IBC Onshore Pipeline Engineering Training Course London June 2016

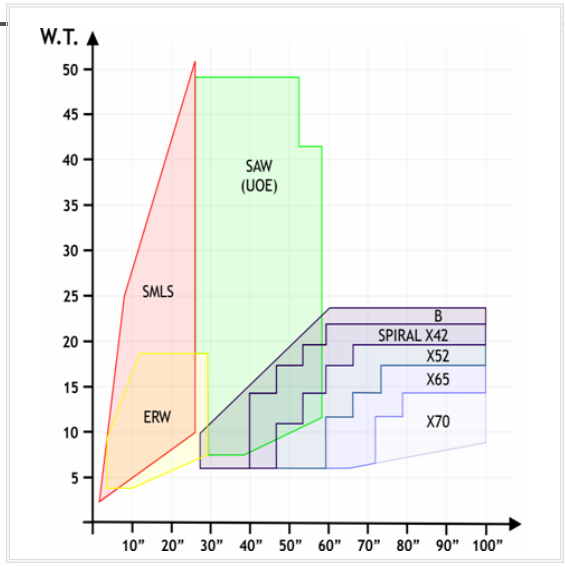
Line pipe manufacture

Alan Denney

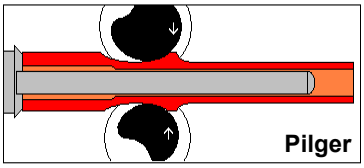
Pipe manufacturing methods

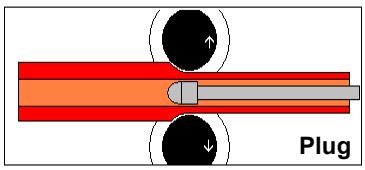
- Seamless pipe
  - made from billets
  - Abbreviation SMLS
- Longitudinal seam submerged-arc welded pipe (or combination welded)
  - made from plate
  - Abbreviation SAWL and COWL
- Helical seam submerged-arc welded pipe (or combination welded)
  - made from coil
  - Abbreviation SAWH or COWH
- Electric resistance or electric induction welded pipe
  - made from coil
  - Abbreviations HFI (high frequency induction) or EW (electric welded)

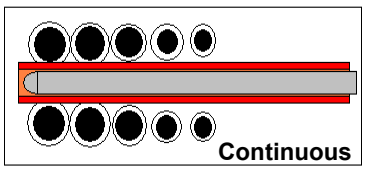
Pipe methods by wall thickness/diameter ranges



Seamless pipe manufacture







Seamless pipe is manufactured by a number of processes including:-

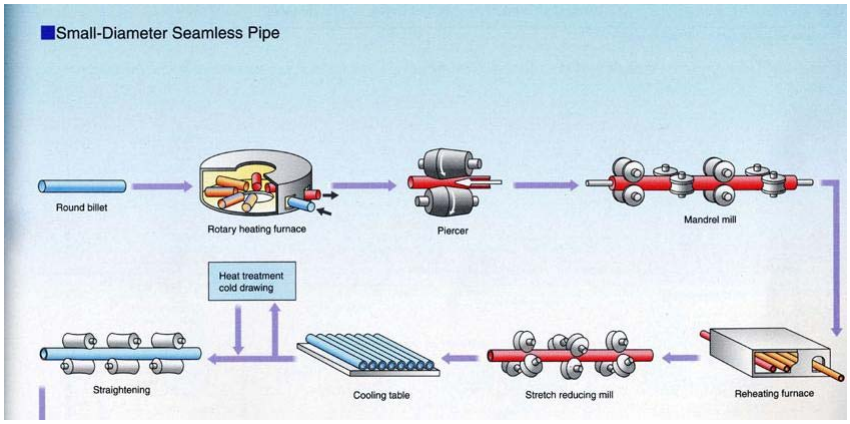
- Pilger Mill
  - Large diameter and heavy wall
- Plug Mill
  - Medium diameter pipe
- Continuous (mandrel) mill
  - Small diameter pipe

The starting point is to pierce an ingot. This is then elongated it by 2- 8 times whilst setting the internal diameter and the wall thickness.

