



CSIR-NML Technology Handbook



CSIR-NATIONAL METALLURGICAL LABORATORY
JAMSHEDPUR -831 007, INDIA

Overview of CSIR-NML

The foundation stone for National Metallurgical Laboratory was laid by Hon'ble Sri C. Rajagopalachari on 21st November, 1946. It was formally inaugurated and dedicated to the nation on 26th November, 1950 by Pandit Jawaharlal Nehru "in a spirit of hope and in a spirit of faith in the future". The laboratory was an element of Sir Shanti Swaroop Bhatnagar's vision of providing India with a network of research institutions for taking the country ahead in science and technology. CSIR-NML played a significant role in the industrial revolution of India starting from 1950 especially in the areas of mineral processing, iron and steel making, ferroalloys and extraction of non-ferrous metals, notably magnesium. Asia's largest creep testing facility was also set up at CSIR-NML in the early 1970s and even today it ranks as the second largest creep testing lab in Asia. CSIR-NML continues to play a vital role in the quest of the country towards scientific and technological leadership and providing scientific solutions to the industries in the areas of minerals, metals and materials.

Since inception CSIR-NML has diversified its research areas ranging from mineral beneficiation and processing, indigenous alloy development, extractive metallurgy, refractories, corrosion, mathematical and physical modeling of metallurgical processes, advanced materials and materials tailoring, integrity evaluation of critical industrial components and cleaner and sustainable metals production. CSIR-NML is also carrying out major activities for creating awareness among the common masses on issues relating to health, environment, rural technology and sustainable development.

With a strong and committed staff having a wide spectrum of expertise and modern facilities, CSIR-NML endeavors to move ahead to meet the challenges of the global economy and reach greater heights.



Vision

To become a global leader and an internationally benchmarked laboratory in mineral and metallurgical research and development



 F O R W O R D

For any R&D organization, the Intellectual property generated and the technologies developed can be considered to be the main asset creations. Licensing the IP and commercializing technologies in the market provides the lifeline for sustenance. CSIR-National Metallurgical Laboratory has emerged as one of the major players in metallurgical and materials research, backed up by substantial share of intellectual property products generated over the entire spectrum of metallurgy and material science. CSIR-NML has filed 135 patents over the last six years out of which around 15 have been successfully commercialized. This Technology Brochure compiling a list of its potential technologies is an attempt to further reach out and commercialize its technologies.

The handbook highlights the processes, products and devices developed at CSIR-National Metallurgical Laboratory in recent times and available for commercialization. I urge upon the minerals, materials and metallurgical industry in India and abroad as well as potential entrepreneurs, venture capitalists and any other stake holder who would be interested in commercializing technologies to explore the knowledgebase developed at CSIR-NML for creating value in the market.

Director
CSIR-National Metallurgical Laboratory
Jamshedpur-831007, India



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MNP001

Column Flotation Technology

Salient Features

The column flotation technology is a new mineral beneficiation method developed on strong scientific principles for processing of fine low grade ores and minerals. The merits of the technology includes improved metallurgical performance in terms of grade and recovery, effective cleaning of froths, small foot print, low capital investment, less operation and maintenance costs with user friendly controls. Improved metallurgical performance is due to: (i) less entrainment and entrapment, (ii) Independent control of operating variables, (iii) Froth washing provision and (iv) Control over bubble size – effective in fines collection. The Reduced operating & capital costs as a result of: (a) No moving parts & Lower energy consumption, (b) Lower reagent consumption, (c) Substantial reduction in floor area – vertical Configuration and (d) One stage of column flotation generally replaces multi stage conventional flotation.

Uses

Flotation of base metal ores (Cu, Pb, Zn ores), iron ores (hematite, magnetite, BHQ etc.), beach sand minerals (Sillimanite), industrial minerals (limestone, barite etc.) and graphite & coal fines

Scale of Development

Laboratory – Pilot – Commercial scale flotation columns.

Commercialization Status

The technology is fully commercialized for both, laboratory and industrial columns. The following industrial columns are in operation: M/s Indian Rare Earths Ltd., Chatrapur, Orissa (Sillimanite) 150 tons/day M/s Indian Rare Earths Ltd., Chavara, Kerala (Sillimanite) 150 tons/day M/s Andhra Barites Co. Ltd., Kadapa, Andhra Pradesh (Barites) 700 tons/day M/s VV Minerals Ltd., Srikakulam, Andhra Pradesh (Sillimanite) 150 tons/day* M/s Oren Hydrocarbons Pvt Ltd., Chennai, Tamilnadu (Barites) 1000 tons/day*

Techno-economics

A typical column flotation plant (conditioning tank to column discharge) with a capacity of 1000 tpd would cost Rs. 300 lakh (approx.)

Technology Readiness Level (TRL)

TRL: 9

Environmental Consideration

No

Major Raw Materials

Not Applicable

Major Plant Equipment/Machinery

Programmable controller, Magnetic flow meters and Mass flow controller, Control valve, air spargers, compressor, feed and reagent conditioners

Technology Package

(i) Process and reagent development in collaboration with M/s Somu Organo Chem Pvt. Ltd., Bengaluru, (ii) Flotation Column design, engineering, erection, commissioning, stabilization and training in collaboration with M/s McNally Sayaji Engineering Limited., Bengaluru.



MNP002

Beneficiation of Tungsten Ores

Salient Features

The technology is based on the novel integrated process flow-sheet involving beneficiation of low- and lean-grade ores and hydrometallurgical extraction of tungsten from wolframite concentrate. The concentration of the lean ore is achieved basically by gravity and magnetic separation techniques followed by hydrometallurgical extraction of tungsten from wolframite concentrate to obtain ammonium para-tungstate.

Environmental Consideration

The process is environment friendly. Tailings and effluents disposal systems are to be installed.

Major Raw Materials

Low-grade wolframite ore, Reagents for extraction of tungsten.

Major Plant Equipment/Machinery

Units for crushing, grinding, classification, gravity & magnetic separation, dewatering, leaching and solvent extraction.

Technology Package

(a) Process knowhow with technological process flow-sheet. (b) Details of equipment. (c) Quality Assurance Methods and (d) Assistance in setting up the plant on separate terms.

Uses

The technology is for beneficiating and extraction of tungsten from low and lean-grade ores. Tungsten so produced is useful for defense, space and other industrial applications.

Scale of Development

Beneficiation: 0.5 tph raw ore, Extraction: 5 kg concentrate, scale-up possible

Commercialization Status

Ready for commercialization

Techno-economics

Available on demand

Technology Readiness Level (TRL)

TRL: 7





MNP0003

Beneficiation of Low-grade Iron Ores

Salient Features

The technology is based on processing of low-grade iron ores primarily involving washing, gravity and magnetic separation. The products are calibrated lumps, sinter and pellet-grade concentrates suitable for iron & steel making. The intermediate products are recycled towards maximization of iron recovery.

Environmental Consideration

The process is environment friendly. No toxic/hazardous waste is discharged. Arrangement for tailings disposal is needed.

Major Raw Materials

Low-grade iron ores.

Major Plant Equipment/Machinery

Units for crushing, washing, classification, gravity & magnetic separation and dewatering.

Technology Package

- Process knowhow with details of equipment
- Process flow-sheet with material balance
- Assistance in setting up the plant on separate terms and conditions.

Uses

The technology developed is for beneficiating low-grade iron ores. The calibrated lumps, fines and concentrate so produced are used for iron & steel making.

Scale of Development

Pilot Scale: 1 tonne/hr

Commercialization Status

The technology is sample specific. It is being commercialized for ore from Bolani and Gua Mines of SAIL.

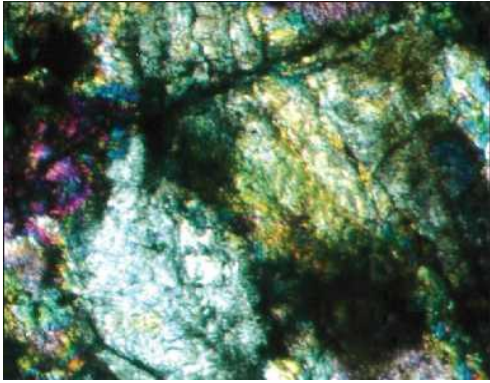
Techno-economics

Available on demand

Technology Readiness Level (TRL)

TRL: 9





MNP004

Beneficiation of Low-grade Baryte Ores

Salient Features

The technology is based on concentration of low-grade barite ore (sp. Gr. ≤ 3.9) by gravity and flotation methods. The low-grade ore is upgraded to marketable grade product with sp. Gr. 4.1. The process also enables processing of off-grade mine waste dumps for suitable industrial applications.

Environmental Consideration

The process is environment friendly. The tailings disposal units are to be established.

Major Raw Materials

Low-grade baryte ores, Flotation reagents.

Major Plant Equipment/Machinery

Units for crushing, grinding, classification, gravity separation, flotation and dewatering.

Technology Package

(a) Process knowhow and equipment details (b) Technological process flow-sheet with material balance (c) Assistance in setting up the plant on separate terms and conditions.

Uses

The technology developed is for beneficiation of low-grade baryte ores and the concentrate so produced is useful for oil well drilling, chemical industries and other applications.

Scale of Development

Pilot scale, 10 tpd. Scale-up possible.

Commercialization Status

Ready for commercialization.

Techno-economics

Available on demand

Technology Readiness Level (TRL)

TRL: 7





MNP005

Recovery of Chromite Values from Tailings/Slimes Produced by Chromite Ore Beneficiation Plant

Salient Features

The technology exploits the difference in density of the chromite ore and the associated gangue minerals for their separation using fine gravity separator. The technology was developed at bench scale and subsequently validated through pilot scale trials. It produces marketable chromite concentrate with final tailings assaying < 10 % Cr₂O₃ meeting IBM guidelines for disposal of tailings. It has several advantages viz.

