TECHNICAL BULLETIN

EHF

TB-1017

Producing ID painted conduit with HF induction welding.

Conduit is a highly competitive, low margin part of the welded tube market. In order to make money, especially on 1/2" & 3/4" EMT conduit, it is essential to run the operation at high speed, with minimal downtime. Secondary operations must also be kept to a minimum, since the most succesful conduit manufactures produce a finished product, bundled & ready to ship, directly off the tube mill.

Conduit Manufacturing Overview

The lowest cost raw material for conduit is hot rolled low carbon steel strip. This is generally cleaned using chemical and mechanical means, formed into a tube, then welded using either low frequency ERW or high frequency induction. After welding, the tube undergoes further in line cleaning & surface preparation. It then passes through an induction preheater and into a hot dip galvanizing bath. After cooling, a clear coating is usually applied & cured by heat or UV light. The product size & manufacturers code is printed on the outside of the conduit "on the fly" & it is finally cut into 10 foot lengths using a flying shear & bundled for sale.

In addition to the zinc and acrylic coatings applied to the outside, most conduit is internally spray painted with a coating which inhibits corrosion & reduces friction, making it easier to draw wires through the conduit. Since this internal coating is organic, it would oxidize readily at the temperatures used for hot dip galvanizing, so an inert gas is used to displace oxygen from the tube ID.

Welding Methods

Two methods are commonly used to provide the longitudinal weld in manufacturing conduit. Each has strengths & weaknesses.

Low frequency ERW is the older of the two process. A motor generator set, or solid state inverter is used to convert 3 phase utility power into single phase power at 60 to 360 hertz. This is applied directly to the tube using a rotating transformer & large copper electrodes. Low frequency ERW is limited to lower speeds because of the stitching effect caused by the current passing through zero twice in each cycle. At zero current, no heat is produced and a stitched weld results. At 500 ft.minute, a 360 hertz welder produces an unwelded stitch every 1.4 milliseconds, or roughly every 1/8". ERW welders also require more expensive & more frequent maintenance than induction welders.

High frequency Induction is far more efficient than low frequency ERW because a much smaller mass of metal is heated. In addition, a well designed induction welder does not produce stitching. In order to realise the high efficiency of this welding method, however, a water cooled ferrite core called an impeder must be positioned inside the welded tube just ahead of the weld area. In conduit production requiring ID coating of the tube, the presense of this impeder in the tube can introduce some problems, especially at smaller tube diameters.

Some conduit is manufactured from pregalvanized strip, however this is generally more costly than in line hot dip galvanizing, and the zinc in the weld area evaporates at welding temperatures, requiring regalvanizing of this area. Pregalvanized strip can also lead to problems with induction welding, since the evaporated zinc tends to sublimate onto the impeder & coil, leading to premature failure.

The application of an internal anti friction coating requires that the inside of the tube be free from coolant. With induction welding, this requires the use of either gas cooled or return flow liquid cooled impeders. Gas cooling is extremely inefficient and expensive to operate because very high volumes of gas are required to remove the waste heat generated in the impeder. Flow rates of 15 to 25 cfm of nitrogen are commonly required. Using chilled nitrogen from cryogenic storage would appear to reduce the volume required, but in fact this is not usually helpful. As the temperature of the ferrite is lowered, more energy is required to overcome the coercive losses in the material, so more cooling is required. If the impeder is not adequately cooled, more electrical power is required to weld the tube. In addition, impeder life is reduced, leading to increased downtime.

The most difficult conduit product to manufacture profitably is 1/2" EMT. This is a light walled tube, with an OD of 0.706", and a wall thickness of 0.035" to 0.042". The ID at the weld point is approximately 0.640". Into this space the following must be placed:

- An impeder with a largest possible mass of ferrite.
- A tube to carry the anti friction paint coating.
- If in line hot dip galvanizing is being used, an inert gas must be introduced past the impeder.
- Cooling water inlet & return lines for the impeder.

Impeder design

A typical impeder for welding 1/2" EMT conduit is 14-15mm in diameter & 230mm (9") long. It has a 4-5mm (5/32" - 3/16") hole through the center for the paint & nitrogen, and two 3mm (1/8") coolant lines. The ferrite generally consists of a bundle of small diameter cylindrical rods. The outer case of the impeder is usually high temperature resin bonded glass fibre tube.

