Working with Stainless Steel

Objective

At the end, trainees will able to:

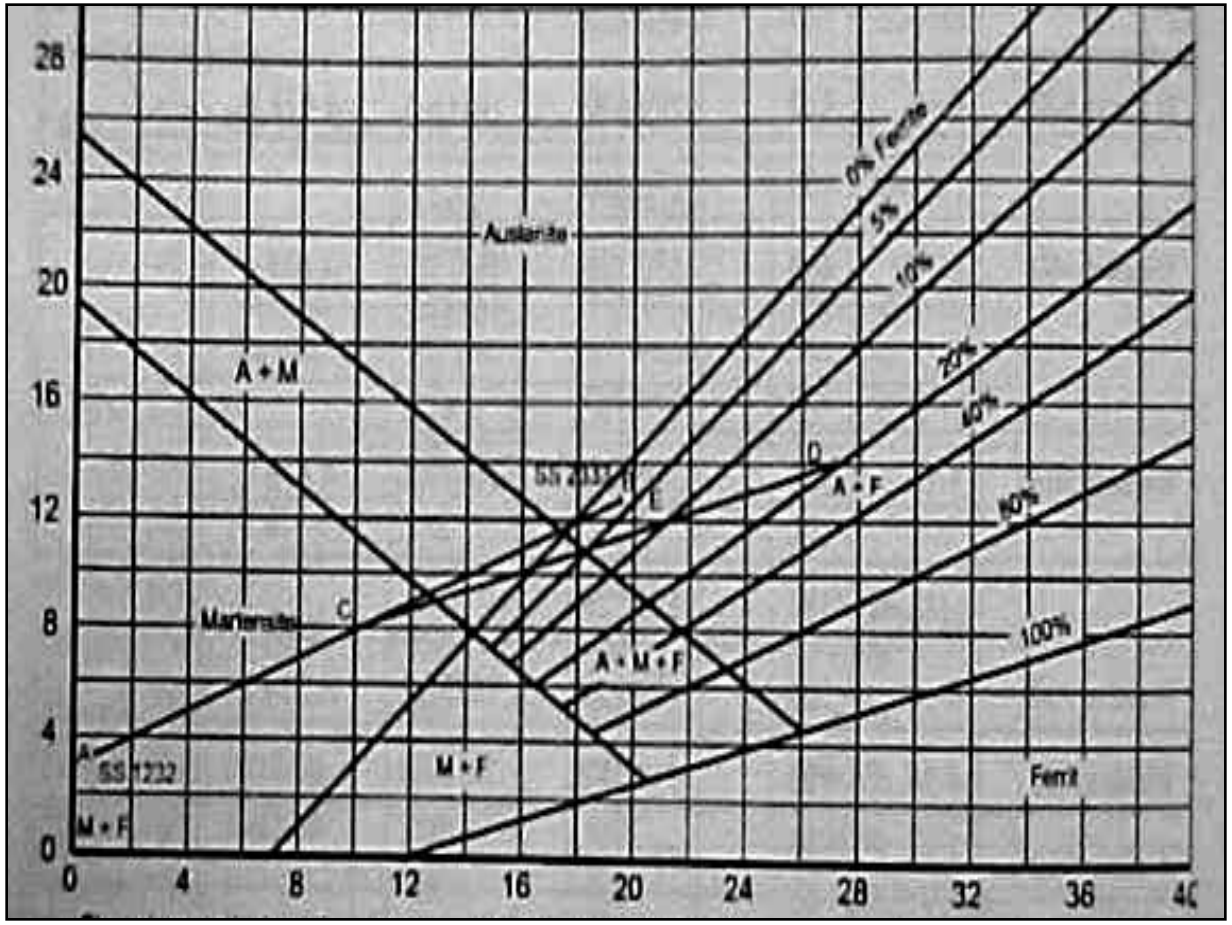
- Identify various types of SS
- Decide proper handling in Workshop
- Follow right metal forming process
- Observe proper welding practices
- Identify corrosion prone areas in coach bathrooms

Introduction- What is SS?