- Additional resource generation.
- Creation of additional space for storage of tailings.
- Reduces potential damage to environment.

Environmental Consideration

Environmental friendly, however tailing disposal system is to be installed.

Major Raw Materials

Tailings/Slime produced by Chromite Ore Beneficiation Plant.

Major Plant Equipment/Machinery

Ball mill, Hydrocyclone, Gravity Separator, Thickener and Filter.

Technology Package

Process know how covering process flow-sheet with material balance, equipment/process parameters. Assistance in setting up of plant on separate terms and conditions.

Uses

For recovering of chromite values from tailings/slimes generated by Chromite Ore Beneficiation Plant.

Scale of Development

Pilot Scale

Commercialization Status

Ready for Implementation.

Techno-economics

Techno-economically favourable.

Technology Readiness Level (TRL)

TRL: 6





MNP006

Separation of Quartz & Feldspar

Salient Features

The process is based on recovery of minerals by froth flotation. The separation of quartz and feldspar from the ground ore-slurry is achieved by differential flotation using a suitable reagent scheme.

Environmental Consideration

Installation of tailings and effluent disposal systems is needed.

Major Raw Materials

Ore/ Mica mine waste dump containing quartz and feldspar, flotation reagents.

Major Plant Equipment/Machinery

Crusher, Grinding Mill, Classifier, Conditioner, Flotation cells, Dewatering Units.

Technology Package

(a) Process knowhow (b) Details of equipment & (c) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

For use in Glass and Ceramic industries.

Scale of Development

10 kg-scale. Further scale-up is possible.

Commercialization Status

Ready for commercialization

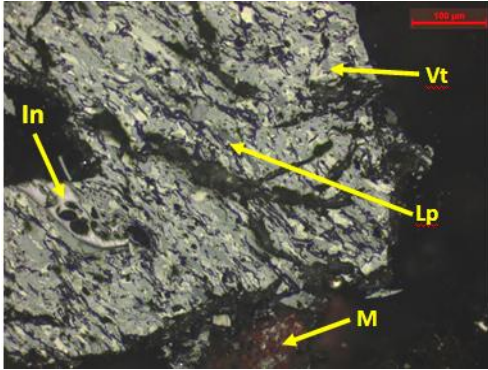
Techno-economics

Available on demand

Technology Readiness Level (TRL)

TRL: 6





MNP007

Dry beneficiation of non coking coal for application in thermal power and DRI

Salient Features

- Producing clean coal with 34% and 25% ash with high yield
- No need of process water
- Prevents generation of coal slime water
- Requires relatively less floor area compared to conventional wet processing
- Less power consumption per ton of coal compared to wet processing of coal

Environmental Consideration

Conserves water, no process water generated which prevents water pollution

Major Raw Materials

Thermal coal

Major Plant Equipment/Machinery

Crushers, Screens, Air fluidized vibrating deck separators, material handling system

Technology Package

Process know and equipment details, Technological process flowsheet with mass balance, Assistance in setting up the plant on separate terms and conditions

Uses

Ash reduction in high ash non-coking coal by dry processing for use in thermal power and DRI application and De-shaling of high ash non-coking coal

Scale of Development

Pilot Scale at 10 tph scale

Commercialization Status

It is to be commercialized with the support of user industries

Techno-economics

Techno-economically feasible, ROI is 2.65 years for 2 MTPY

Technology Readiness Level (TRL)

TRL: 7





MNP008

Beneficiation of Dumped Low-grade Iron Ore Fines for Iron and Steel Making

Salient Features

The process is based on upgradation of dumped low-grade iron ore fines involving scrubbing-washing-classification of the dumped fine ore followed by gravity and magnetic separation of classified materials. The process ensures optimum recovery of iron values through closed loop operation and processing of intermediate products.

Environmental Consideration

The process is environmental friendly. However tailing disposal system needs to be in place.

Major Raw Materials

Low-grade dumped iron ore fines.

Major Plant Equipment/Machinery

Crushers, Grinding mills, Scrubber, Jig, Spiral, Hydrocyclone, Wet High Intensity Magnetic Separator, Dewatering units.

Technology Package

(a) Process knowhow with details of equipment (b) Technological process flow-sheet with material balance & (c) Quality Assurance Methods. Assistance in setting up the plant on separate terms

Uses

This technology is for production of pellet-grade concentrate for iron & steel industries

Scale of Development

0.5 tph. Further scale-up is possible.

Commercialization Status

The technology has been commercialized and a plant with capacity of 1.35 mtpy has been commissioned.

Techno-economics

The capital investment for a plant of 1.35 mtpy capacity would be around Rs. 300 crores.

Technology Readiness Level (TRL)

TRL: 7





MNP009

Phosphate Concentrate

Salient Features

The process technology is based on separation of phosphate containing minerals from low-grade ore by froth flotation. The product is suitable for the manufacture of phosphoric acid and phosphatic fertilizers.

Environmental Consideration

The process is environmental friendly. Arrangement of disposal of tailings and effluents is needed.

Major Raw Materials

Rock phosphate, flotation reagents.

Major Plant Equipment/Machinery

Crushers, Gridding mills, Flotation and dewatering units.

Technology Package

(a) Process knowhow with equipment details (c) Technological process flow-sheet with material balance & (c) Assistance in setting up the plant on separate terms and conditions.

Uses

For the manufacture of phosphoric acid and phosphatic fertilizers.

Scale of Development

200 kg/h

Commercialization Status

Ready for commercialization

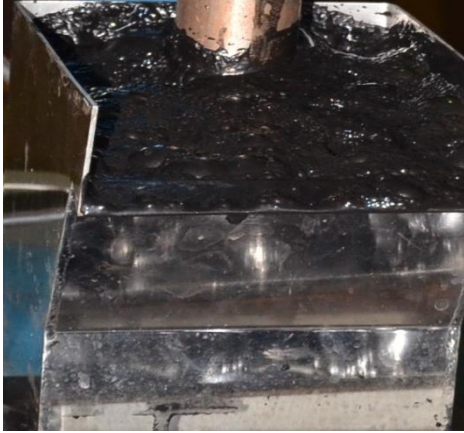
Techno-economics

Available on demand

Technology Readiness Level (TRL)

TRL: 7





MNP0010

De-ashing of high non-coking coal

The process is based on treating the high-ash thermal coal for reducing the ash level by adopting the gravity concentration and flotation techniques. The ash level can be reduced to 10-15% from a feed of 30-35% ash depending on the coal characteristics.

Environmental Consideration

Installation of tailings disposal units shall be needed.

Major Raw Materials

High-ash thermal coal, flotation reagents

Major Plant Equipment/Machinery

Crusher, jig, spiral concentrator, flotation bank, thickeners, filters

Technology Package

(a) Process knowhow (b) Details of equipment (c) Quality Assurance Methods. Assistance in setting up the plant on separate terms and conditions.

Uses

Clean coal fines for injection in blast furnace

Scale of Development

The process has been developed on 5 tpd scale. Scale-up possible.

Commercialization Status

Ready for commercialization

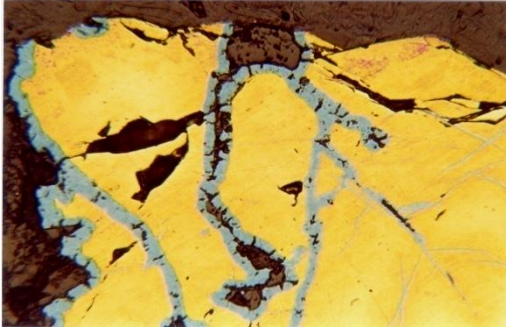
Techno-economics

Available on demand

Technology Readiness Level (TRL)

TRL: 6





MNP011

Copper Concentrate from Copper Ores

Salient Features

The process is based on froth flotation of copper bearing minerals from ore after milling. The concentrate is dewatered and used for extraction of metal by pyro-metallurgical route.

Uses

The copper concentrate is used for extraction of metal by pyro-metallurgical route.

Scale of Development

The process has been developed on 24 tpd scale.

Commercialization Status

(1) A 1000 tpd plant at Rakha Copper Project is based on CSIR-NML flowsheet. (2) 6000 tpd Malanjkhand copper project is based on CSIR-NML flowsheet.

Techno-economics

Available on demand

Technology Readiness Level (TRL)

TRL: 8

Environmental Consideration

There should be well planned disposal of tailings.

Major Raw Materials

Copper Ore; Flotation Reagents.

Major Plant Equipment/Machinery

Crushers, Grinding mill, Classification circuit, Flotation cells and Dewatering units.

Technology Package

(a) Process knowhow with technological process flow-sheet and material balance, (b) Details of equipment & (c) Assistance in setting up the plant on separate terms and conditions.





MMA001

Biomimetic Electrospun Collagen-Graphene Nanocomposites

Salient Features

Exfoliation of natural graphite using collagen. It bypasses the graphite oxide route, hence lesser defects. Spinning of graphene-collagen with PVA polymer to form fibres with varied applications. Yield varies from 0.03-0.05% as compared to the reported best of 0.3%.

Environmental Consideration

Eco friendly process. No high temperature, pressure requirements

Major Raw Materials

Natural Graphite, Collagen and PVA, analytical grade

Major Plant Equipment/Machinery

Electrospinning unit for fibre formation.

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout and (d) Quality assurance Methods. Assistance in setting up the plant on separate terms.

