

TATA STEEL
INDUSTRIAL
CONSULTING
YOUR ASPIRATIONS, OUR ENDEAVOUR



Tata Steel Industrial Consulting **Scientific Services**

About Tata Steel

Tata Steel was established in 1907, as one of Asia's first integrated private steel company and with this, began the development of India's first industrial city at Jamshedpur. Today, it is among the leading global steel companies – authoring innovations, pioneering practices, committed to continually developing teams of world-class employees. In its journey towards excellence, Tata Steel has developed its strengths in diverse areas such as Exploration and Mining, Technology and Best Practices, Human Resource Management, Organisational Efficiency, Research among other vital areas of importance.



Tata Steel Industrial Consulting

The industrial consulting arm of Tata Steel brings to the table the Group's collective experiences and expertise. The journey of the Company's organisational excellence enables it to offer important insights and valuable recommendations that are applicable across industry groups. Tata Steel through this, offers more than just consultancy – the vertical comprises practitioners and experienced subject-matter experts who have delivered results in the organizational context, equipping them to leverage their practical experience and execute unique and proven solutions.

Our expertise includes but is not limited to the following areas:

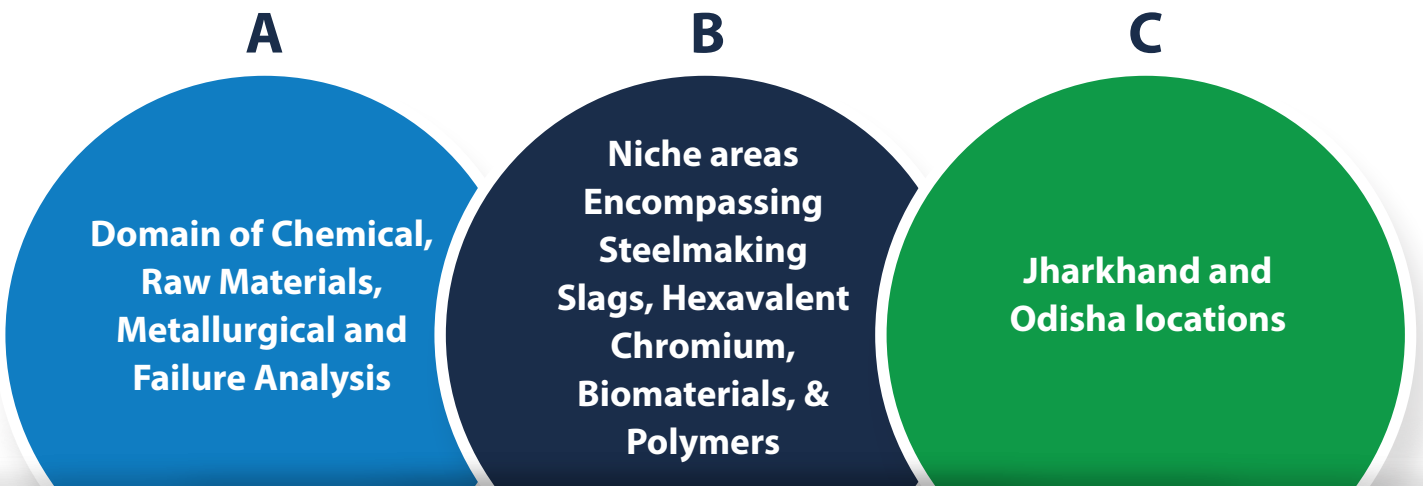
- 1. Exploration and Mining
- 2. Technology and Best Practices
- 3. Organisational Excellence
- 4. Human Resource Management
- 5. Research and Analysis
- 6. Digital transformation and Automation Solutions

About Scientific Services

Scientific Services is a group of NABL accredited laboratories which provides technical support related to **Chemical, Mechanical and Metallurgical analysis**, Scientific Services, through its Testing, Characterization, and Metallurgical Analysis, provides services to the entire value chain right from Raw Materials, Iron Making,

Steel Making, Rolling and Finished Products and even at customer end. Apart from the infrastructure, the core strength of the group lies in its experts and experienced professionals which enable significant fundamental research that is essential in solving issues and challenges.

