

Stainless Steels and Advanced Ferrous Alloys

Contents of PG Elective Course

A) Lecture Sessions at IIT Kharagpur:

1. Overview of Stainless Steel

- a. What is Stainless Steel?
- b. Alloying elements in Stainless Steel and their effect on microstructure and properties.
- c. Major grades of Stainless Steel: Austenitic, Ferritic, Martensitic stainless steels and precipitation hardening grades.
- d. Recent and advanced grades of stainless steels: superferritic, superaustenitic, duplex, Lean Duplex (high Mn and high N), Superduplex and Hyperduplex Stainless Steels.
- e. Cost implications of alloy addition and substitutes.

2. Applications of Stainless Steel in various Segments

- a. Automotive, Railways & Transport
- b. Architecture, Building & Construction
- c. Reinforcement bars
- d. Roofing sheets
- e. Material Handling applications
- f. Process Industries
- g. Life Cycle Cost Analysis
- h. Physical, Mechanical and Surface Properties required for different applications

3. Physical metallurgy of Stainless Steel

- a. Relevance of Nickel equivalent and Chromium equivalent
- b. Why Fe-C diagram is inadequate for Stainless Steel?
- c. Role of alloying elements in ferrite and austenite stabilisation
- d. Precipitation in stainless steel (M_7C_3 , $M_{23}C_6$, Cr_2N , sigma, chi etc.) and their effect on properties.
- e. Deformation behaviour of stainless steels. Role of stacking fault energy and the deformation induced transformation

4. Stainless Steel (SS) making and processing

- a. Complete overview covering Electric Arc Furnace, Argon oxygen decarburisation, Ladle Refining, Vacuum Oxygen Decarburisation, Vacuum degassing, Ingot casting vis-à-vis Continuous casting, Hot Rolling, Annealing &

Pickling, Cold Rolling, Final Annealing and Pickling, Skin Pass Mill, Strip Grinding Line

b. Inclusion control in stainless steel

5. Stainless Steel fabrication

a. Cold roll forming (CRF) process mechanism

b. Welding of Stainless Steel

Effect of alloying elements on weldability of SS

i. Schaeffler De Long diagram and the modified versions.

Sensitization/Weld decay: Causes, mechanisms, remedies

ii. High temperature sensitization

iii. 475 C embrittlement

iv. α' phase transformation

c. Issues faced during fabrication of stainless steel and their solutions

i. Distortion and Ridging: Causes, mechanisms, remedies,

ii. Hot-Cracking, Edge cracking, Sliver (surface crack)

6. Corrosion in Stainless Steel

a. Major types of corrosion

b. Galvanic corrosion: Mechanism and prevention

c. Pitting Corrosion: Mechanism and prevention, Interpretation of PREN

d. Crack propagation mechanisms

i. Inter-granular

ii. Trans-granular

7. Advanced Ferrous Alloys

a. Maraging steels,

b. Steels for power plants and nuclear reactors including ODS alloys,

c. Advanced high strength automotive steels

d. High strength, high toughness steels for strategic application

e. High silicon steels for electrical application

f. High Ni steels (1%, 3%, 9%) for cryogenic application

g. Fe-Cr-Al alloys for high temperature application

B) Plant visit for students (JST plants at Hisar, Haryana, or Jajpur, Odisha)

General demonstration along with brief lectures and demonstration of followings:

Fabrication and surface treatment of stainless steel:

a. Tools and Equipment

- b. Cutting of Stainless Steel
- c. Various Finishes in Stainless Steel
- d. Colour Coating of Stainless Steel
- Testing, Handling and Storage of Stainless steel
- e. PMI technique
- f. Other NDT methods
- g. Recommended procedures for storage

Detailed break-up of Classroom Sessions

- 1. Overview of Stainless Steel: 4 sessions**
- 2. Applications of Stainless Steel in various Segments: 4 sessions**
- 3. Physical metallurgy of Stainless Steel: 7 sessions**
- 4. Stainless Steel (SS) making process: 6 sessions**
- 5. Stainless Steel fabrication: 7 sessions**
- 6. Corrosion in Stainless Steel: 5 sessions**
- 7. Advanced ferrous alloys: 7 sessions**
- 8. Plant visit: 2 days@6-8 hours / day 'OR' 3 days@4-6 hours/day = 12-16 h**

Total contact hours: 40 h Lectures + 2/3 days of plant visit covering weekends.