Uses

Biomedical applications, Electronic applications /coatings

Scale of Development

Laboratory Scale (01 litre)

Commercialization Status

Ready for commercialization

Techno-economics

Capital Investment: Rs. 50 Lakh
Production cost Rs 1000/- /kg

Technology Readiness Level (TRL)

TRL: 5





MMA002

Aqueous Ferro-fluids

Salient Features

Single-step synthesis at ambient conditions. Stable colloidal solution with particle size within 5-10nm.

Magnetite	: 01-0.3%byVol
Size	: <6nm
Dispersant	: biomolecules & water soluble polymers (0.05 - 2.5% by Volume)
Water	: 97-98% by Vol
Solubility in water	: Complete
Appearance & odor	: Black no odor
Specific Gravity (at RT)	: 0.996
Viscosity	: 0.982
Boiling Point (°F)	: 212°F
Magnetization	: Fluid: 0.23 emu/gm,
dried power	: 43.34 emu/gm
Colloidal stability	: Zeta PI:-15-18 mv
Hydrodynamic dia	: ~150-175 nm
Polydispersity index	: 0.1 - 0.2

Environmental Consideration

Eco-friendly process

Major Raw Materials

Ferrous/ferric salts, biocompatible polymers, liquor ammonia, analytical grade

Major Plant Equipment/Machinery

Magnetic stirrer. Hot Plate, Incubator, Pipette, Burette and glassware

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout & (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

In pharmaceutical industry as a biocompatible contrast agent in Magnetic Resonance Imaging (MRI), heating agents in Magnetic Fluid Hyperthermia (MFH) and drug carriers in targeted drug delivery.

Scale of Development

Laboratory scale (1 litre)

Commercialization Status

Ready for commercialization

Techno-economics

Capital investments. 5 Lakh. Production cost: Rs 1000/-/litre

Technology Readiness Level (TRL)

TRL: 5





MMA003

Development of Biphasic Calcium Phosphate blocks

Salient Features

The product novel three dimensional load bearing biphasic calcium phosphate nanocomposite is osteoinductive. It can induce the stem cells to differentiate into new bone forming cells. So the nanocomposite can be used as bone healing & synthetic bone graft. The mechanical compressive strength of the 3D BCP is in the range of 6-26 MPa analogous to cancellous bone.

Environmental Consideration

Not applicable

Major Raw Materials

Calcium salt and phosphate salts ammonium solution NH₃, Distilled water, polymer

Major Plant Equipment/Machinery

Magnetic stirrer (rpm): 1000/min, pH meter, Mould made of perplex sheet (15 cm x 15 cm x 10 cm) & Distilled water plant Muffle Furnace

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout & (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

Synthetic Bone Graft/Scaffolds

Scale of Development

Process demonstrated at 100 gm/batch scale

Commercialization Status

The know-how transferred to G. Surgiwear Ltd, Shajahanpur

Techno-economics

For 100 gm/batch scale Capital Cost ~Rs. 5.0 Lakh (excluding land & shed)

Technology Readiness Level (TRL)

TRL: 7





MMA004

Biomimetic Polymer based Hydroxyapatite Block

Salient Features

The product is novel three dimensional load bearing polymer-hydroxyapatite nanocomposite. It has been synthesized through biomimetic route. The process is in situ, simple and cost effective. It does not involve any toxic cross linker and works at near ambient conditions. The application of the nanocomposite is as a load bearing synthetic bone graft. The compressive mechanical strength of the nanocomposites is in the range of 2-12 MPa.

Environmental Consideration

Not applicable

Major Raw Materials

Calcium salt and phosphate salts, ammonium solution NH₃, distilled water and polymer

Major Plant Equipment/Machinery

Magnetic stirrer (rpm): 1000/min, pH meter. Mould made of perplex Sheet (15 cm x 15 cm x 10 cm) & Distilled water plant.

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout and (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

Synthetic Bone Graft

Scale of Development

Process demonstrated at 100 gm/batch scale

Commercialization Status

The know-how transferred to M/S G. Surgiwear Ltd, Shajahanpur

Techno-economics

For 100 gm/batch scale Capital cost ~ RS. 3.0 Lakh (excluding land & shed)

Technology Readiness Level (TRL)

TRL: 7





MMA005

High Carbon High Chromium White Cast Iron with Improved Wear Resistance for Grinding Media Applications

Salient Features

- Heat Treatment is optimized to get better wear resistance.
- Oil temperature and viscosity of the oil is optimized to have faster quenching rate and also to achieve distortion free grinding media.
- The stress relieving practices is optimized to relieve the residual stresses generated in the quenching.
- The process is economical and energy intrinsic. Heat generated in quenching process is utilized for the stress relieving process. No external or additional furnace is used for stress relieving process.
- Tray used as container of grinding media for the purpose of feeding in heat treatment furnace has been designed to achieve a homogenized temperature of optimized temperature on each grinding media in heat treatment furnace.
- Hardness of 66-67.8 HRC has been achieved.
- Specific wear rate of $5.4\text{mm}^3/\text{N}^{\text{m}}$ is achieved in comparison to that of $6.7\text{mm}^3/\text{N}^{\text{m}}$ of original balls
- Improvement in Wear Resistance is about 25-35%

Environmental Consideration

The efficiency of comminution process is improved by usage of grinding media developed by this technology. Comminution consumes about 60% of the total energy and the technology can reduce the energy consumption.

Major Raw Materials

Scrap of high chromium high carbon steel or cast iron. Alloying elements such as Silicon, Manganese, and Chromium etc.

Major Plant Equipment/Machinery

Induction Furnace, Heat Treatment Furnace, Quenching Bath at 90-150°C

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout and (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms

Uses

The grinding media so developed is used for grinding clinker for cement production. The developed GM has better wear rate than existing product in market.

Scale of Development

Under Ball Mill Field Trial from August, 2017-till date with approx. 1969178-2000000 tonnes of cement production

Commercialization Status

Field Trial and Technology Transferred to M/s Shree Cements

Techno-economics

Improvement of the wear property of the grinding media is at the level of 25-35 % of the existing process.

Technology Readiness Level (TRL)

TRL: 6





CAL001

Anti-Tarnishing Lacquer for Silver and Copper-based Alloys

Salient Features

Anti-tarnishing lacquer developed at CSIR-NML is a one component fast drying interior lacquer for use on brass, copper, bronze and silver surfaces.

- It prevents tarnishing (blackening) and provides a durable finish resistant to water, acid and alkali environments.
- The formula contains active corrosion inhibitors chemically bonded to acrylic polymer backbone, hence prevents tarnishing of copper, brass, bronze and items for long durations of several years.
- This one component acrylic resin lacquer is nontoxic (Lead and Cadmium free) when dry.
- The lacquer can be applied by spraying, brushing, or dipping and takes 10 minutes to dry. Post treatment like baking not required.
- The coating passes 500 hours of salt spray test (ASTM B 117) and 72 hours of flower of sulfur test (ASTM B 809).

Appearance: Transparent | Gloss @20°: 65-70 | Hardness :2H
 Film Thickness: 2-5 micron | Coverage: 15-20 m²/litre | Dry: 10min.
 VOC: 750-800 g/L | Acid resistance: Pass | Lead < 1 ppm
 Alkali resistance: Pass | Salt Spray Test: 500 hrs | Cd<1ppm

Environmental Consideration

The product contains organic solvents/VOC. Use in ventilated areas. No liquid waste or gas emission during lacquer production.

Major Raw Materials

Commercial grade chemicals like Acrylic monomers, substituted triazoles, Toluene, Acetone, and Dicyclohexylcarbodiimide (DCC).

Major Plant Equipment/Machinery

Reflux unit, Stirring unit, Filtering unit

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout & (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

- Use on brass and copper handicrafts to prevent tarnishing
- As a coating on copper or brass components and hardware to prevent corrosion
- On silver jewelry and decorative items to prevent tarnishing

Scale of Development

500 litres/batch

Commercialization Status

Product Commercialized by

- Mahashraya Chemicals (P) Ltd. , Balasore, Odisha
- M/S. Multicoat Surfaces (P) Ltd., Kolkata.

Techno-economics

Capital cost: Rs. 10 Lakh
 Unit price: Rs. 400/litre

Technology Readiness Level (TRL)

TRL: 8





CAL002

Dip Cleaner cum Brightener for Gold and Diamond

Salient Features

Gold & diamond jewelry dip cleaner developed at CSIR-NML can be used to clean, brighten and enhance glitter of used gold & diamond jewelries at home.

- The advanced formulation is free from harmful mineral acids and other harsh chemicals making it safe for domestic use.
- Cleaning is performed by dipping the jewelry in cleaning solution for 30 minutes followed by washing in water.
- Metal loss during cleaning is negligible even if gold items remain in solution for several hours.
- Gold jewelry with embedded precious stones can be safely cleaned using the dip cleaner.
- Rubbing is not required for cleaning and hence difficult to access areas in jewelry can be cleaned quickly and efficiently by simply dipping it into the solution.
- The cleaning solution can be used as the medium in ultrasonic cleaning bath to clean bulk quantity of gold jewellery in short time without affecting the embedded precious stones.
- Same cleaning solution can be used several times and can be safely disposed off without any environment pollution.

Uses

- Cleaning and brightening of used gold & diamond to enhance the glitter.
- Ultrasonic cleaning of bulk quantity of gold and diamond jewellery
- Jewellery cleaner for domestic use

Scale of Development

100 litres/batch

Commercialization Status

Product Commercialized by
M/S. Mahashraya Chemicals (P)
Ltd., Balasore, Odisha

Techno-economics

Capital cost: Rs. 2 Lakh
Unit price: Rs. 300/litre

Technology Readiness Level (TRL)

TRL: 8

Environmental Consideration

No solid or liquid waste is generated during the production and cleaning process.