The impeder is a critcal part of the induction welding process, however its role can be reduced to some extent by optimizing the presentation of the strip edges & minimizing the distance from the exit side of the coil to the weld point. This second point can be difficult to achieve on small diameter tubing because of constraints placed on the design of the weld rolls & the induction welding coil. Ideally the length of the coil should be equal to its ID, or slightly less. For 1/2" EMT, this dimension is typically 25mm (1"). The distance from the exit side of the coil to the weld point should also be in the order of 25mm (1"), however this requires the use of extremely small weld rolls. Small rolls result in high rotational speeds, causing bearing life to be a limiting factor. Good results are reported by some manufacturers by using alumina or silicon

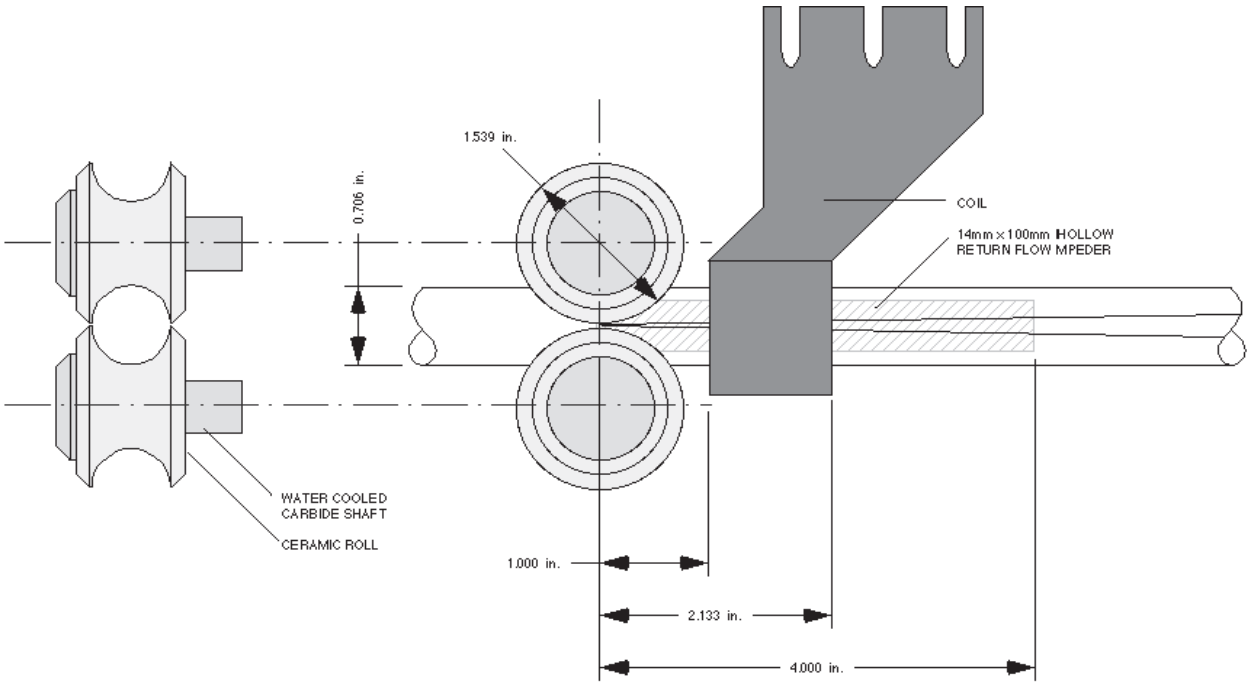
nitride rolls running directly on water cooled TiN coated carbide shafts without bearings. This type of weld roll arrangement cannot apply high forging pressure to the weld, so strip edge presentation must be correct.

Welder Mechanicals

By carefully optimizing the mechanical aspects of the coil & weld rolls, it is possible to weld 1/2” and 3/4” EMT conduit using impeders that are only 100mm (4”) long. The shorter impeders generate less internal heat, simplifying the cooling requirements. There is also less resistance to coolant flow, so flow rates can be as much as 30% higher.
Welder frequency also plays a role in efficiency. All the energy used for welding is coupled magnetically from the welding coil to the tube. The amount of energy transferred in this manner is proportional to the strength of the magnetic flux and the rate at which it changes (frequency). By raising the frequency, a weaker magnetic field can be used. This reduces the flux in the impeder impeder & also reduces the amount of energy dissipated in the ferrite. A frequency of 600-800kHz. is ideal for small diameter conduit, however larger sizes benefit from a lower frequency in the 350-450kHz. range. Some modern tube welders allow the operating frequency to be controlled over a two to one range & this can be of benefit for conduit manufacturers. In practice, it is rare for 1/2” through 4” conduit to be produced on the same mill, but with the right choice of equipment, it can be done.