Seamless pipe can also be manufactured by:

- *Extrusion*
- *and Centrifugal casting*

Continuous (retained mandrel) mill



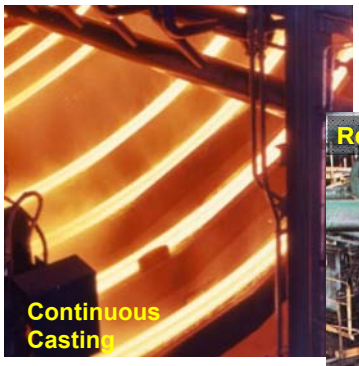
The continuous mill is used for sizes up to about 180mm (7 inch) diameter

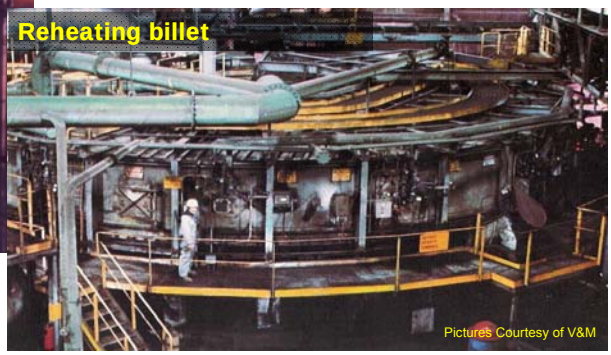
Key manufacturing steps

The feedstock is a billet (or ingot) produced by:

- continuous casting - small diameter
- ingot casting - large diameters

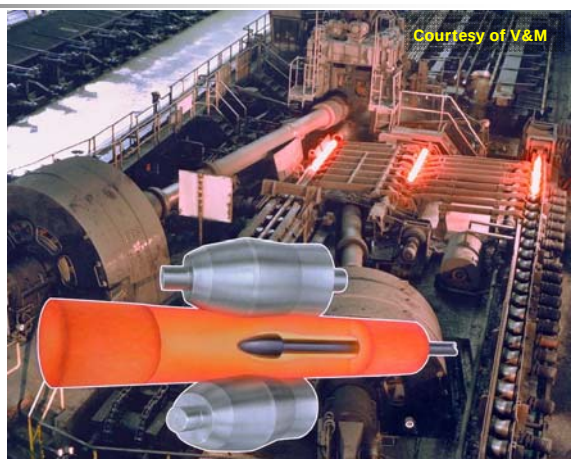
The billet is reheated in a rotary hearth furnace to a temperature of 1200 – 1300 ºC prior to piercing





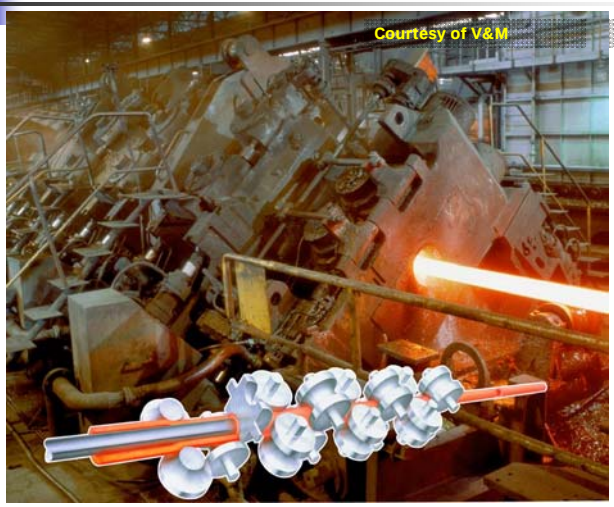
Piercing the billet

A void is formed down the centre by the combination of contra-rotating rolls and the mandrel

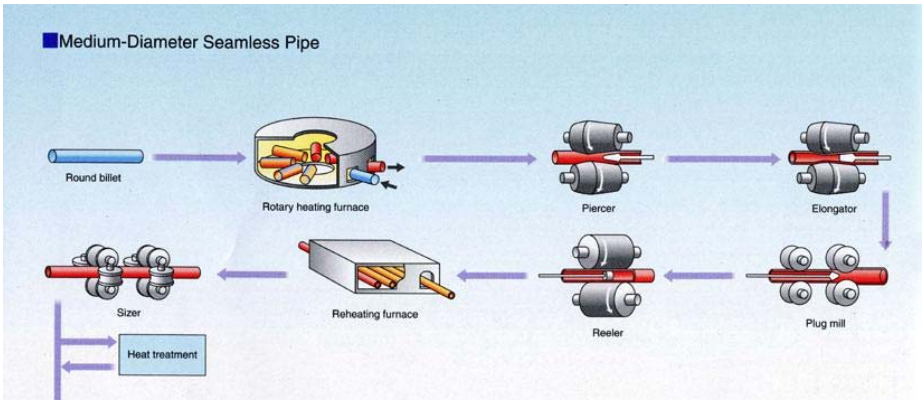


For video see http://www.tenaris.com/en/MediaAndPublications/Videos/Corporate.aspx