Major Raw Materials

Sodium hypochlorite, sodium hydroxide

Major Plant Equipment/Machinery

Stirring unit

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout & (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.





Uses

- Cleaning and brightening of used tarnished silver to enhance the glitter
- Ultrasonic cleaning of bulk quantity of silver
- Silver tarnish remover for domestic use

Scale of Development

100 litres/batch

Commercialization Status

Product Commercialized by Mahashraya Chemicals (P) Ltd., Balasore, Odisha

Techno-economics

Capital cost: Rs. 2 Lakh
Unit price: Rs. 250/litre

Technology Readiness Level (TRL)

TRL: 9

CAL003

Dip Cleaner/Tarnish Remover for Silver

Salient Features

Silver dip cleaner developed at CSIR-NML can be used to clean, brighten and enhance glitter of tarnished silver items at home.

- The advanced formulation is free from harmful mineral acids and other harsh chemicals making it safe for domestic use.
- Cleaning is performed by dipping tarnished silver in hot cleaning solution for 30 minutes followed by washing in water.
- Metal loss during cleaning is negligible even if silver items remain in solution for several hours.
- Silver items with embedded precious stones can be safely cleaned using the dip cleaner.
- Rubbing is not required for cleaning and hence difficult to access areas in silver statues and decorative items can be cleaned quickly and efficiently by simply dipping it into the hot cleaning solution.
- The cleaning solution can be used as the medium in ultrasonic cleaning bath to clean bulk quantity of silver in short time without affecting the embedded precious stones.
- Same cleaning solution can be used several times and can be safely disposed off without any environment pollution.

Environmental Consideration

No solid or liquid waste is generated during the production and cleaning process.

Major Raw Materials

Sodium Carbonate, thiourea, surfactants

Major Plant Equipment/Machinery

Stirring unit

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout & (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.





CAL004

Anti-Corrosive Chemical for Steel Sheet, Rebar and Wire

Salient Features

An anti-corrosive chemical has been developed for the corrosion prevention of steel sheet, rebar and wire. The developed chemical has the following salient features:

- Synthesis protocol consists of mixing of chemicals
- Improves anti-corrosion properties of metals; > 200 h salt spray
- Can be applied on a surface by dip coating followed by drying at room temperature for 1 h or by curing at 150°C for 5 min
- Cured coated products at 250° C give golden and brown colors with 5 and 10 min curing time, respectively
- Cured product gives good lustre
- Coating forms a good adhesion on a surface
- Can also be applied on a surface using brush and spray

Environmental Consideration

Insignificant as the process does not release any gases and used chemicals are non-toxic and non-hazardous.

Major Raw Materials

Epoxy Resin, ISO-propanol and cross linker, Copper nanoparticles, Tin nanoparticles

Major Plant Equipment/Machinery

Magnetic stirrer for mixing of chemicals, Container of 100 litres

Technology Package

(a) Process-Know-how, (b) Details of equipment & (c) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

Anti-corrosive chemicals are useful for the corrosion protection of metals in a saline environment.

Scale of Development

Product is prepared on the scale of 50 liters

Commercialization Status

Ready for commercialization

Techno-economics

Rs. 300/litre

Technology Readiness Level (TRL)

TRL: 7





CAL005

Cyanide free process for leaching and recovery of gold

Salient Features

- Cyanide free Gold leaching process as fast as cyanide (2-5 min)
- Close loop process of gold leaching and recovery
- Operated at room temperature
- Gold plated on any surface can be recovered without damaging the base material
- Ready for commercial use in plant scale

Environmental Consideration

Non-toxic chemicals are used for leaching and recovery of gold. The process operates in close loop and no hazardous substance is released to the environment.

Major Raw Materials

Commercially available iodine chemicals, hydrogen peroxide

Major Plant Equipment/Machinery

Plastic tanks, filter unit, Centrifuge

Technology Package

(a) Process know how (b) Details of equipment & machinery (c) Plant layout (d) Quality assurance methods. Assistance in setting up of plant on separate terms.

Uses

- Leaching of gold from gold plated parts without affecting the base metal
- Recovery of gold from gold plated scraps

Scale of Development

Pilot scale (100 liters/batch)

Commercialization Status

Process implemented at TITAN Company Ltd, Watch Division, Hosur, Tamil Nadu

Techno-economics

Capital cost: 10 lakh
Chemical cost: As per scale of operation

Technology Readiness Level (TRL)

TRL:6





CAL006

Cyanide free alkaline electrolyte and electrochemical process for rust removal from plain carbon steel components

Salient Features

- Very fast electrochemical rust removal process (1-2 min)
- Alkaline cleaning process – No hydrogen embrittlement and cleaned surface is passivated to prevent immediate rusting
- Electrolyte is free from toxic elements like cyanides
- Operation at room temperature
- Very small components (screws) and big components can be cleaned
- Ready for commercial use in plant scale

Uses

- Cleaning of small rusted steel components
- Surface cleaning of steel components before Ni, Zn or other metal electroplating

Scale of Development

Pilot scale (25 liters/batch)

Commercialization Status

Process implemented at TITAN Company Ltd, Watch Division, Hosur, Tamil Nadu

Techno-economics

Capital cost: 10 lakh
Chemical cost: As per scale of operation

Technology Readiness Level (TRL)

TRL:6

Environmental Consideration

Non-toxic chemicals are used for removing rust from steel. Require waste water treatment before water is released to the environment.

Major Raw Materials

Commercially available alkaline chemicals, sulfur containing chemicals.

Major Plant Equipment/Machinery

Rectifier, Plastic tanks, mixing unit

Technology Package

(a) Process know how (b) Details of equipment & machinery (c) Plant layout (d) Quality assurance methods. Assistance in setting up of plant on separate terms.





Without coated



Zn-Ni-Cu Coated Steel

Uses
Coated steel for: Anti-bacterial applications (ACs, Refrigerators, Windows, Air coolers), Automobile fuel tank.
Scale of Development
30 cm X 20 cm steel substrates
Commercialization Status
Ready for commercialization
Techno-economics
For current level, investment is only HVOF unit and then major raw materials. It will be around Rs. 20 Lakh
Technology Readiness Level (TRL)
TRL:5

CAL007

Zn-Ni-Cu Coatings for Anti-Bacterial and Fuel Tank Applications

Salient Features

The salient features of Zn-Ni-Cu coated steel are:

- Improved corrosion resistances in foul fuel media as well as microbial attack.
- Antibacterial characteristics of the coated steels by killing the microbes.
- The coatings do not require hexavalent chrome passivation.
- It is easy to scale up.

Environmental Consideration

No significant environmental issues with the process or coatings

Major Raw Materials

Zn, Ni and Cu powders with 98-99% purity, Kerosene/LPG as fuel for thermal spraying system

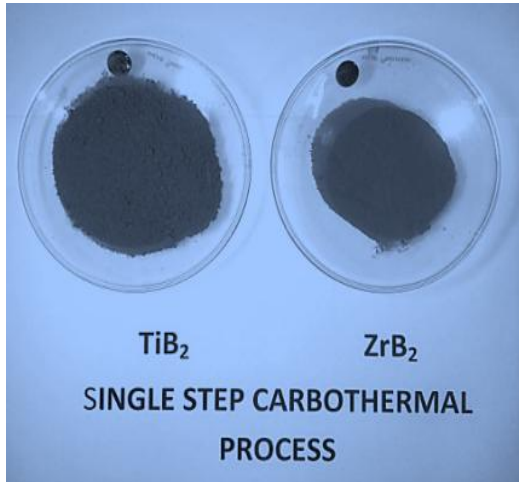
Major Plant Equipment/Machinery

Thermal spray technique using High Velocity Oxy Fuel equipment (HVOF)

Technology Package

- Detailed knowhow for the deposition of Zn-Ni-Cu coatings
- Demonstration at the scale of 30 cm x 20 cm scale
- CSIR-NML can help in Scaling up the process on request.
- Assistance or guidance at different stages of process implementation and product evaluation (on separate terms)





CAL008

Single step production of Zirconium boride and Titanium boride powder either by Carbothermal or SHS process

Salient Features

Production of Zirconium boride or Titanium boride powder by single step process is difficult. The developed technology for the production of single phase Zirconium/Titanium diboride powder requires single step of processing. The process also requires low cost raw materials and therefore economical and easy to scale up.