Towards becoming a benchmark in Laboratory and Scientific Services we aspire to be the one stop solution point for accurate testing and characterization of Steel, Raw Materials, and related products. With more than 100 years into the business, Scientific Services has expanded its boundaries and footprints across:



Our prime focus is on faster and accurate analysis

Our Offerings:

Metallurgy



- » Metallurgical failure analysis of engineering components (Steel and Non-Steel)
- » Metallurgical root cause analysis of defects and failures of flat and long products
- » Physical, chemical, and high temperature testing of raw materials such as Coal, Coke (CRI, CSR) Sinter, Iron ore and Pellets (RI, RDI, Swelling Index).

Materials



- » Characterization of materials
- » Indigenous development and enhancing lifecycle of engineering components through material and design changes
- » Proper selection of materials for applications (materials specification)



Failure Analysis and Consultancy



- » Training on failure analysis and Metallography, XRF, ICP, and IR Absorption spectroscopy
- » Establishing quality assurance plans for critical components to reduce potential failures
- » Addressing high temperature and corrosion failures. Consultancy on NABL, BIS and ISO certification and laboratory setup

Our Strengths

Experience & Collaboration

- » 100+ years of experience in Metallurgical investigation and raw materials analysis
- » Collaboration with reputed research and academic institutes
- » Having professionals empaneled as External Assessors by the National Accreditation Board for Testing and Calibration Laboratories (NABL)
- » No. of failure cases handle per month on average: 20 with average response time: 10 days

Accreditations & Publications

- » Accreditation of Chemical and Mechanical testing Labs to ISO/ IEC: 17025 (2017) standards
- » Participation in certification of certified reference materials from external agencies such as the Bureau of Analyzed samples, UK
- » No. of publications in reputed journals per year: 10

Facilities & Expertise

- » State of the art facilities with wide range of equipment to test wide range of materials
- » Expertise in failure analysis of components and product defect investigation
- » Well trained and experienced professionals from reputed institutes (PhDs, M. Tech., and B.Tech. mostly from premier institutes like IITs, IISc in Metallurgy, Mechanical and Chemical Engineering)

Laboratory Services

With experience in running NABL-certified specialized laboratories involved in testing and certification of incoming raw materials(ores, fluxes, ferroalloys etc.), in-process Chemical and Metallurgical testing at various stages of iron and steel making and final product testing of finished steel

products longs (wires, bars, rods), flat products (HR & CR)), by-products (slags, scrap, etc.) and Metallurgical Testing of components (steel, non-ferrous, composites, rubber and ceramics), failure analysis etc., at Tata Steel, we are best placed to help you in your journey towards excellence.

Incoming Raw Material



- » Ores
- » Fluxes
- » Ferro Alloys

- » Chemical
- » Metallurgical



In Process

Finished Steel & Byproducts



- » Longs- wires, Bars, rods
- » Flats- HR and CR
- » Byproducts slag and scrap

- » Steel
- » Non Ferrous
- » Composites
- » Rubber
- » Ceramics

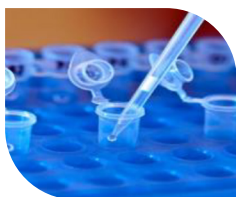


Metallurgical

Failure Analysis



Services we provide



1. Testing & Failure Analysis



2. Training & Consultancies



3. Projects

A.1.1. Testing and Analysis of Engineering materials



Metals and Non-metals

- » Steel
- » Stainless steel
- » Copper
- » Aluminium
- » Polymer
- » Composites
- » Ceramic, etc



Testing of Polymers and Composites

- » Microstructural analysis
- » FTIR analysis
- » Raman Spectroscopy
- » XRD analysis
- » Shore hardness



Metallurgical Testing

- » Product defect analysis: Flat and long products
- » Product evaluation and development
- » Product certification
- » Macrostructural analysis
- » Microstructural analysis
- » Inclusion rating
- » Grain size analysis
- » Scale analysis
- » SEM-EDS analysis
- » XRD analysis
- » Profilometry
- » In-situ metallurgical analysis of engineering components



Mechanical Testing

- » Tensile testing
- » Impact testing
- » Bulk hardness testing
- » Micro-hardness testing
- » Bend/ Rebind testing
- » Wear Testing