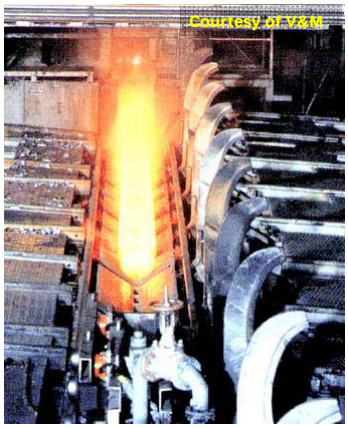
Continuous mill



Plug mill



Plug mill



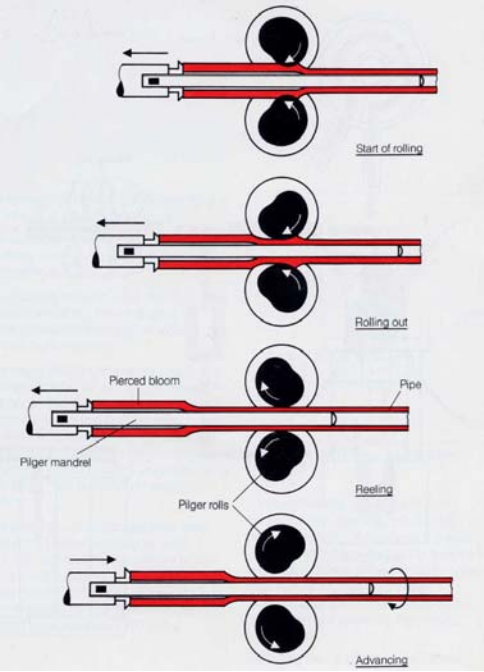
- The plug mill is used for sizes from about 200mm diameter to 350mm diameter
- Larger sizes, up to about 508mm diameter are made by plug mill and then expanded on a rotary expander

Pilger mill

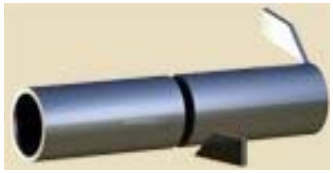
Pilger mill can be used for tube sizes up to 711mm od (28”) and for thick wall pipe

Pilger

- The pipe is formed from the feed stock in a series of steps
- The feedstock is fed forward fed though the rollers
- The rollers then roll backwards and the reduced gap forms the outside diameter
- Rolling continues to smooth this part of the pipe into the first part
- The open roller gap appears and the feedstock is moved forward into it for the next step.



Typical finishing operations 1



7. Cutting to length

8. Cold Straightening

9.Reheating

10. Quenching

11. Tempering

12. Calibration

Illustrations: courtesy Volzshky Pipe Mill

Typical finishing operations 2

13. Hot straightening

14. Cooling

15. Cold straightening

16. Bevelling

17. Hydrostatic testing

18. End Inspection (MPI)

Illustrations: courtesy Volzshky Pipe Mill

19. Ultrasonic Inspection

Supply condition

Available conditions:

- Hot rolled
- Normalised
- Quenched & tempered

Quenching is carried out internally and externally to:

- homogenise microstructure
- minimises distortion

Notable features –seamless pipe

- May be in R, N or Q supply condition
- Internal diameter may be eccentric from piercing
- The motion of the external rollers gives a spiral of thicker material
  - Wider tolerances than with other processes
- Poorer surface condition than pipe made from plate or coil
- Steel has a higher ‘carbon equivalent’ grade for grade compared with pipe made from plate or coil
  - There is impact on welding and on meeting sour service criteria
- Because of the higher alloy content hot formed bends are generally manufactured from seamless pipe rather than pipe made from coil or plate