The important characteristics of the produced powder are:

Carbothermal process

XRD analyses: TiB_2 or ZrB_2 phase in the product

Purity: > 95% | Average particle size: $10\mu m$

SHS process

Purity: $\geq 95\%$ | Particle sizes: 200 nm - $2\mu m$

XRD analyses: Single phase of borides

Powder Sinter ability: Excellent

Environmental Consideration

Carbothermal

CO and CO_2 evolution

SHS

No significant issues except generation of ultrafine MgO powder & Acid leached residue generation

Major Raw Materials

Carbothermal

Oxide powders of Zirconium, Titanium and Boron, and carbon powder. Inert gas (Argon)

SHS

Oxides or chlorides of Zirconium, Boron, and elemental Mg powder. Inert atmosphere (Argon). suitable acid for leaching MgO for SHS process

Major Plant Equipment/Machinery

For carbothermal

High temperature graphite furnace, Ball Milling facility

For SHS

SHS reaction chamber and byproduct leaching set up

Technology Package

- Detailed knowhow of the powder production process
- Demonstration at the scale of 200 gm
- CSIR-NML can help in Scaling up the process on request.
- Assistance or guidance at different stages of plant setting and product evaluation (on separate terms)

Uses

Ultra high temperature wear and oxidation resistant components, thermocouple sleeves, nuclear components (boron capture), sputtering targets, evaporation boats, electrode for Al-extraction (Hall Heroult), Hypersonic aero-engine components, rocket nozzles, Dome for Re-entry vehicle etc

Scale of Development

200 gm per batch

Commercialization Status

Technology for ZrB_2 and TiB_2 powder production is transferred to M/s Aum Techno Ceramics, Gujarat by carbothermal process by SHS process

Techno-economics

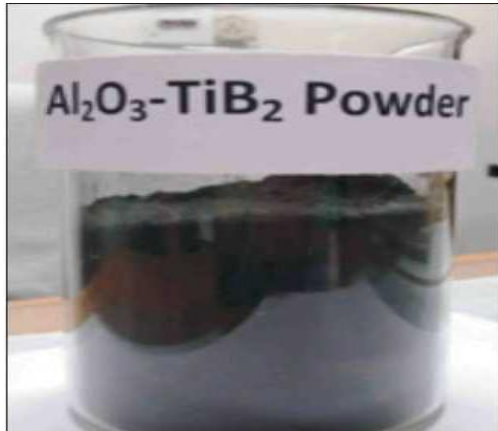
For current level investment is only furnace and milling equipment around 60 L for carbothermal

For current level investment around 15 L for SHS process

Technology Readiness Level (TRL)

TRL:5





CAL009

Alumina - (Ti, Zr) Borides Composite and Composite powder

Salient Features

The developed technology for the production of superhard Alumina-Zirconium/Titanium diboride in-situ composite and composite powder by self-propagating high temperature synthesis route is economical as it uses low cost raw materials and does not need any high temperature furnace. The process can be upscaled easily and it also takes only 10 minutes for synthesis and compaction. Total time milling, synthesis, and compaction etc < 1h per batch. The in-situ composites with tailored microstructures exhibit excellent mechanical properties. The in-situ compacted samples has:

Density: 93-97% of theoretical density

Grain size range: for both alumina and borides phases (1-2 μ m)

XRD analyses: only boride and alumina phases.

Hardness of the in-situ composites: 25-32 GPa

Only composite powder also can be made 500gm batch

Environmental Consideration

No significant environmental issues

Major Raw Materials

Oxides of zirconium, Titanium and Boron, and elemental Al powder.

Major Plant Equipment/Machinery

Equipment for reaction and in-situ densification of the composite

If powder is also of interest then reaction chamber

Technology Package

- Detailed knowhow of the SHS dynamic compaction process
- Demonstration at the scale of 500 gm (composite powder) and 75mmx75mm x 10mm for in-situ compacted samples.
- CSIR-NML can help in Scaling up the process on request.
- Assistance or guidance (on separate terms)

Uses

Wear and oxidation resistant components, Armor, Cutting Tools, Refractory lining materials etc.

Scale of Development

Composite powder: 500gm per batch

In-situ compact sizes: 75mmx75mm x 10mm

Commercialization Status

Ready for commercialization

Techno-economics

For current level investment will be around Rs.15 Lakh

Technology Readiness Level (TRL)

TRL:5





Uses

Wear and oxidation resistant coatings, Cutting tool, recording device, Automobile components (Piston, rings and combustion chamber). Replacement of hard chrome and DLC coatings.

Scale of Development

75mm x 75mm flat area or 50 mm x 20 mm dia pipes (Coatings on outer surface)

Commercialization Status

Ready for commercialization

Techno-economics

At the current level (75mm x 75mm) of development, sputtering chamber cost is the main cost which will be around Rs. 50 Lakh.

Technology Readiness Level (TRL)

TRL:5

CAL010

Nano-Composite Hard Coating

The developed nano-composite Ti-Si-B-C coatings exhibit excellent mechanical properties, good tribological properties with low coefficient of friction. The coating also shown excellent resistance to chemical corrosion (salt spray 500 hrs, no degradation) and oxidation resistance up to 800oC.

The important features of the process and hard coatings include:

Process of deposition: Magnetron sputtering

Hardness can be tailored: 10-40 GPa

Coefficient of friction: 0.1-0.2

Nano-crystalline grain size in amorphous matrix: 2-100 nm

Stable up to 700-800 C

Good corrosion resistance: accelerated salt spray test showed no degradation for 900 hr exposure.

Environmental Consideration

No significant environmental issues

Major Raw Materials

Powders of Borides and carbides of Ti, Si. Metallic Si powder, Argon and nitrogen IOLAR Grade

Major Plant Equipment/Machinery

Magnetron sputtering system

Technology Package

- Detailed knowhow of the deposition process including the target preparation.
- Demonstration at the scale of 75mm x 75mm scale
- CSIR-NML can help in Scaling up the process on request.
- Assistance or guidance at different stages of process implementation and product evaluation (on separate terms)





ISM001

Certified Reference Materials

Salient Features

Certified Reference Materials (CRM) of ores, minerals, refractories, ferro alloys and different grades of steel. CRMs are available as turnings, powders and solid discs. These CRMs have been prepared following ISO Guide 34, 35 and other allied standards. Each unit of CRM is accompanied with a composition certificate with uncertainty.

Environmental Consideration

Normally no environmental issues are involved in the present set of CRMs available with NML. However, material safety data sheet will be prepared whenever and wherever it is needed. Certificate for each CRM gives its shelf life.

Major Raw Materials

Raw materials depend upon the nature of the sample and its chemistry

Major Plant Equipment/Machinery

Crusher, Grinder, Lathe, Analytical equipments such as DRS, AAS, ICP-OES etc.

Technology Package

Technology package will depend on the specific requirement of CRM and its scale of development. It may be customized as per client's demand. The package will cover all the steps from sourcing of raw materials to packaging of finished products

Uses

Validation of analytical data, standardization of analytical techniques, calibration of analytical instruments, checking proficiency of analytical chemists

Scale of Development

Normally 100-150 kg batch from which 100g units are bottled.

Commercialization Status

After certification, the CRM is ready for commercialization. Currently NML is marketing more than 30 different types of CRMs.

Techno-economics

Techno-economics is different for different CRMs. Different components affecting techno-economics include sourcing of raw material, its processing, homogeneity establishment, certification through inter laboratory comparison and packaging. CRM development, in general, is a commercially viable process.

Technology Readiness Level (TRL)

TRL:8





After Casting



After 90 days trial at the hydel power plant

Uses

- Underwater turbine components
- Impellers of pumps
- Cavitating bends and valves of pipes and tubes
- Propellers of ships and submarines

Scale of Development

40 kg in lab scale; component of ~100kg was prepared in actual and was tested at hydel power plant during monsoon

Commercialization Status

Field trial at 100kg level component has been completed. The field trial by BHEL is under negotiation

Techno-economics

A component of ~100 kg costed ~ Rs.10 Lakh

Technology Readiness Level (TRL)

TRL:5

ISM002

Erosion Resistant Steel

Salient Features

- The alloy steel has multiphase steel and developed based on TRIP effect; hence can be used at room temperature as well as lower temperatures.
- This steel is being developed through normal casting and heat treatment process.
- This steel has similar hardness and tensile strengths as that of presently used cast 13%Cr-4%Ni steel.
- This steel has higher impact toughness (3 times as that of the 13%Cr-4%Ni) at room temperature as well as zero degree temperature.
- This steel exhibits higher erosion resistance as well as cavitation resistance as required for underwater components of turbine hydro generators.

Environmental Consideration

Not Applicable

Major Raw Materials

Low carbon steel scrap, low carbon ferro alloys

Major Plant Equipment/Machinery

Melting furnace, casting bay, heat treatment furnace, spectroscopy, machining equipments

Technology Package

(a) Process-Know-how (b) Details of equipment (c) Plant Layout & (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.





ISM003

Graphene Coated Steel

Salient Features

A simple process consisting of dip coating followed by heating in inert atmosphere is available for the production of graphene coated steel. The same process can also be extended for graphene coating over other substrate like quartz. The graphene coated substrates produced using this process have the following salient features:

- Improves the anti-corrosion properties of bare steel
- Quartz shows sheet electrical resistance of 10kΩ with transparency > 83%, can be used as a transparent conductor

Environmental Consideration

H₂O and CO₂ gases release during heating

Major Raw Materials

Shellac biopolymer and Iso-propanol

Major Plant Equipment/Machinery

A furnace capable of heating up to 100°C with controlled atmosphere facility. Argon gas or mixture of 90 % Ar & 10 % H₂, steel and quartz substrates.

Technology Package

(a) Process-Know-how, (b) Details of equipment & (c) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

Graphene is a new allotrope of carbon, which has promising applications in the areas of corrosion, fuel cell and electronic devices.

Scale of Development

Process is demonstrated on a A4 size cold-rolled steel sheet using batch-annealing furnace at Tata Steel, Jamshedpur

Commercialization Status

Process-know-how is ready for commercialization, up to A4 size substrate

Techno-economics

Rs.10-20 for A4 size substrate

Technology Readiness Level (TRL)

TRL:5





ISM004

Synthetic Flux and a Process for De-phosphorization of Steel in Induction Furnace

Salient Features

Approximately 90% of nearly 15 million tonnes of steel produced in Indian induction furnaces, using DRI as the major feed material and containing phosphorous in the range of 0.08 - 0.11 % is used for structural purpose. Both BIS and ASTM standards stipulates the same in the range of 0.03 - 0.06%, depending upon the application. The developed flux and the process offers the following distinct features:

- Ease of slag formation
- Controlled consumption of furnace lining
- Power consumption in the range of 30-40 KWh/ts during refining
- Steel with phosphorous below 0.05%

Environmental Consideration

The process would generate approximately 15 – 20 kg/ts of basic slag.