To summarize, for efficient induction welding of small diameter conduit, the following recommendations should be followed.

- Use a welder capable of operating at 600-800kHz for sizes below 1”
- Use the shortest possible induction welding coil.
- Use the smallest possible weld rolls. Ceramic, carbide or Ampco 25 are preferred materials.
- Use water cooled hollow return flow impeders
- A coolant chiller with pressure boost pump & filter will greatly extend impeder life.



Welding 1/2” and 3/4” EMT conduit at speeds of 1000 ft. per minute does not require a lot of weld power. With an efficient setup, 250-300kW should be adequate.

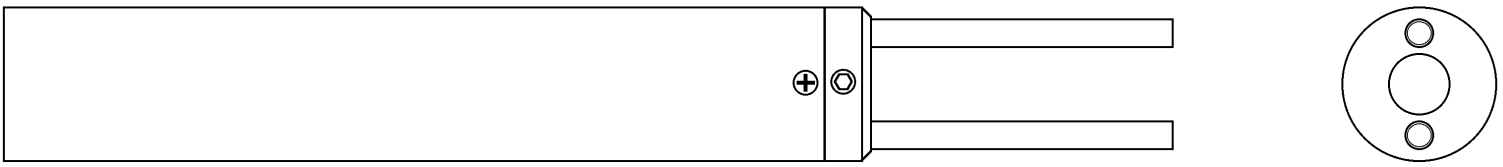
EHE manufactures a range of special impeders and coils for conduit manufacturing. Impeders are available with Silglass™ or Alumina ceramic outer covers. We can also supply coolant systems that guarantee a source of cool, clean impeder & coil coolant to extend the life of these critical components.

Impeders for ID Painted Conduit

EHE impeders for conduit use a high efficiency, single ferrite design which results in increased production speeds and reduced downtime. The use of high power, low loss ferrite materials significantly reduces the amount of cooling required by the impeder. Impeder covers are high temperature inorganic glass reinforced composite materials (Silglass™) or alumina ceramic.

These impeders use double silcone rubber O rings for a reliable fluid seal

NOMINAL SIZE	EMT CONDUIT			IMC CONDUIT			IMPEDER OD	IMPEDER LENGTH	SILGLASS™ PRICE	CERAMIC PRICE
	OD	WT	ID	OD	WT	ID				
1/2"	0.706 in.	0.042 in.	0.622 in.	0.815 in.	0.070 in.	0.675 in.	14.00mm	230 mm.	$68.00	$98.00
3/4"	0.922 in.	0.049 in.	0.824 in.	1.029 in.	0.075 in.	0.879 in.	19.00mm	230 mm.	$72.00	$115.00
1"	1.163 in.	0.057 in.	1.049 in.	1.290 in.	0.085 in.	1.120 in.	22.00mm	230 mm.	$82.00	$155.00
1-1/4"	1.510 in.	0.065 in.	1.380 in.	1.638 in.	0.085 in.	1.468 in.	25.00mm	230 mm.	$95.00	$175.00
1-1/2"	1.740 in.	0.065 in.	1.610 in.	1.883 in.	0.090 in.	1.703 in.	32.00mm	230 mm.	$102.00	$190.00
2"	2.197 in.	0.065 in.	2.067 in.	2.360 in.	0.095 in.	2.170 in.	38.00mm	230 mm.	$105.00	$198.00
2-1/2"	2.875 in.	0.072 in.	2.731 in.	2.857 in.	0.140 in.	2.577 in.	50.00mm	330 mm.	$230.00	n.a.
3"	3.500 in.	0.072 in.	3.356 in.	3.476 in.	0.140 in.	3.196 in.	63.00mm	330 mm.	$330.00	n.a.
3-1/2"	4.000 in.	0.083 in.	3.834 in.	3.971 in.	0.140 in.	3.691 in.	69.00mm	330 mm.	$380.00	n.a.
4"	4.500 in.	0.083 in.	4.334 in.	4.466 in.	0.140 in.	4.186 in.	75.00mm	330 mm.	$425.00	n.a.



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