No. of samples tested per day:

300-400

Average Response time:

15 minutes per sample

No. of LP samples

tested per month: **700**

Average response time

per sample: **1 hour**



A.1.2. Testing and Analysis of Raw Materials



Types of Raw Material

- » Iron ore
- » Iron ore pellets
- » Iron ore sinter
- » Coal and coke
- » Fluxes used in steel making
- » Bulk and noble ferro alloys



Chemical Testing

- » Chemical composition of iron ore, iron ore pellets, sinter, fluxes and ferro alloys including Alkalis and ROHS elements
- » Proximate and Ultimate analysis of coal and coke
- » Ultra-low carbon steel
- » Low carbon steel
- » High Carbon steel
- » Stainless Steel
- » Cast Iron
- » Cu, Al
- » Refractory



A.1.3. Physical and High-Temperature Testing



Coal

CSN, Fluidity, dilatation, HGI, Coal petrography, Moisture



Coke

CSR-CRI, Size analysis, Moisture, Micum index, Porosity, Bulk density



Sinter and Iron ore

RI/RDI, Tumbler index, Abrasion index, Size analysis, Shatter index, Moisture



Pellet

CCS, Tumbler index, Abrasion index, swelling index, porosity, Shatter index, Moisture



Fluxes and ferro alloys

Size analysis



A.1.4 Failure Analysis

No. of failure cases
handle per month: **20**

Average response
time: **10 days**

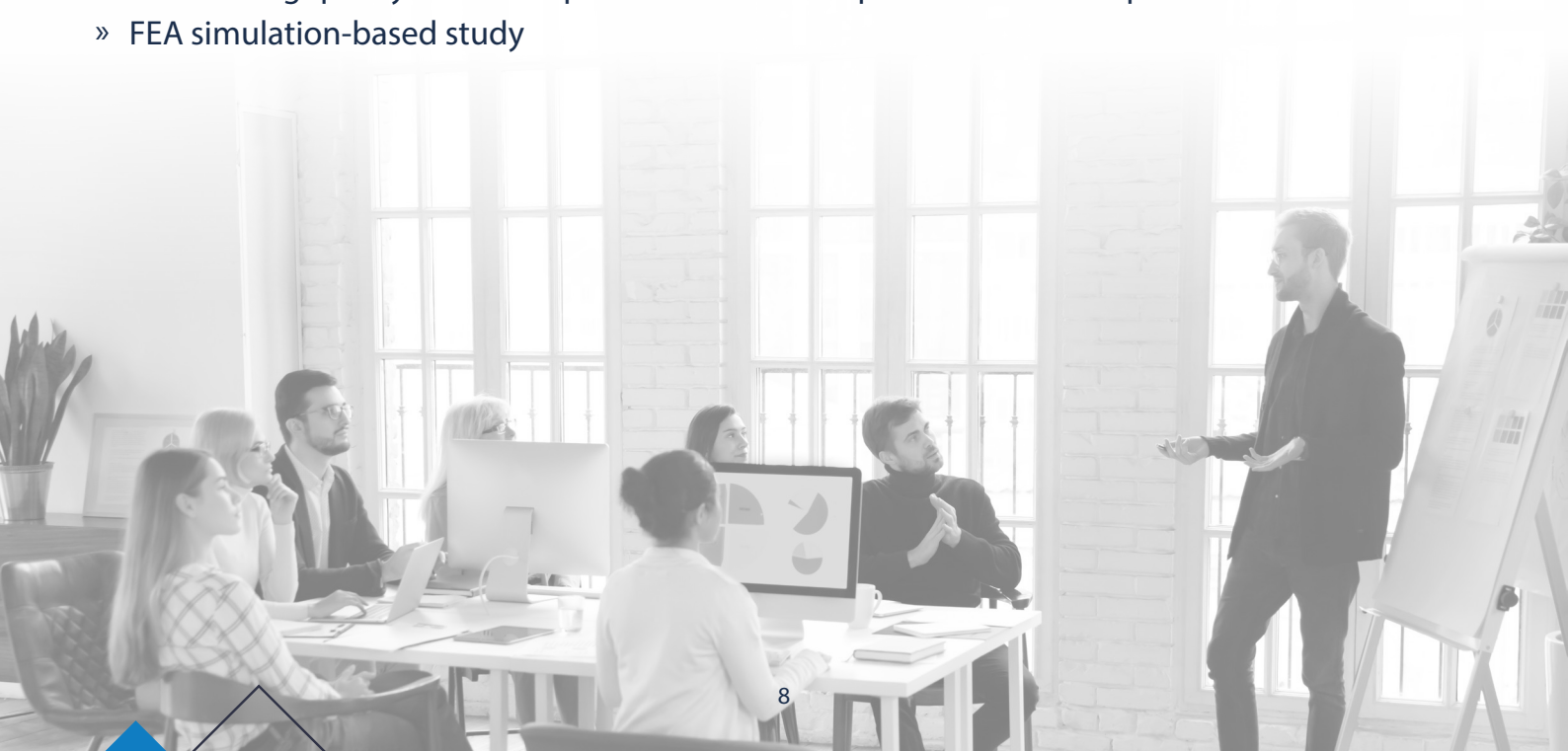
- » Engineering
- » Polymer and composites
- » Power Transmission components such as shafts, gears, coupling etc.
- » Bearings
- » Thermocouple
- » Bolts and fasteners
- » Structural components
- » Pipes and tubes
- » Boiler failure
- » Roll failure
- » Weld failures
- » Corrosion
- » High temperature oxidation
- » Fatigue and brittle failures
- » Wear and abrasion
- » Creep