Major Raw Materials

Commercial grade quartzite, limestone/dolomite, soda ash, mill scale, manganese ore etc

Major Plant Equipment/Machinery

Melting facility for production of pre-fused flux commensurate with induction furnace capacity

Technology Package

Includes (a) Process Know-How and (b) Quality Assurance Methods. Assistance in setting up the flux making plant on separate terms

Uses

Production of quality steel, especially in terms of phosphorous, in induction furnace while DRI is used as major feed material

Scale of Development

- Flux has been produced in 200 Kg capacity pilot scale furnace
- Process developed in 20 Kg induction furnace

Commercialization Status

Process and the flux have been successfully tested in commercial induction units of upto 6T capacity. Modality for technology transfer is being worked out

Techno-economics

Cost of the developed flux is estimated to be approximately Rs. 25/Kg.

Technology Readiness Level (TRL)

TRL:7





ISM005

Ferrosilicon from BHQ, BHJ & Low Reactive Coal

The most remarkable feature of this process is to use of non-standard materials such as BHQ, BHJ and Jhama coal for production of standard Ferro-Silicon which is more suitable for iron and steel sector.

Uses

Ferrosilicon is used as (i) an alloying element and deoxidizer in iron and steel industries, (ii) reductant in Pidgeon process for production of magnesium and (iii) electrode coatings in arc welding

Scale of Development

Pilot Scale (15 Tones): 500 kVA Submerged Arc Furnace (200 Kg FeSi /Shift),

Commercialization Status

Ready for commercialization

Techno-economics

Cost of the Ferro-Silicon (FeSi 55-65%) produced to be approximately Rs. 64,000 to 70,000/ ton.

Technology Readiness Level (TRL)

TRL:6

Environmental Consideration

- Generation of slag 2 to 3 kg per ton of FeSi produced
- Generic emission factor 4 to 5 for 60% FeSi
- No liquid effluent generated.

Major Raw Materials

(i) Banded Hematite Quartzite (BHQ), (ii) Quartzite (iii) less reactive carbonaceous material such as Jhama Coal (iv) Banded Hematite Jasper Ore (BHJ) (v) Pet. Coke and (vi) Scrap

Major Plant Equipment/Machinery

For Commercial scale production : 10 – 25 MVA and its accessories

Technology Package

Complete flow-sheet with mass balance, equipment details, process description, cost estimate, product specification. Assistance in setting up the plant as per organization terms and conditions





ISM006

Production of Directly Reduced Iron (DRI)

The process utilizes ~100% waste raw materials. This invention is useful for converting steel plant / mining wastes such as iron ore fine/ slime and lean grade coal in to a high quality value added product (DRI). The product is a suitable feed for electric arc furnace, BOF and induction furnace for steel making

Uses

The product developed by this process will be used as feed material for electric furnace, BOF and induction furnace for steel making.

Scale of Development

Laboratory scale: 1 to 5 kg

Commercialization Status

Ready for commercialization

Techno-economics

Cost of the DRI produced to be approximately Rs. 14,000 / ton.

Technology Readiness Level (TRL)

TRL:6

Environmental Consideration

- (i) Environmental friendly as generation of coal char is only 100-150 kg per ton of DRI
- (ii) No liquid effluent generated.

Major Raw Materials

- (i) Waste / lean grade iron ore fines / slime (ii) waste / lean grade coking or non coking coal.

Major Plant Equipment/Machinery

- (i) Tunnel Kiln furnace (ii) saggars (iii) Ball mill (iv) Pelletizer etc.

Technology Package

Know-How, Complete flow-sheet with mass balance, Equipment details, process description, product specification. Assistance in setting up the plant as per organization terms and conditions





ISM007

Highly Metallised Low Sulphur Directly Reduced Iron (DRI) from Iron Ore Slime and Rejected/Middling Coal

Uses

The produced DRI will be used as a feed /substitute of scrap in Induction furnace, Electric arc furnace and BOF for steel making.

Scale of Development

Commercial Tunnel Kiln: 12 to 18 TPD

Commercialization Status

Ready for commercialization

Techno-economics

The techno-economics of the process have been arrived and found to be very favorable (i.e., 2/3rd of the conventional DRI process cost due to utilization of waste raw materials) than the conventional DRI making processes.

Technology Readiness Level (TRL)

TRL:6

Environmental Consideration

Less than conventional DRI processes

Major Raw Materials

Waste / lean grade iron ore fines, slime etc. and waste coal containing 25 to 65% ash such as middling coal, rejected coal or likewise.

Major Plant Equipment/Machinery

Tunnel kiln, saggars, pelletizer etc.

Technology Package

(a) Process Know-how (b) Details of equipment (c) Plant Layout and (d) Assistance in setting up the plant as per CSIR-NML norms





ISM008

Process for Production of Highly Metallised Directly Reduced Iron Cylinders (DRIC) from Lean Grade Raw Materials

Salient Features

The process utilizes ~100% waste/lean grade raw materials to produce value added product. This invention is useful for converting steel plant and mining waste such as iron ore fines/slimes and lean grade coking or non-coking coal (>32% ash) into a highly metallised (metallization >96%) low Sulphur (0.008%S) DRI Cylinders suitable as a feed for induction furnace, electric arc furnace and basic oxygen furnace steelmaking.

Environmental Consideration

This process utilizes waste fines/lean grade raw materials generated in mines head and steel plant. This process not only converts the waste/lean grade raw materials into a value added product but also solves the problem of disposal, environment and loss of minerals. It also saves electricity while melting. Therefore, this process is very favorable to environment compared to conventional DRI processes.

Major Raw Materials

Waste/lean grade iron ore fines, slimes etc. and waste or lean grade coking or non-coking coal

Major Plant Equipment/Machinery

Tunnel Kiln, saggars/crucibles, pressing machine etc.

Technology Package

- Process-Know-How
- Details of equipment
- Plant layout
- Quality assurance methods and
- Assistance in setting up the plants as per CSIR-NML norms

Uses

The Directly Reduced Iron Cylinders (DRIC) produced by this process can be used as a feed / substitute of scrap for melting in Induction Furnace (IF), Basic Oxygen Furnace (BOF) and Electric Arc Furnace (EAF) for production of steel.

Scale of Development

Laboratory scale: 4 to 6 kg

Commercialization Status

Ready for commercialization

Techno-economics

The techno-economic of the process have been arrived and found to be favorable (i.e., 2/3rd of the conventional DRI process cost) than the conventional DRI making processes. The electricity consumption during melting of DRIC in Induction Furnace has been arrived and found to be less (i.e., 25-30%) than the conventional pellet melting.

Technology Readiness Level (TRL)

TRL:6





ISM009

Highly Metallised Directly Reduced Iron (DRI) from mill scale and lean grade non coking coal in Tunnel Kiln

Salient Features

The process utilizes mill scale and lean grade non-coking coal for production of highly metalized DRI through Tunnel Kiln. This invention is useful for converting mill scale generated in primary and secondary sector of iron and steel industries in to highly metalized DRI. Lean grade non-coking coal left in the mines head are utilized as a reductant for conversion of mill scale in to DRI. DRI produced from this process have very high degree of metallization (Metallisation > 92%) and are suitable as a feed for induction furnace, electric arc furnace and basic oxygen furnace for steel making.

Uses

The produced DRI is suitable as a feed for Induction furnace, Electric arc furnace and BOF for steel making.

Scale of Development

Pilot Plant in Commercial Tunnel Kiln: 18 TPD

Commercialization Status

Transferred to M/s. SMRW, Ranchi and available for implementation to user industries

Techno-economics

The techno-economics of the process have been evaluated in collaboration with user industries and found to be much cheaper (2/3rd of the conventional DRI process) than the conventional DRI making processes.

Technology Readiness Level (TRL)

TRL:9

Environmental Consideration

Negligible compared to the conventional process of DRI making.

Major Raw Materials

Mill scale generated in primary and secondary sector of iron and steel making and lean grade non-coking coal or likewise.

Major Plant Equipment/Machinery

Tunnel kiln, Saggars, Ball Mill, Pelletizer etc.

Technology Package

(a) Process Know-how (b) Details of equipment (c) Plant Layout and (d) Assistance in setting up the plant as per CSIR-NML norms



ISM010

Cold Bonded Carbon Composite Pellets for Utilization of Iron Ore Micro-fines and Carbon Bearing Fines

Salient Features

This process produces micro-pellets with high C content which will be used in sintering of iron ore for reduction of coke breeze consumption and in smelting reduction process. The salient feature of the process are as follows

- This is a cold bonding process, so it is energy efficient. Curing time is very short (5-10 min).
- It utilizes iron ore micro-fines and coal fines or coke fines or carbon containing waste fines in iron making or sintering.
- The micro-pellets provide energy to the sinter bed for reduction in coke breeze consumption. 38-48 % reduction in coke breeze has been found when 38 % blast furnace flue dust containing pellets were mixed with iron ore in sintering(12 kg scale)
- Since it is a composite pellet, it can be reduced faster than normal pellets
- CO₂ in steel plant's waste gas is utilized in strengthening of pellet

Environmental Consideration

No harmful effect on environment, it will decrease CO₂ emission since, CO₂ will be used in strengthening of micro-pellets

Major Raw Materials

Iron ore for normal sinter mix, iron ore concentrate, non coking coal, fluxes viz lime stone/lime, dolomite, steel plants solid wastes such as B.F. Flue dust etc.

Major Plant Equipment/Machinery

Conventional sintering set-up, pelletization set-up, CO₂ treatment facility at room temperature, charging facility with existing mixing drum of sintering set-up.

Technology Package

(a) Process-Know-how, (b) Details of equipment & (c) Quality Assurance Methods. Assistance in up-scaling and setting up the plant on separate terms.