Longitudinal seam submerged-arc welded pipe

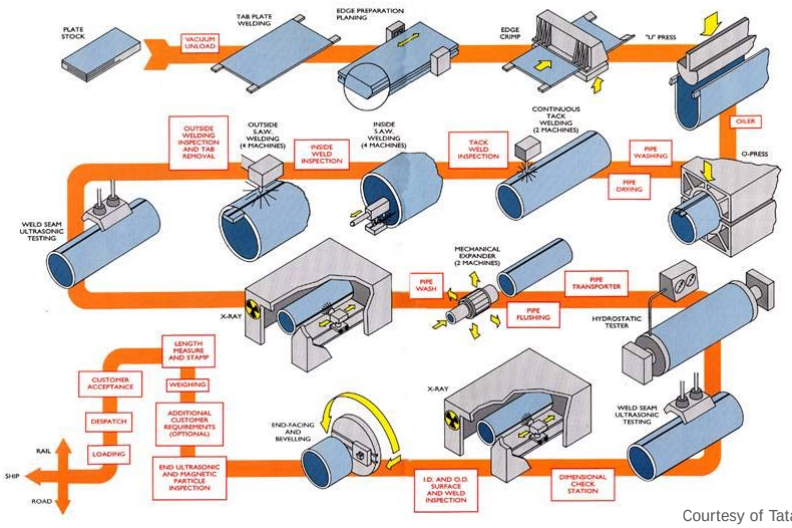
A single longitudinal seam welded both internally and externally.