B. Training & Consultancies

- » Failure Analysis and Metallography
- » XRF, ICP, IR Absorption spectroscopy
- » Consultancy on NABL, BIS and ISO certification and laboratory setup

C. Projects

- » Life enhancement of engineering components
- » Indigenous development of engineering components
- » Selection of welding electrodes
- » Establishing quality assurance plans for critical components to reduce potential failures
- » FEA simulation-based study



Chemical Analysis

Our experts from Chemical Lab provide 24X7 services, 365 days right which includes combination of wet chemical analysis and different instrumental techniques that are critically required by significant production units such as the Blast Furnace (BF), Sinter Plant (SP), Coke Plant (CP) and Steel Making Shop (SMS).

Current Portfolio

Raw Material Testing	In-Process Sample & Product Testing
Iron ore	Hot metal analysis
Iron ore pellets	Process steel samples during steelmaking
Iron ore sinter	Test piece analysis
Coal and coke	Iron and steel-making slags
Fluxes used in steel making	Byproduct plant analysis (Coke plant)
Bulk and noble ferro alloys	Long product and flat product testing
Additives used in iron and steel making	
Incoming refractories	

A.1.iii. Major Facilities in Chemical Labs



1. Robotized and Manual Optical Emission Spectrometers

- » Used for a complete analysis of Iron and steel samples
- » Both Automatic & Manual OES are available in Labs supporting SMS

2. LECO-C, S Analyzers

- » Used for steel, hot metal and Ferro Alloy samples
- » CS-744 and CS-844 available





3. LECO Nitrogen & Oxygen Analyzers

- » Used for analysis of nitrogen and oxygen in steel samples

4. DH 603 Hydrogen Analyzers

- » Used for total hydrogen analysis in Fe-based samples

5. XRF Spectrometer

- » Used for analysis of nitrogen and oxygen in steel samples

6. ICP Spectrometer

- » Used for analysis of unknown source samples from different customers



7. LECO TGA Analyzers

- » Used for proximate analysis of coal and coke samples

8. Karl Fischer Auto Titrator

- » Used for determining moisture content in oil

9. LECO Ultimate Analyzers

- » Used for analysis of nitrogen and oxygen in steel samples

10. Gas Chromatograph

- » Used for quantitative analysis of gas constituents in the gas mixture for by-product plant



Physical & High-Temperature Testing

Central Raw Materials Testing (CRMT) Lab, a part of scientific services which was established in 1982 to cater to sampling and testing requirements of raw materials. It is responsible for the physical & high-temperature characterization of raw materials used in the iron-making process. It also supports R&D and process technology groups in raw material research, plant trials, projects, and process improvement activities.