Uses

Iron and Steel industries

Scale of Development

100 kg/ batch micro-pellet making, micro-pellets used in 12 kg sinter pot

Commercialization Status

Up-scaling is required

Techno-economics

Capital cost depends upon scale of plant. All raw materials used are wastes

Technology Readiness Level (TRL)

TRL:6





ISM011

Pellet-Sinter Composite Agglomerate (PSCA) of Iron Oxide Fines for use in Blast Furnace

Salient Features

In Pellet-Sinter Composite Agglomerate (P-SCA), iron oxide pellets are embedded in to the sinter mass. P-SCA for use in blast furnace has been developed with Indian iron ore to utilize the micro-fines in sintering. The salient features of the process are as follows:

- It also uses steel plant's waste materials viz. LD sludge, mill scale etc (5-10%) with iron oxide microfines.
- The process yields a very good quality sinter even at the lower basicity that is usable in blast furnace.
- It increases the fines acceptability (30% above normal) improving permeability and decreases energy consumption (~20%) and flux consumption.

Environmental Consideration

- Environment friendly since it reduces Energy consumption
- No harmful/hazardous effect on environment

Major Raw Materials

Iron ore fines, LD Sludge, BF-Blue Dust

Major Plant Equipment/Machinery

Pelletizer, Conventional sintering facility, charging system

Technology Package

(a) Process-Know-how, (b) Details of equipment & (c) Quality Assurance Methods. Assistance in up-scaling and setting up the plant on separate terms.

Uses

Iron Making

Scale of Development

12 kg/batch

Commercialization Status

Up-scaling is required

Techno-economics

Present sinter strand in steel plant can be used for Up-scaling. Only a pelletizer of suitable capacity with charging facility has to be installed. Raw materials are fines and wastes.

Technology Readiness Level (TRL)

TRL:6





ISM012

Fluxed Sinter through Micro-Pelletization

Salient Features

A fluxed sinter using 100% ultra-fine waste oxide material generated in steel plant viz. LD sludge, BF flue dust and lime fines (10 to 55%) through micro-pelletization for their recycling. The salient features of the process are:

- Micro-pellets are hard (CCS: ~10 kg/pellet) to withstand cold handling.
- Sintering is possible neither using any external heat nor any coke breeze and the waste material itself is the heat source.
- The produced sinter is suitable for using in both iron and steel making processes.

Environmental Consideration

No harmful/hazardous effect on environment

Major Raw Materials

LD Sludge, BF-Blue Dust and Lime Fines

Major Plant Equipment/Machinery

Pelletizer, CO₂ treatment facility, Sinter Plant, charging system of micro-pellets

Technology Package

(a) Process flowchart and details, (b) Details of equipment & (c) Quality Assurance Methods. Assistance in up-scaling and setting up the plant on separate terms.

Uses

Iron and steel making

Scale of Development

10 kg / batch

Commercialization Status

Up-scaling is required

Techno-economics

Capital cost for the Pelletizer, CO₂ treatment facility depends upon amount of up scaling. Conventional sinter strand will be used. Raw materials used are wastes.

Technology Readiness Level (TRL)

TRL:6





ISM013

Briquetting of Ore Fines

Salient Features

This technology produces briquettes of ore fines with suitable binder through briquetting press. Ore fines and industrial waste can be utilized through the technology.

Environmental Consideration

This is a green technology for utilization of ore fines as well as waste products of industry such as mill scale, flue dust etc. Greenhouse gases and other harmful ones are not generated through this technology.

Major Raw Materials

Ore fines, Binder, Fluxes, Metallurgical Wastes

Major Plant Equipment/Machinery

Mixing unit, Briquetting Machine

Technology Package

(a) Process knowhow & (b) Assistance in setting up the plant on separate terms.

Uses

Ore fines and valuable industrial wastes can be utilized for metal production through this technology

Scale of Development

500 kg/day; Scale-up is possible

Commercialization Status

Ready for commercialization

Techno-economics

Available on demand

Technology Readiness Level (TRL)

TRL:6





DPI001

Wide Metallic Glass Ribbon Processing Unit

Salient Features

25mm wide 25-50 micron thick continuous glassy ribbon can be prepared by planar flow casting method using melt spinning system. It uses 1 kg (for ferrous alloy) capacity induction furnace. The liquid metal is poured on water cooled Cu-wheel which can rotate at a speed of 1000 -3000 rpm. The system can be operated in normal and controlled atmospheres. The type of alloys that can be prepared through this melt-spinning system are:

- Glassy magnetic alloys: Fe-Si-B, Fe-Ni-B, Co-Si-B
- Nanostructured magnetic alloys: Fe-Nb-Cu-Si-B, Fe-Co-Nb-Si-B
- Brazing alloys: Cu-Ni-Mn, Ni-Fe-Cr-B-Si
- Ferromagnetic shape memory alloy: Ni-Mn-Ga, Co-Ni-Al

Environmental Consideration

No hazardous gas emitted.

Major Raw Materials

- Fe, Co, Ni, Cr, Nb, Cu, Si, B, Al, Mn, Ga depending on the type of alloys to be produced
- Excel grade argon gas
- Chilled water

Major Plant Equipment/Machinery

Electric Arc Furnace, Induction melting unit coupled with water cooled rotating copper disc

Technology Package

Equipment details, process description, Cost estimation & product specification. Assistance in setting up the plant on separate terms.

Uses

Rapidly solidified material processing unit for

- Magnetic alloys: Transformer core, magnetic sensor applications, saturable reactor cores, choke coils, core materials for circuit breaker etc.
- Brazing Alloys: Joining materials for heat-exchanger for automobile and aircraft industries

Scale of Development

Single unit can produce 500g alloy/ batch leading to 50kg/ month capacity

Commercialization Status

Licensed for manufacturing to M/s Vacuum Techniques Pvt. Ltd., Bangalore, on non-exclusive basis

Techno-economics

Rs. 1 Crore (excluding land & shed) per unit & Recurring Expenditure depends on type of raw material used

Technology Readiness Level (TRL)

TRL:6





DPI002

MagStar: A Portable Magnetic Hysteresis and Barkhausen Emissions based Electromagnetic Device for Non-Destructive Evaluation of Steel Structure/Component

Salient Features

The developed electromagnetic NDE device works by exciting the sensor by an alternating current source. The sensor is to be placed on test body to get signal corresponding to the characteristics of the test objects. The output signals from the sensor are the measure of the magnetization, coercivity and magnetic noise (Barkhausen emissions) which change with microstructure and stress state of the materials. The salient features of the device are as follows:

Magnetic Hysteresis Loop (MHL) measurement

Frequency Range : 20mHz to 200mHz

Excitation : 0-1500 Oe

Wave Shape : Sinusoidal / Triangular

Magnetic Barkhausen Emission (MBE) measurement

Frequency Range : 10Hz to 200 Hz

Excitation : Up to 1500 Oe

Number of Cycles : 3 to 10

Gain : 0 - 20 dB (in steps of 1 dB)

Filter setting 10KHz to 300KHz independently variable Low pass and high pass.

Power Requirement : 230V, 50Hz, 200VA

Weight : 3.25Kg

Control, Display and Analysis : External laptop /notebook/ PC

Environmental Consideration

Not Applicable

Major Raw Materials

Electronic components, Soft magnetic core materials

Major Plant Equipment/Machinery

Sensing probe, power source, amplifier, data acquisition & analysis system

Technology Package

(a) Details of equipment, (b) Operating Manual and (c) Quality Assurance Methods.

Uses

- Evaluation of microstructural changes during heat-treatment/ ageing,
- Evaluation of ferromagnetic phases and its correlation with mechanical properties and
- Residual stress analysis

Scale of Development

Portable Laboratory based device and scope for automation for in-service operation

Commercialization Status

Licensed for manufacturing to M/s Technofour, Pune, on non-exclusive basis. Four units sold to NTPC (NETRA), BARC, JSW (R&D) and IIT (BHU) & Royalty received by CSIR-NML.

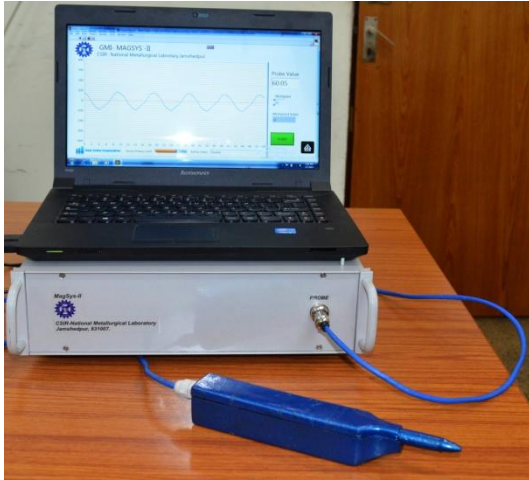
Techno-economics

Cost: Rs. 20 Lakh/unit. Additional Sensor: Rs. 2.0 Lakh/unit

Technology Readiness Level (TRL)

TRL:8





DPI003

MagSys: A portable Giant Magneto-Impedance (GMI) based Magnetic Sensing device for NDE Applications

Salient Features

MagSys is a portable magnetic sensing device where nanostructured Fe-Co based magnetic wires of diameter 80-120 micron prepared by in-rotating water quenching technique is used as a core material in the probe-head. The magnetic wire material exhibit Giant Magneto-Impedance (GMI) properties. The output signal of the sensor is proportional to the magnetic field generated by the test object. If there is change in composition, microstructure or residual stress of the test object due to in-service operation, the magnetic properties also change and hence the output signal of the sensor.