- The UOE process is dominant

…it is also made by

- 3 roll bending
- Press forming

UOE pipe manufacture



Courtesy of Tata

Preparations for long seam welding

Welding leading and trailing pieces

Courtesy of Europipe

Trimming and bevelling longitudinal plate edges

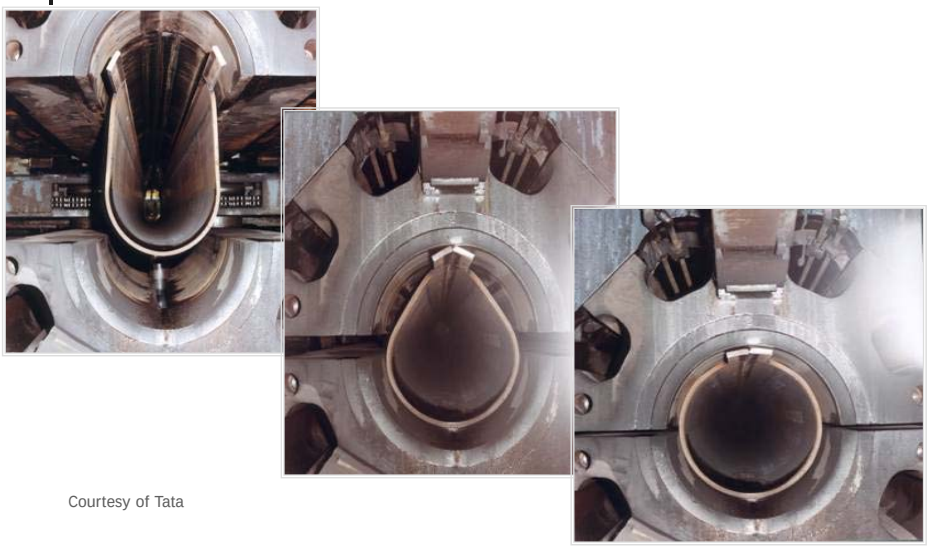
Crimping longitudinal plate edges

Courtesy of Tata

U-ing

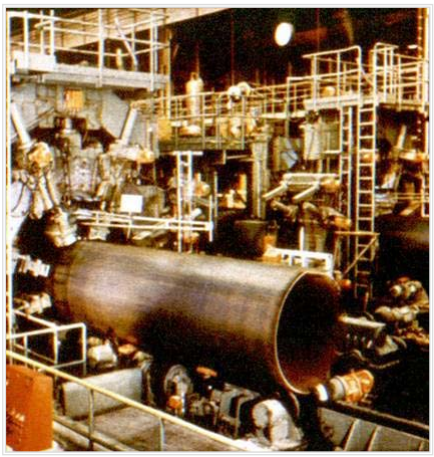
Courtesy of Tata

O-ing



Courtesy of Tata

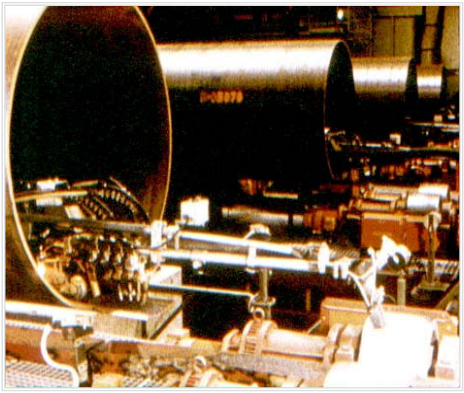
Tack welding



Courtesy of Europipe

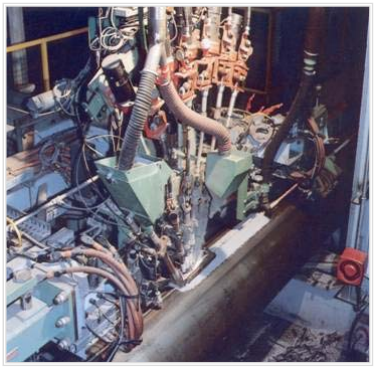
Inside welding

Courtesy of Tata



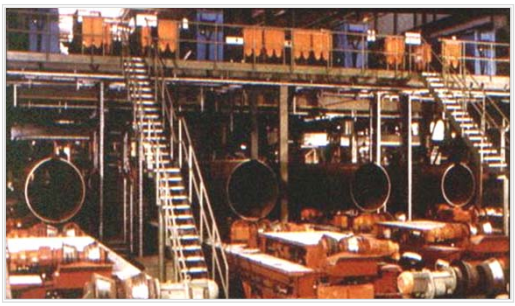
Courtesy of Europipe

Outside welding



Courtesy of Tata

Courtesy of Europipe



Expansion and hydro testing

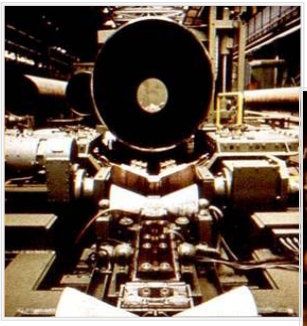
Mechanical expansion

Courtesy of Tata

Hydrostatic testing

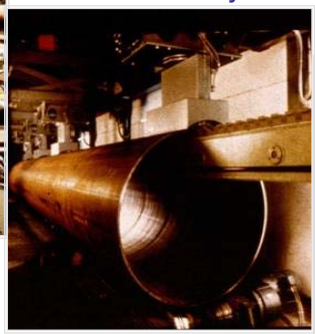
Courtesy of Europipe

Non-destructive testing



US - testing weld

Weld seam X-ray

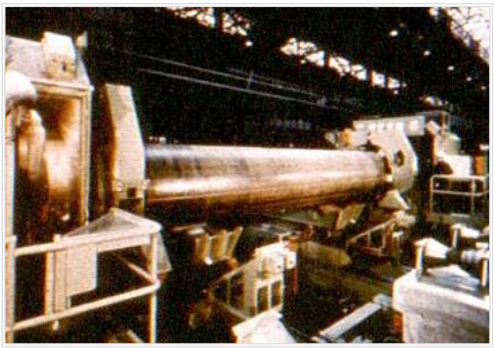


Internal and external magnetic particle inspection

Courtesy of Europipe

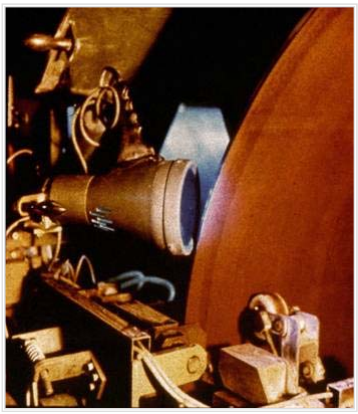
Weld bevels

Bevelling pipe ends



Courtesy of Europipe

Magnetic particle inspection of ends

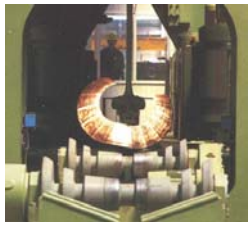


Notable features – UOE pipe

- Plate produced for pipe manufacture is a specialised product involving a lot of mill expertise and sophisticated manufacturing plant
- Lean plate chemistry and TMCP results in high strength and high toughness pipe with good weldability
- A UOE pipe mill is a large sophisticated plant, with high production rates
- The use of plate and the cold expansion step give good and consistent dimensional properties
- Available in wide range of steel grades - up to X120
- Relatively expensive manufacturing route

JCOE forming – heavy wall pipe

- Press forming to form a J shape
- Continuing to press to form a C shape
- Welding the long seam to form a complete circle (O)
- Hydraulic expansion (E)



Pictures 1 & 3 courtesy of Eisenbau Kramer GmbH

Roll forming of tubulars from plate

The steps in 3 or 4 roll ending are as follows:-

- Welding of run on run off plates
- Crimping of the edges
- Forming the tubular in the rolling mill

- Longitudinal seams submerged arc welding using conventional multi-pass techniques
- Re-rolling to improve circularity
- Inspection and dimensional checks.