Current Portfolio

Sampling	Physical and high-temperature testing
Raw materials	The rheological characteristics of component coals and coal blends, including CSN, Fluidity and Dilatation
Intermediate product and final product from CP, SP, BF, Pellet Plant, IBMD, RMHS & Stores	CSR-CRI, Size analysis, Moisture, Micum Index, Porosity and Bulk density of coke
Support to an iron-making unit, Product	RI/RDI analysis for sinter
Technology group and R&D units in plant trials	Cold crushing strength (CCS)
Sampling of purchased raw material	Porosity measurements
	Particle size analysis

1.1. Testing Facilities for Coal & Coke

Facilities for Coal Test	Facilities for Coke Test	Support Services
Dilatometer	Micum Drum	Sample Preparation for Proximate Analysis
Plastometer	Air Oven	Sample Preparation for Coal & Coke Petrography
HGI Apparatus	CSR/CRI Apparatus	
Sieve Shaker/ Screens for Size Analysis	Ultimate and Proximate Analyzer for Coke samples	
Bulk Density Apparatus		
Air Oven / Microwave		
Ultimate and Proximate Analyzer for coal samples		



1.2. Major Facilities for Coal & Coke Test



1. CSR/CRI Apparatus

- » Dilatometer for measurement of contraction and expansion property

2. Coal Petrography



3. Porosity Apparatus

4. Micum Drum

- » Micum Apparatus for measurement of coke Micum Index



5. Dilatometer for Measurement of Contraction & Expansion Properties

6. Plastometer for Determination of Fluidity of Coal & Coal Blend



2.1. Testing for Iron Bearing Materials

- » Physical tests like Size analysis, Tumbler Index, and Shatter Index
- » High-temperature tests like Reduction Degradation Index (RDI), Reducibility Index (RI)
- » Chemical analysis, like carbon analysis in different raw material intermediates
- » Moisture Analysis, Granulation Index for intermediates

Facilities for Sinter/ Iron Ore Test	Facilities for Pellet Test
RDI Apparatus	Tumbler Apparatus
RI Apparatus	RDI/RI Apparatus
Tumbler Drum	LECO C-S Analyzer
Softening-Melting Equipment	
Shatter Apparatus	
Granulation Index Apparatus	

2.2. Major Facilities for Coal Testing

- » Rheological properties of coal like Fluidity, Dilation and Crucible swelling number
- » Pilot Oven testing of coals to predict expected CSR and expansion in the plant scale
- » Proximate & Ultimate analysis
- » Petrography studies

2.3. Major Facilities for Coke Testing

- » CRI, CSR
- » M40 and M10

2.4. Major Facilities for Sinter & Iron Ore Testing

- » RI, RDI testing facilities
- » Sinter Microstructure
- » Chemical analysis by ICP



1. Blaine Apparatus



2. RDI/RI Apparatus



3. LPSA Apparatus



4. CCS Apparatus



5. Tumbler Index



6. Shatter Test Apparatus

Mechanical Testing

Scientific Services has a fully equipped and competent in-house Mechanical Testing facility to provide precise, reproducible, and reliable results for mechanical tests like Tensile Tests, Compressive Tests, Bend/Rebend Tests, Impact Tests (Charpy), Hardness Tests and various other tests for mechanical and engineering properties. Tests are meticulously conducted according to national and international standards like IS, ASTM, BS, ISO, etc. or client-specified standards, and the compliance of test items to various specifications is decided.

Mechanical Tests of Products:

- Tension Tests of Flat and Long Products
- Brinell Hardness Test
- Rockwell Hardness Test
- Vickers Hardness Test
- Microhardness Test
- Impact tests (Charpy and Izod samples)
- Bend and Re-Bend Test
- Bend Test on Reinforcement for a Concrete

