# Domain of Research Activities for i-PSG

The primary focus for all the activities will be:

- o Novel methodology / materials with improved efficiency/properties, where bench marking will be existing one
- o Import substitution, which becomes commercially viable also, if not stated otherwise.

## Alloy development

- Indigenization of CRGO and CRNO grade electrical steels including coating
- High strength steels for structural application, against severe corrosive environment, resistance against extreme wear and erosion
- Ferrous alloys for strategic applications e.g. lean alloys for armour applications
- Linepipe steels for high-pressure hydrogen transport
- High strength medium manganese steel
- Alloys for high temperature applications: bench marking with Ni-based superalloys
- Any other alloys with future potential

## Material processing

- Protocol for AM-grade powder
- Processes for ultra-thin sheets (sub-200 µm range) from complex alloy steels like medium manganese, high silicon alloys etc.
- Welding electrodes / protocols for special steels like armour grade, erosion resistant grade, etc.
- Wire arc additive manufacturing (WAAM) practices for reclamation of critical engineering components

## RLA of engineering components

- Development of methodology and flowsheet for remaining life assessment of components and their reclamation strategies for specific application.

## Mechanics of Materials

- High temperature deformation behaviour of advanced alloys (Fatigue & Creep)
- Improving fracture toughness of metallic materials

## Materials Modelling

- Modelling and simulation for understanding or predicting microstructure, deformation behaviour as well as mechanical and physical behaviour; with experimental validation, if possible.

## Advanced materials & synthesis

- Synthesis of 2D materials for supercapacitors
- Bulk rare earth free and NdFeB magnet from secondary sources
- Coated microwire sensor for devices

### Industrial coatings

- Hot dip galvanized coating for advanced high strength and hot forming steels
- Zn-alloy coatings (such as Zn-Mg-RE, Zn-Fe, Zn-Mg, etc.) through different methods such as electrodeposition and HVOF for engineering applications
- Functionally graded coatings for heat-exchangers

### Coatings for strategic components

- Rare earth and silicide based thermal barrier coatings through different routes for high pressure and high temperature components.
- Composite coatings such as WC-Ni, NiW-WC, etc. through HVOF and electrodeposition methods to combat corrosion
- Application oriented high performing stealth coatings, EMI shielding and radiation absorbing coatings e.g. aerospace, drone and thermo-electric components
- Coatings for strategic components, with benchmarked properties

### Corrosion inhibition

- Flow assisted corrosion, inhibitor design and assessment, corrosion of RE-added API grade steels, stainless steels and weathering steels, light weight Al / Mg alloys
- Molten Salt corrosion with respect to environment, inhibitors, and engineered grain boundaries
- High temperature corrosion related to Aero/Gas turbine applications
- Hydrogen damage resistant alloys and coatings, hydrogen ingress detection based on conductivity / resistivity measurement techniques
- Simulation of corrosion proceses

### Applied chemistry

- Quality improvement of low grade coal for better utilization
- Analytical method development and validation for reliable analysis of critical minerals/elements
- Development of CRMs as Technology development for Critical Metal and related Ores

### NDT in material science (*electromagnetic, ultrasonic & advanced ultrasonic, thermography*)

- Sensors and sensing technologies for non-destructive evaluation
- Ultrasonic / advanced ultrasonic techniques (guided wave, nonlinear wave mixing) for material evaluation, including composite materials.
- Health monitoring of industrial components using NDE.

### Extraction and recycling

- Use of molten salt electrolysis for the extraction and processing of metals
- Advanced separation process for efficient metal extraction
- Extraction of critical metals including rare earth elements (Focus on heavy REE) from primary and secondary resources
- Hydrothermal metallurgy for recovery of metals
- Development of high purity metals using metal distillation or zone refining method.
- Valorization of industrial waste of mineral and metallurgical industries

- Recovery of critical metals from end of life alloys such as defence equipment, aircrafts, drones, medical devices etc.
- Development of innovative/ path breaking technologies for utilization of iron ore fines and non-coking coal.
- Improvement in quality of steel produced through the various routes of steelmaking
- Mathematical and physical/cold modelling of various metallurgical processes for process optimisation and improvement
- Extraction of strategic, critical and REE at elemental level

## Sustainability

- $CO_2$ sequestration in metallurgical industry using their waste and by-products.
- Green and sustainable steel making and ferro alloy making process
- Use of renewable energy in metallurgical process
- LCA for all metallurgical processes for sustainable Iron and steelmaking
- Commercially viable technologies for utilization of steel plant tailings and mine wastes
- Innovative solutions for addressing the challenges faced by the iron & steel industry
- DRI using hydrogen in horizontal furnace/kiln

## Mineral processing

- Fine Particle Processing
- Processing of critical/strategic minerals
- Dry Processing
- Recovery of valuable minerals from low-grade ore, mines waste, slime, overburden
- Development of mathematical model for mineral processing operations and plant optimization
- Decarbonisation and development of green technology in mineral based industries
- Improving efficiency in process, operations and recovery of by-products
- Developing low capital and energy saving processing systems
- Simulation of various unit operation for process optimization / improvement

## New thrust areas

- Creation of extensive metallurgical data repository (at NML)
- Use of AI/ML in application oriented alloy discovery substantiated by experiments
- Use of AI/ML in correlating microstructure, process, mechanical properties and monitoring of metallurgical processes
- AI/ML for clean steelmaking including inclusion control.
- Design and fabrication of indigenous / in-house facilities, unique and not readily obtainable in the market (aimed at advancing metallurgical research and/or meeting internal institutional as well as national needs)

*Dated : 22/08/2025*