Forming stages

Crimping of plate edges

3 Roll bending

Electric welded pipe

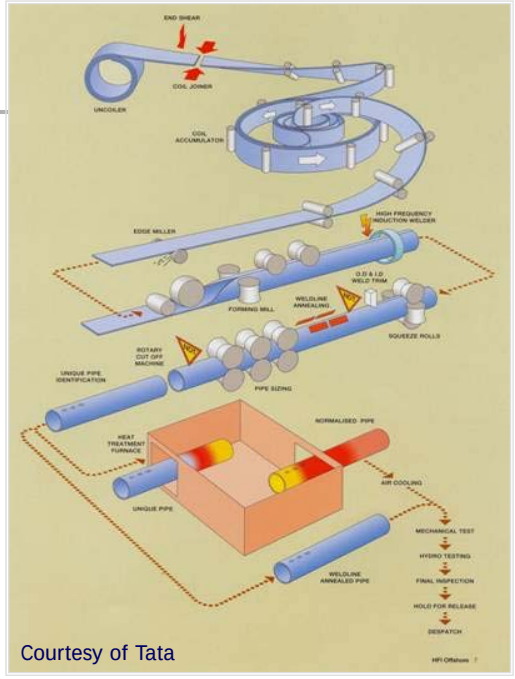
- Electric resistance welded pipe (ERW) (EW in ISO 3183)
- High frequency induction welded pipe (HFI). (HFW in ISO 3183)

There is no filler or welding consumable with these processes

The process starts with the manufacture of steel strip which is purchased in the form of coils

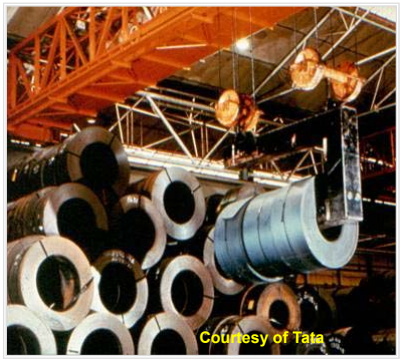
Electric welded pipe

- Heat is generated by the electric resistance of the work
- With induction heating there is no physical contact
- Induction avoids arc strikes outside the weld area
- High frequency current (> 70 Hz) is preferred
- The weld seam and the heat affected zone is heat treated to improve the toughness.



Courtesy of Tata

Steel Coil



Coil

Coil accumulator

Forming

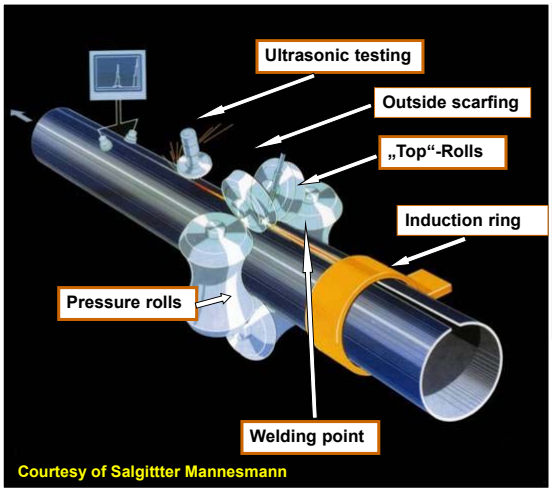
First forming stage

Courtesy of Tata

Overall view of forming

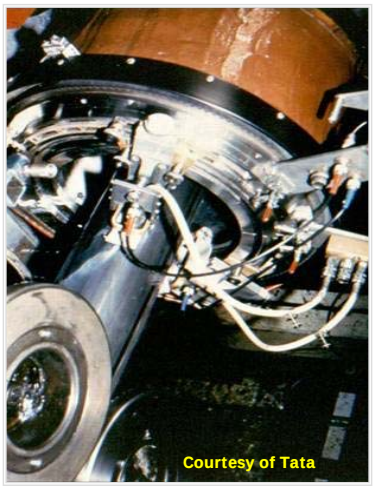
Fin roll

At the point of welding



Exit from welding

Removal of ‘flash’



Online ultrasonics

Online heat treatment

Weld line annealing

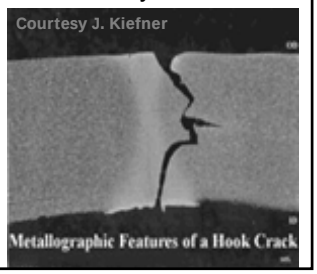
Full body normalising

Electric welded pipe – issues

Generally M or N condition

ERW pipe has a poor reputation due to:

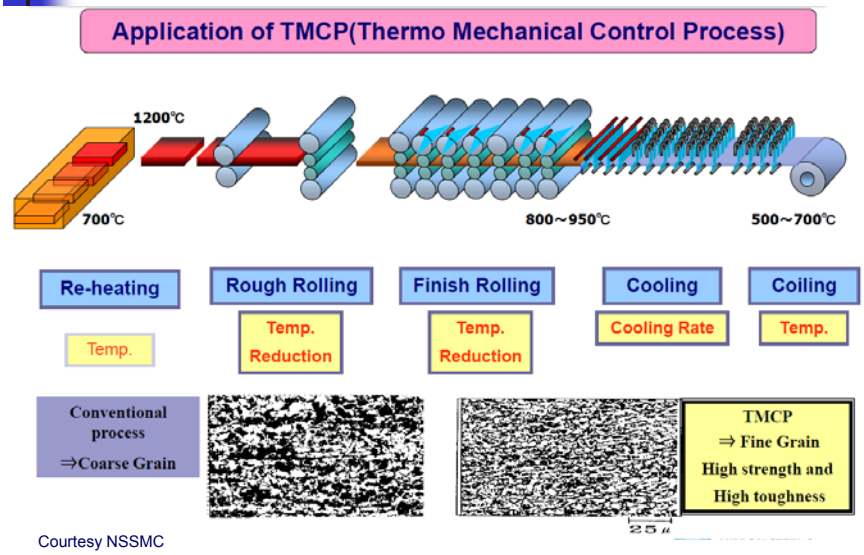
- Low toughness on weld line
- Lack of Fusion Defects: 'penetrators and weepers'. Defects may be tightly closed and transparent to ultrasound.
- Pressure reversal: failure occurs at a pressure level below a previously applied hydrostatic test level.
- Hook cracks: longitudinal line of inclusions or cracks closely parallel to the weld.
- Bad performance in sour gas environments



Other issues

- Grooves resulting from internal flash removal
- Radial offsets at weld line

Modern rolling practice for coil



Courtesy NSSMC

Modern high frequency welded pipe

Many problems have been overcome by:

- Lean chemistry steels – low carbon for toughness
- Use of de-sulphurised and de-phosphorised steels and clean steelmaking practice to reduce inclusions
- Weld line annealing or full body normalising
- Improved non-destructive testing
- Rigorous quality control tests and supervision

Continuing limitations

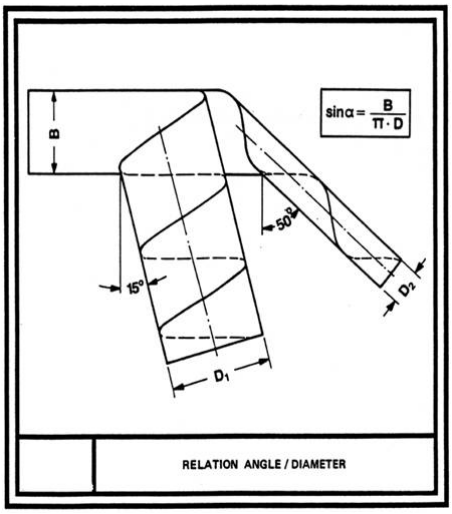
- Not readily obtainable with CV test temperatures below -20°C
- Limited in terms of sour service performance

Helical seam (spiral) welded pipe

Strip of constant width is formed at a specific angle into pipe

By altering the forming angle, strip of a given width can be formed into pipe of different diameters

Spiral welded pipe to API 5L must be submerged arc welded.



Courtesy of Mannesmann/Europipe

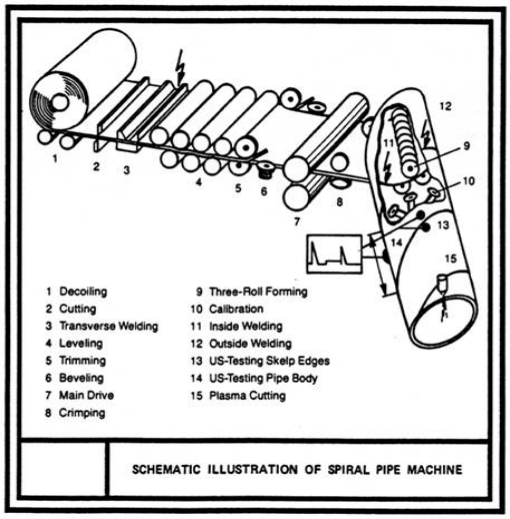
Spiral welded pipe manufacturing process