- An alloy of Iron with minimum 12% Cr
- A complex passive film over the surface
- Three varieties
  Ferritic
  Austenitic
  Martensitic
- Only Ferritic & Austenitic grades used in Rlys.

Schaeffler Diagram

Ni
equivalent
= %Ni +
30 x % C
+ 0.5 x %Mn



Cr equivalent=%Cr + %Mo + 1.5%Si + 0.5%Nb

Introduction- Manufacture of SS

- Secondary Steel Melting Process
- Generally with low carbon
  Needs long period of oxygen blowing
  Large amount of Cr loss also takes place during blowing
- Hence cost factor goes up for low ‘C’ variety
- Ingots are generally cold rolled

Introduction- Manufacture of SS

- Various type/degree of surface finish depending on end use
- IS 9511 covers various grades of Ferritic, Martensitic & Austentic stainless steel plates, sheets & strips for common use.
- In Rlys,
  - sheets of 4mm thick to plates upto 32mm thick for wagon.
  - Sheets of 1.25 to 2mm thick for coaches

Characteristics of SS

- Resists corrosion in Oxidising atmosphere
  - Protective film self repairing
- Susceptible to Stress Corrosion cracking
- Ferritic SS magnetic in nature
  - Cheaper variety of utensils
- Austenitic SS non-magnetic in nature
- Higher yield stress compared to MS

HANDLING & FORMING

Surface Protection Films

- Primarily for protecting surface from scratches & scuffing during handling
- Normally pasted with spl. Adhesive
- To be removed before fabrication
- Variety of coating is available for different handling conditions

Polyethylene

- White polyethylene
  - About 80 micron thick white film
  - Transparent or black adhesive
    - Transparent can't withstand sun for long
    - Black can withstand sun for a few months
  - Can be cut with film in place
    - Directly from the back
    - O_2 assisted from top
  - Spl. Films for laser cutting also available

Poly Vinyl Chloride

- Light blue
  - Rubber based adhesive
  - Can't withstand sun for long
  - Can't be cut with film in place
    - Toxic fumes
- Black
  - Heavy duty, about 120micron thick
  - Can withstand sun for months
  - Can't be cut with film in place

Stripping & Surface Cleaning

- At times the film becomes friable
- The adhesive leaves a residue
- The surface soaked with MEK (Methyl Ethyl Ketone), Eucalyptus oil etc.
- Wipe with clean cloth
- If tide marks are left, wash with alkaline detergent and hot water

Handling of SS

- Biggest safeguard is not to bring into **abrasive contact** with STEEL. Traces of steel left behind:
  - Impedes self-repairing process
  - forms Galvanic cell with large Cathode-Anode ratio
  - Very fast rate of corrosion in anode i.e. stee
  - Mar aesthetics, may lead to crack due to corrosion across the thickness

Material Handling

- During transport by crane use Polythelene endless round sling
- During transport by fork lift use SS lugs
- In fixture, use 3mm thick SS plate
- During Welding: SS wire brush & Chisel

Material Handling- Cleaning

- Use Acetic acid, Citric acid & mild soap
- Washing Soda, Sodi-bi-Carb helps to remove stubborn stain
- For oily or greasy stain Petroleum Hydrocarbon, Alcohol or Acetone base solvents work better.
- Avoid abrasive contact with steel
- Don’t use even SS wool on shining surface
- Don’t use Chlorine base solvent

Material Storing

- Corrosion resistance of ferritic SS is not very good, particularly grades used in Rlys
- Try to store in vertically inclined position
- Use SS/wood separator to avoid crevice formation
- Store in well ventilated area
- Don’t keep in close contact with steel for long

Material Forming- Shearing

Shearing

- Capacity reduced by 30-40%
  - Higher yield stress
- Blades of High Carbon-High Chromium
- Blades must be sharp & correctly aligned
- Slower shearing speed to prevent shear break
- Use nominated press for SS or wipe areas of contact thoroughly before handling SS