S. No.	Mechanical Testing	Testing Standard	Equipment Details	Sample Details		
			Scope of Lab	Sample Type	Size	Grades
1.	Tensile Testing	IS 1608	100-1500 kN	Rebars	6 to 40 mm (Diameter)	Fe 500, Fe 500D, Fe 500SD, Fe 550D, Fe 500 CRSD, Fe 600, Fe 600 D, Fe 600 HD, Others
				Plates	12-40 mm (thickness)	I17011
				Foundation Bolts	16-63 mm (Diameter)	IS 1875: 15C8, IS 1367 (Part 3): Class 4.6, IS 2062: E 250
				Shaft	15-60 mm (Diameter)	All shaft grades within machine capabilities
2.	Charpy Impact Testing	IS 1757	0-300 J	Moil point, Shaft, Bolts, Pins, Plates etc.	55mm X 10mm X 10mm	Grades within machine capabilities
3.	Bend/ Re-bend Test	IS 1599	0-2000 kN	Rebars	6 to 40 mm	Fe 500, Fe 500D, Fe 500SD, Fe 550D, Fe 500CRSD, Fe 600, Fe 600 D, Fe 600 HD, Others

Significant Work in Mechanical Testing Laboratory

1. Addressing Low Bend Re-Bend Cycle of Rebars

Cold bend re-bend tests were performed on the rebars produced under different operating conditions. Based on the studies, an optimum range of quenching parameters was achieved to improve mechanical properties having optimum strength and toughness.

2. Estimating Shear Strength of Rebars

Sometimes, it is desired to test the shear strength of rebars. However, no such facility is available in India for shear testing. Our mechanical laboratory developed an indigenous fixture to conduct shear testing for rebars in Tensile Testing Machine.



Shear testing setup



Setup fixed with
Tensile machine



Shear testing of rebar

B. Failure Analysis & Root Cause Analysis Consultancy

Scientific Services is engaged in Metallurgical Failure Investigation of both steel products and engineering components of over 125 cases per month generating mammoth expertise and experience over the years. This expertise can be extended for the greater good across other laboratories & industries in the areas of sheet metal defects, wire defects and component failures.

B.1 Engineering Component Failure Analysis

Scientific Services is an expert group in materials testing, quality assessment, and failure analysis. The metallurgical experts investigate failures of various engineering components. Our services include identifying damage mechanisms such as thermal degradation, creep, oxidation, corrosion, fatigue, and fracture evaluating the root cause of failure followed by recommendations.

Investigation Process



Collaborative Approaches for Proceeding and Arriving at Conclusion

Our analyses are based on an assortment of several inputs received from different subject matter experts within the department and as well as outside the department, whenever required. To achieve this, we have several technical forums to discuss several cases. These forums do not only include lead investigators—but also our supervisors and technicians, who process the samples. Therefore, we arrive at conclusions after several discussions at following forums:

- ▶ **CRMT_TechBoard**
- ▶ **TechCafe**
- ▶ **Collaboration with National Laboratories e.g., NML**
- ▶ **Collaboration with Academia (IITs, NITs etc.)**
- ▶ **Technical Discussion**
- ▶ **TechBoard Discussion**

Significant Work in Failure Analysis

1. Failure Analysis of Coke Dry Quenching Car Liners in Coke Plant

Coke dry quenching (CDQ) bucket is used to carry hot coke to the CDQ chamber for cooling. The imported liners inside the bucket were getting buckled and cracked after 6–7 months of service. It was observed that the liner plates failed prematurely due to microstructural degradation at higher service temperatures. A detailed investigation was carried out in which a suitable material was recommended, which was developed indigenously. The new material doubled the service life and led to huge savings.

2. Improvement of Wagon Tippler Disc Spring Life by Design Modification

The disc springs of the side arm changer of the wagon tippler were failing prematurely. Disc springs absorb shock loads generated while coupling wagons during the positioning of single/double wagons on a tippler platform for unloading raw material. The mathematical calculation for expected fatigue life was carried out to find the cause of the premature failure of springs.

3. Failure Investigation of Worm Wheel Gearbox in a Wire Rod Mill

Failure of the gearbox has always incurred huge losses to the industries due to interruption in operation and consequent repair or replacement costs. After going through the observations and experimental results, it was concluded that the shaft failed in fatigue mode due to multiple impacts of the key. The sharpness of the key was found to be the main contributing factor to crack initiation.