Three sections to mill

A strip run-in section which can tilt the strip to the forming angle

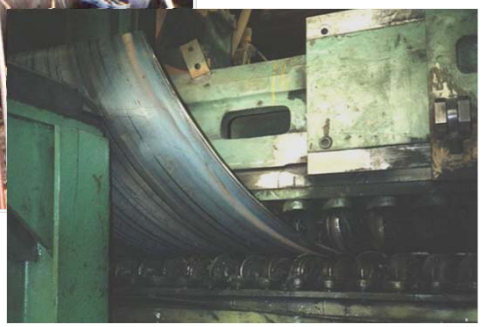
A forming section including a 3-roll bending system and an internal SAW welding station

Pipe run-out section with an external SAW welding station, weld testing and pipe cutting equipment.

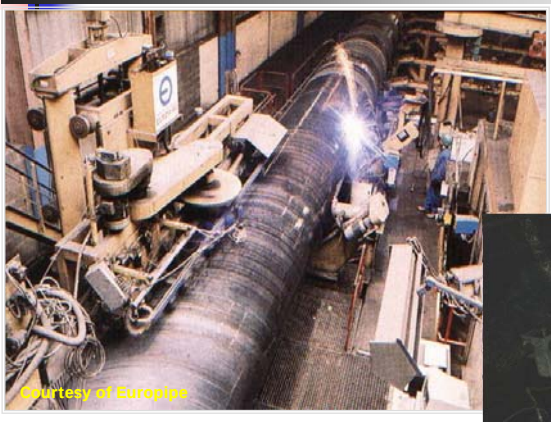


Courtesy of Europipe

Spiral pipe manufacture



Spiral pipe manufacture



Coated spiral welded pipe

Experience

Experience

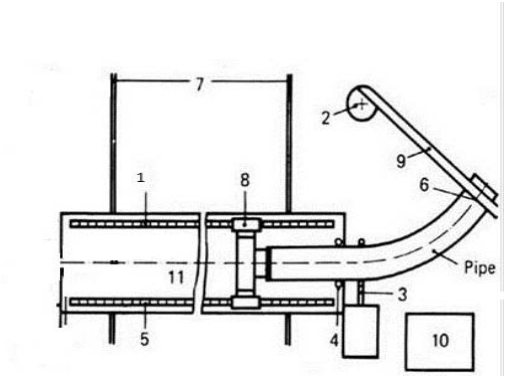
- Used for many water pipelines onshore
- Popular for oil and gas pipelines in developing nations where local plants have been established
  - used for the BTC line in Turkey (Botas)
- Used offshore in the Baltic, the Mediterranean and the Gulf of Mexico.

Attention areas

- Correct alignment and relative positions at the welding station
- Diameter/circularity tolerances and means of checking
- Poorer tolerances could make automatic site welding challenging
- 'Spring' due to the forming process giving a tendency to lose circularity
- Bend radii are greater with spiral pipe than longitudinal seam pipe

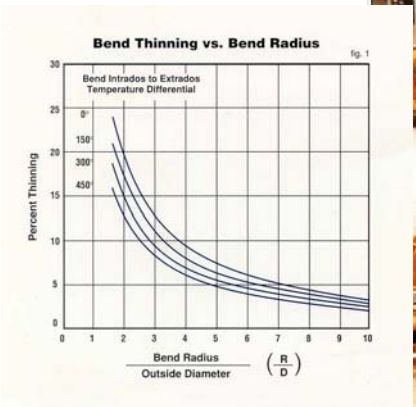
Quality is pipe mill dependant and should not be taken for granted

Induction bending



1. Guidance rails
2. Pivot
3. Inductor
4. Guide rollers
5. Drive chains
6. Clamp
7. Bed adjustment rails
8. Feed carriage
9. Bending arm
10. Power source
11. Machine bed

Induction bending



Courtesy of Angle Ring Co.

Induction bends - attention areas

- Wall thinning is inevitable
- Be aware of the risk of loss of mechanical properties with thermo-mechanically treated
- Investigate the effect on weld line properties
- Have a dialogue with the tube manufacturer and the bend producer on the composition of the feed stock
- Material for bends should be separately identified in purchase orders
- Conduct trial bends
- Juddering at stop/start of bending causing ripples
- Micro-cracks on the external radius (the extrados).

The end