Material Forming- Cutting

- DA or LPG cutting not possible
- LASER & Plasma cutting best suited
- Arc Cutting possible
  - N_1 class of electrode
  - Grind about 2mm after cutting
  - Dedicated grinding wheel
- Abrasive Cut-off wheel
  - Vitrified or resinoid bonded Al. Oxide disc
  - Water soluble oil as ccolant/lubricant
  - Zirconia-Silicon carbide not recommended

LASER CUTTING

- Very high temp with low energy
- Rly. uses CO_2 LASER
- Only 2500W for cutting 3mm thick SS sheet
- In ICF
  - cutting of side & end wall sheets
  - LASER beam of 0.001” dia
  - 2500W LASER output
  - 15 bar pressure N_2 gas for blowing
- Extremely low HAZ

Plasma Cutting

- for plates <20mm,
  - compressed air (300-500KPa)
  - Air cooled nozzle
- for plates>20mm,
  - compressed air (600KPa)
  - Water cooled nozzle

Material Forming- Bending

- Capacity reduced to 40% compared to CS
- Greater spring back, 5% more over 90^0
- Inner bend radius> twice the thickness
- Bending transverse to rolling direction
- Reverse bending at RT not allowed, preheat to 150^0C
- Bending before weld to prevent HAZ crack
  - Problem of residual stress

SS in Railways

SS Coaches: Matl. Type & Use

S No	Class of Steel	Composition				Application
		C%	Cr %	Ni %	Others	
1	409M (Ferritic)	0.08	10.5-11.75	-	Ti- 6 X C	Side wall & End wall of LHB Coach Side wall below window of EMU, Underframe & Side wall below window of All SSEMU
2	301 (Austenitic)	0.15	16-18	6-8	-	Trough floor , vendor compartment deck sheet, inside panelling, partition wall, drivers cabin etc. of EMU
3	304 (Austenitic)	0.08	18-20	8-12	-	Roof and trough floor of LHB Coach, trough floor roof and side panel above window of all SS EMU, Brake pipe of EMU.

SS in Coaches

- Ferritic SS is cheaper than Austenetic SS
- Corrosion resistance also is poorer
- Used in vertical sections
  - Accumulation of water is less
- In horizontal areas austenetic SS
- For water tank, 316L variety
  - better resistance to pitting corrosion

SS in Wagons

- Ferritic Steel of M-44 grade
- In BOXNHR, only the shell
- In BOXNHL, both shell and underframe
- Commonly known as 3Cr12 steel
- Composition
  C: 0.03%, Cr: 10.8 – 12.5%, Ti: 0.75 Max

Weldabilty & Welding

Weldability of SS

- Weldability of Austenetic variety is good
- Ferritic more difficult to weld
- Three physical properties grossly different from MS which affects welding
  - Low Thermal conductivity
  - High Co-efficient of expansion
  - High Electrical resistivity

Weldability of SS

- Low Thermal conductivity
  - High Temp build up in HAZ
- High Co-eff of thermal expansion
  - Higher distortion
- High Electrical resistivity
  - Red hot electrode in higher current
    - Peeling off of flux – poor shielding

Comparative Physical properties of SS & MS

Property	Martensitic	Ferritic	Austenitic	Carbon Steel
Thermal Conductivity Cal/sec.cm² ºC/cm	0.059	0.049	0.033	0.104
Coefficient of Expansion µ m/m/ºC	11.2	11.2	18.2	13.2
Electrical Resistivity µ Ώ/cm	58	60	70	15
Melting Range ºC	1483-1532	1427-1510	1398-1454	1538

Welding Procedure

Any welding activity can be subdivided into

- Preparation prior to welding
- Actual welding
- Care after welding
- Some special care needs to be taken for welding SS with Corten Steel/MS

Preparation prior to welding

Edge preparation **prior to Welding**

- No edge preparation up to thickness of 3/16“
- For higher thickness bevel preparation
- For unequal thickness butt joints, taper of 1 in 6 to 1 in 4 to be provided
- LASER/Plasma cutting or Arc cutting followed by grinding to be adopted