B.2 Product Failure Analysis and Materials Characterization

A. Analysis of Product Surface Defects

1. Silver/Lamination
2. Scab/Scum
3. Rolled in defects
4. Un-coated/Peel-off
5. Powdering/Flaking
6. Red/Black Scale

B. Analysis of Fabrication Failures

1. Wheel cracking
2. Cracking of deep-drawn components
3. Weld failures
4. Failure of Automotive parts

Characterization & Analysis Techniques

- » Grain size measurement (ASTM E112)
- » Non-Metallic Inclusions in steel (ASTM E45)
- » Case depth measurement (ASTM E1077)
- » Macro-etching evaluation (ASTM E340)
- » Microstructural analysis and defect investigation (ASM Vol#9)
- » Estimation of Phase fraction in Microstructures
- » Bulk Hardness (Rockwell ASTM E18, Brinell IS1500)
- » Micro Hardness (Vickers ASTM E92)
- » Scanning Electron Microscopy (SEM)/EDS Analysis (ASTM E1508)
- » Coating and Scale characterization
- » Surface Profile measurement
- » Scale loss analysis
 - Fractography
 - EDX Analysis
 - XRD Analysis
 - EBSD Analysis
 - Raman Analysis
 - FTIR Analysis

Significant Work in Metallurgical Laboratory

1. Analyses of GA Surface Defect (Pin Prick)

The work provides an intensive analysis of the pin prick defect which is a typical impression mark formed on some galvanized (GA) sheet surfaces, causing significant rejections in the finished product used for automotive skin panels. Defective coils were studied in detail and mapping of defect location, intensity and frequency was carried out. Certain pattern concerning the distribution and severity of the defects was observed, which suggests the splashing of liquid Zinc due to the Coanda effect attributed to the air knife design. Modification of the air knife configuration was recommended.

2. Microstructural Characterization for Structure-Property Correlation in EDD steels

In EDD grade steels, variation of mechanical properties was a chronic issue. Microstructural characterization using various advanced techniques such as SEM, EBSD, and XRD was carried out to correlate mechanical properties with microstructural features to minimise variation in property band. It was found that higher C, Si, Al and P were leading to grain refinement which would eventually lead to high YS. It was recommended to keep the chemistry lean for C, Si and Al.

3. Comparative Analysis of Cracking During Upsetting in Rebar

Cracking during the upsetting of 32 mm rebar (Fe 500D) caused major rejection at the customer's end. A detailed comparative analysis was carried out to understand the root cause. Metallurgical analysis revealed that supplied rebar work hardened more under the chosen upsetting parameters. High hardness both at the core as well as the rim of the rebar led to cracking under high upset load. Plant trials were taken with leaner chemistry and uniform tempering which solved the cracking issue.

4. Analysis of Breakage of Welding Wire Rod During Processing

An intensive analysis of the premature failure of wires during cold drawing operations has been done. The investigation suggests that the wire happened due to a light brown hard phase (martensite) which makes the material brittle and initiates chevron cracks during drawing operations. X-ray mapping doesn't reveal any segregation along or near the light brown hard phase. Different plant trials and thermo-mechanical studies suggest that the martensite formed due to the incomplete transformation of wire rods during retarded cooling process at the hot rolling stage.

5. Study of White Patch Defect in Automotive Grade Interstitial Free Steel

The surface of cold-rolled steel intended for automotive body panel applications is expected to be defect free. The presence of surface defects hampers the aesthetics and average surface roughness and thereby deteriorates the paintability of the steel sheet. Overall analysis indicated that grease contamination on cold-rolled steel sheets in the early stages of the electrolytic cleaning line caused the generation of white patch defects after heating in an annealing furnace.

6. Longitudinal Facial Crack of Strip Associated with Mould Failure

Longitudinal facial cracks (LFC) in steel strip products were analysed. The study revealed that thermal degradation caused softening of the Cu mould at the meniscus level that initiated a crack under cyclic thermal load. The presence of thermal cracks on the mould surface retarded the heat transfer rate at the mould-slab interface which eventually caused thinning of the shell. This thinner shell got ruptured due to ferro-static pressure while the strand was still inside the mould. This eventually caused surface defects along the length of the slab. On further rolling, this slab crack resulted in LFC in the coil.

B3 Product Quality Certification

- » Metallurgical Testing for Certification
- » BIS
- » ISO
- » Documentation and Training



TATA STEEL

 WeAlsoMakeTomorrow



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