at the highest possible temperature puts less stress on the scarfing tooling.

consistent, uniform cooling or no cooling at all. Do not subject the scarf tooling to splash or submergence cooling because it cannot withstand the thermal shock load. You must shield the cutting inserts from direct contact with the coolant on both the OD and ID.

Use return-flow impeders to improve inside bead scarfing. If the ID is too small to accommodate return-flow units, attach extensions to flow-through impeders to carry the coolant downstream past the ID scarfing stand or employ offline suction to reduce coolant carryout.

Steel's strength varies with temperature (see **Figure 1**). As its strength varies, so does its resistance to scarfing. Steel exhibits an increase in apparent strength as it cools from about 600 degrees F to 400 degrees F. When the weld bead upset is cooled excessively, the work load on the OD rolling and cutting tooling, the ID bead scarf tooling and rolling mandrel, and the stand increases rapidly. This can cause the mandrels to pull apart and the tooling to shatter. Thus the mantra, "Hotter is better." Scarf as soon as possible after welding, and don't do anything to make life more difficult, like cooling the weld zone. Also be sure the weld seam doesn't roll away from the 12 o'clock position.

Process speed and tension directly affect scarf tooling life. Uniform speed and constant pulling through the scarfing zone are mandatory. Worn roll tools, misaligned roll shaft shoulders, and poor drive setup create intermittent push-and-pull shock loading that leads to accelerated scarf tooling wear. A varying mill speed changes the weld approach angle and, therefore, heat penetration into the strip edge. This, in turn, changes the scarfing cross section. This can lead to two scarfing strands instead of the normal single strand.

FOCUSING ON THE SCARFING PROCESS

Poorly maintaining scarfing stands, selecting improper toolholders, and using the wrong insert grade can affect the scarfing cut finish and, ultimately, tool life.

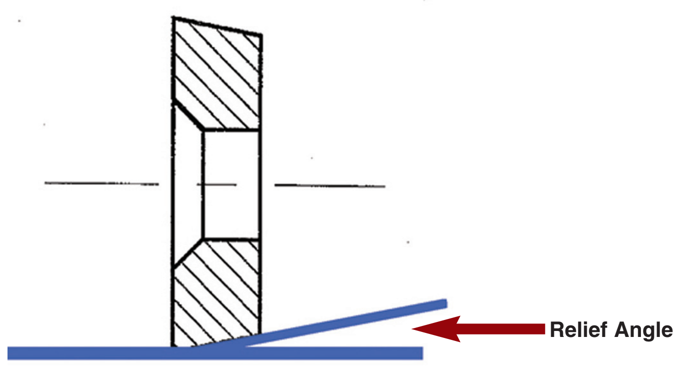
Poor maintenance of gibs and slides causes the toolholder to bend under load. This changes the attack angle between the tool and the tube or pipe, and it affects the tooling work load. Cutting with a shallower angle of attack (that is, an angle that is more laid back against the direction of travel) puts a lower scarfing load on stands and increases tool life. One clue that belies a shallow attack angle is a rippled appearance (chatter marks) in the scarfing zone. A chattering sound is a clue that the scarfing tooling requires maintenance.

As a rule, the angle of attack should be around 15 degrees for most carbon steel applications for OD scarfing (see **Figure 2**) and 30 degrees or more for ID scarfing.

Cutting tools are back-relieved by approximately 18 degrees so they do not drag on the scarfed surface. Steeper and shallower back angles have advantages and disadvantages. Shallower angles create less tool drag and reduce cutting force, but they also have a smaller cross section and mass in contact with the bead.

Selecting scarf tools for a variety of material grades and speeds is not easy. Only a dedicated collection of operational data and proper experiment controls can provide accurate guidance in finding the best balance. Such work always pays off, so don't give in to the next great craze in inserts. Experiment with a variety of scarfing tooling, but depend on actual results to justify tool selection.

Selecting the right radius is also criti-



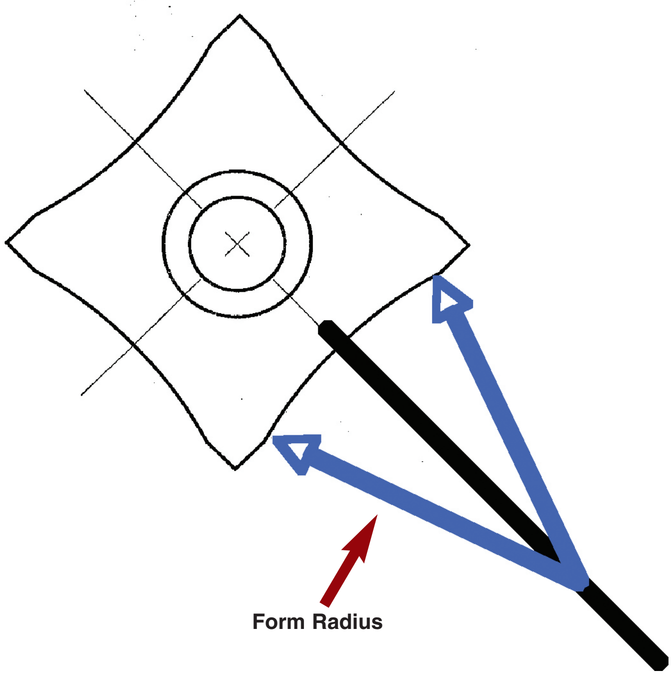


Figure 2

Select OD scarf tooling that has the proper relief angle (about 18 degrees for most carbon steel applications) and proper form radius (between 110 percent and 150 percent of the tube's OD).

cal. Using tooling that has a larger radius than required can create a flat. Tooling that has a smaller radius than required can create fluke gouging from the corners of the tool. Improper radius selection can lead to increased tool consumption, lost uptime because of frequent tool changes, and customers rejecting the finished tube. As a rule of thumb, select a radius that is between 110 percent and 150 percent of the tube OD.

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Note

1. NOMEX® IIIA is a blend of NOMEX meta-aramid and Kevlar® para-aramid fiber manufactured by E.I. du Pont de Nemours & Co. It is resistant to flames; dissipates static; and is resistant to many chemicals, including organics, acids, and bases. The fire resistance does not wash out during laundering. It is widely used for clothing for military personnel, firefighters, auto racers, and industrial workers.