Preparation prior to welding

Cleaning

- Area about 15 mm from each side
  - free from dust, dirt, grease, oil, paints etc.
- Non-corrosive organic solvent (Kerosene oil, Benzene etc.)
- Chlorine base solvents not to be used
- To remove tenacious layer of Cr-O use
  - SS wire brushes
  - Dedicated grinder

Actual welding

- MIG and LASER (suitable forPUs) or
- Rutile or basic coated electrode
- Preheating & Welding parameter as recommended is must
- For MMAW process, (DC+) or 70 OCV
- Welding current on lower side of the range
- Short arc length to minimise the loss of Cr
  - Prevent formation of pure Austenite bead

Actual welding

- Resort to stagger welding
- Use smaller dia. electrode to minimise heat input
- De-slag properly using SS Chisel and Brush
- Put stringer beads
- Weaving < twice the diameter of electrode

Post weld care

- Grind weld reinforcement
- Finish by using fine grinder
  - This is necessary as stainless steel is susceptible to corrosion if the surface is rough
- Avoid over heating during grinding
- For SS to Corten/MS, paint the surface as quickly possible, as both are anodic to SS

Spl. Consideration for joining SS to Corten/MS

- Different Mech. properties
- Chemical composition widely different
- Physical properties widely different wrt
  - Thermal conductivity
  - Coefficient of expansion
  - Electrical conductivity
  - Melting Point

Spl. Consideration for joining SS to Corten/MS

- Variation in Chem. Composition leads to
  - dilution of filler material chemistry due to mixing
    - Forming unsuitable inter-metallic compounds
- Variation in Physical properties leads to
  - Uneven heat flow causing differential stresses
  - Uneven melting of base materials
  - Uneven expansion causing warping and distortion

Spl. Consideration for joining SS to Corten/MS

- Selection of proper electrode
- Welding parameters
- Dip transfer to minimise dilution
- Arc directed more towards MS/Corten Steel

OTHER ISSUES

Joint Design

- Butt Joints
  - Full penetration for dynamic load application
  - Back grinding or gouging in the reverse side for full penetration > 3mm plate thickness
  - Partial penetration only for static load application
  - Sealing back side to prevent crevice formation

Joint Design

- Fillet joint
- In many application, not load bearing
- Leg length depends on plate thickness

Base Metal Thickness (mm)	Min. Weld Size (mm)
Upto 6	3
6-12	5
12-19	7
Above 19	10

Huck Bolting

- A Process to replace Riveting
  - Least gap between plates
  - Lesser manpower
  - Lesser sound pollution, no smoke
- Medium carbon steel pin, Zn coated
- Low carbon socket
- The pin is pulled against plate
- At end position, the socket is crimped to the thread of pin, excess broken off

Huck Bolting Machine

Huck Bolting Photo

Coach Painting -New

- Degrease with Petroleum Hydrocarbon solvent, low aromatic grade to IS 1745-78
- Grit blast to a surface finish of Sa2.5
- Epoxy Zn Phosphate Primer
  - 2 coats
  - 120 micron DFT

Coach Painting - New

- Epoxy Putty
  - DFT 10 micron
  - Air Dry
- No undercoat
- PU base Topcoat
  - 2 coats
  - 80 micron DFT

Coach Painting – IOH & POH

- IOH – 18 months
  - C schedule - only touch up in 5 days
    - Primer>Putty>Topcoat as necessary
- POH – 36 months
  - A schedule – All over Painting in 9 days
    - Paint removal by chemical
    - Primer>Putty>Topcoat like new painting

Wagon Painting – New

Wagon Painting – IOH & POH

SS in Bathrooms

- In SS coaches, all fittings & inlays are made of composite
- Other coaches are being converted to SS inlays
- AISI 304 type – 19% Cr., 9% Ni
- Large scale Corrosion in
  - Joint area of SS inlay with CS frame
  - Discharge Chute

SS in Bathrooms

- For inlays,
- the issue is bimetallic corrosion
- Water is aggravating the condition
- The joint area is taken to vertical wall
  - Less water & easier replacement
  - **Prope**r application of paint with ROZC primer after welding is recommended
- Discharge chute is replaced by HDPE