- Operating frequency ranging between 250 kHz and 1 MHz
- Power Requirement: rechargeable 5V battery with 4 hours back- up time
- Weight :2Kg
- Control, Display and Analysis: External laptop /notebook/PC

Environmental Consideration

Not applicable

Major Raw Materials

Nanostructured wire for core materials that can be prepared at CSIR-NML by in-rotating water quenching apparatus. Raw materials for wire are Co, Fe, Cr, Si, B. Raw materials for electronics circuit are Resistance, Capacitors and ICs.

Major Plant Equipment/Machinery

Sensing probe, AC power source, amplifier, data acquisition & analysis system

Technology Package

(a) Details of equipment, (b) Operating Manual and (c) Quality Assurance Methods. Nanostructured GMI wire to be supplied by NML along with the technology package.

Uses

- In petrochemical industries where properties of stainless steel based component changes due to carburization
- Detection of presence magnetic phases in nonmagnetic steel that take place during in-service operation or manufacturing process
- Detection of low magnetic field

Scale of Development

Portable Laboratory based device and scope for automation for in-service operation

Commercialization Status

One Unit delivered to R&D centre, IOCL, Faridabad.

Techno-economics

Cost: Rs. 15 Lakh/unit Including sensor

Technology Readiness Level (TRL)

TRL:7





DPI004

FlawGuard: A Cost Effective Device for Defect Detection in Wires during Cold Drawing

Salient Features

Presence of transverse cracks in wires leads to premature failure. This system works based on the principle of encircling coil differential probe eddy current. This should be installed in the drawing line and wire passes through the core of the probe. Probe diameter can be changed based on the wire diameter. Features of the present system are as follows:

- Test material diameter: 1.5 mm – 13 mm
- Operating frequency: 10 – 250 kHz
- Depth Resolution: 100 μ m
- Drawing line speed: up to 12 m/s
- LCD display
- Alarm: LED & Buzzer
- Graphical representation, data logging and post processing
- Defect characterization: defect location and severity
- Real time data in ASCII format
- Interfacing through LAN
- Customized software for smart monitoring & control, real time data through IOT, SMS & E-mail facility
- Standalone as well as laptop based.

Power Requirement: 220V/50Hz

Weight: 1.5 Kg; Dimension: 300 x 300 x 100 (all in mm)

Environmental Consideration

Not applicable

Major Raw Materials

Electronic components, enameled copper wire, cables and accessories

Major Plant Equipment/Machinery

Sensing probe, power source, data acquisition & analysis software

Technology Package

(a) Process-Know-how, (b) Details of equipment & (c) Quality Assurance Methods. Assistance in setting up the plant on separate terms

Uses

Online surface and subsurface defects viz. transverse cracks, weld joint, crack feet etc. detection in wires during cold drawing

Scale of Development

Prototype developed, implemented at one of the biggest wire mills in India

Commercialization Status

Ready for commercialization

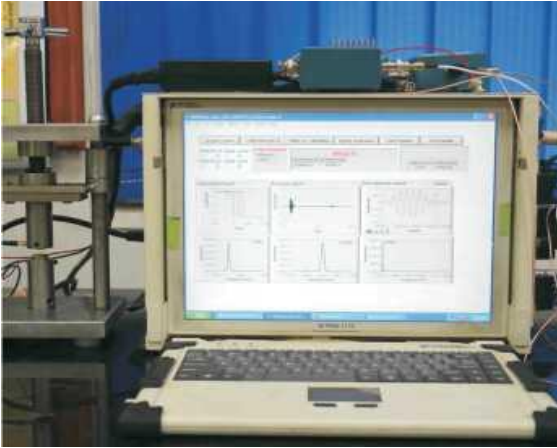
Techno-economics

Capital Cost:~ Rs. 7 Lakh

Technology Readiness Level (TRL)

TRL:7





DPI005

Ultra- β : A Portable Nonlinear Ultrasonic Device

Salient Features

It is a portable, site worthy damage parameter measurement set-up based on higher harmonic analysis of ultrasonic signal. Moreover, the modification in the design of the commercially available system based on higher harmonic analysis of ultrasound wave makes it applicable to in-service components assessment for other structural damage evaluation like fatigue, creep etc. It assesses as well as quantifies the pitted area which could be useful to predict the crack initiation site in the structure in service.

- Pulsar voltage: 1200 V max. step 100V
- Frequency range: 100 kHz to 10 MHz
- Burst cycles: up to 10 cycles
- No. of channel: Single
- Gain: 40dB
- "Cal β "; Software for online nonlinear parameter determination
- Inbuilt controller
- Power Requirement: 220 V/ 50 Hz
- Weight: 5 Kg; Dimension: 330 x 240 x 300 (all in mm)

Environmental Consideration

Not applicable

Major Raw Materials

PXI based chassis

Major Plant Equipment/Machinery

High power pulser, pre-amplifier, data acquisition card, analysis software

Technology Package

(a) Process-Know-how, (b) Details of equipment & (c) software for damage parameter analysis

Uses

Damage assessment viz. fatigue, creep, corrosion pitting of Industrial components, high power pulser for EMAT, guided wave ultrasonics

Scale of Development

Portable device is ready

Commercialization Status

Ready for commercialization

Techno-economics

Capital Cost:- Rs. 35Lakh

Technology Readiness Level (TRL)

TRL:6





DPI006

Ultrasonic Flow Gauge: A device for fluid flow rate measurement through a narrow tube

Salient Features

Propellant availability onboard is one of the main factors determining the spacecraft life. It is essential to gauge the propellant accurately for estimation of spacecraft end-of-life (EOL) and to optimize mission strategy. Project aimed for GEOSAT class spacecrafts and interplanetary missions. The developed ultrasonic flow gauge can be integrated in the spacecraft for onboard propellant gauging. Can also be used as a gas and liquid flowmeter. Light weight, low power consumption, analog as well as digital output ports, test points in the circuits, capable of measuring flow rate from 0.1 LPM to 6 LPM are the major salient features of this device.

Environmental Consideration

NA

Major Raw Materials

Electronic items

Major Plant Equipment/Machinery

NA

Technology Package

(a) Process-Know-how (b) Details of equipment. Assistance in setting up the plant on separate terms. (c) software

Uses

1. Onboard propellant gauging of space craft
2. as a gas flow meter
3. as a liquid flow meter

Scale of Development

Prototype Developed

Commercialization Status

Technology transferred

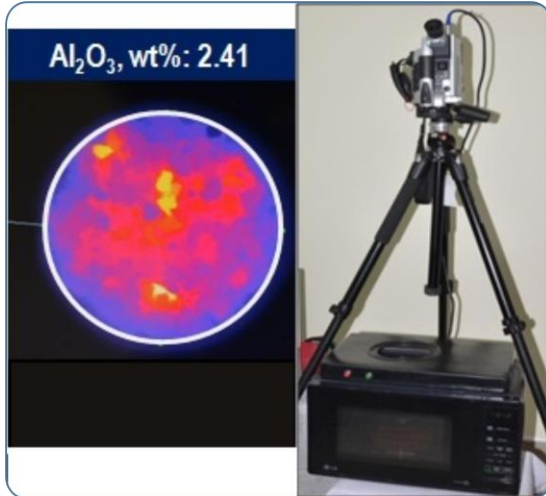
Techno-economics

Technology Readiness Level (TRL)

TRL:6



DPI007



Microwave-IR SORT: A rapid, reliable, non-invasive technology for iron ore for iron ore compositional analysis

Salient Features

Fast, Reliable non-invasive technique to detect alumina/Fe in iron ore. This technology relies on the conversion of microwave energy to heat energy based on the dielectric properties of the mineral constituents of iron ore. Thermal behavior of the ore is imaged using Infra-red camera with high temperature sensitivity and the average temperature rise is related to the wt% of alumina/Fe in iron ore.

- IR camera: Long range
- Temperature Resolution: 0.1 °C
- Microwave power: 650 - 700 Watt
- Iron ore size:-10mm
- Time of estimation: 30 secs/sample

Environmental Consideration

Not applicable

Major Raw Materials

Iron Ore/ Coke/ Bauxite

Major Plant Equipment/Machinery

Computer controlled IR camera, Microwave, Laptop

Technology Package

(a) Process-Know-how, (b) Details of equipment & (c) Assistance in setting up the plant on separate terms and (d) Software

Uses

- Detection of alumina, silica, iron in iron ore
- Alumina in bauxite
- Moisture in coke

Scale of Development

Fully Developed

Commercialization Status

Implemented at Noamundi mines. On belt analysis is also possible.

Techno-economics

Capital Cost:- Rs. 5 Lakh

Technology Readiness Level (TRL)

TRL:6





DPI008

PABI: Portable Automated Ball Indentation System

Salient Features

The device has the ability to estimate hardness, yield stress, yield ratio, tensile strength, strain hardening constant and fracture toughness- all in just one test. Other features of the device are (i) Ball impression is less than an mm in diameter making it nearly non-destructive test, (ii) hardness mapping of non-uniform samples like weld zone and HAZ, (iii) adaptor for bench testing of small sample, (iv) adaptor for field testing of large components, (v) stress or strain controlled test modes, (vi) estimation of multiple properties with one run and (vii) software controlled operation and analysis

Environmental Consideration

Not applicable

Major Plant Equipment/Machinery

Electronic components, load cell, LVDT, power source, amplifier. Data acquisition & analysis system, PC etc.

Technology Package

(a) Details of equipment, (b) Operating Manual, (c) Quality Assurance Methods, (d) Training & (e) data for validating the systems

Uses

To evaluate key mechanical properties of metallic components/ materials

Scale of Development

Portable Laboratory based device and scope for automation for in-service operation

Commercialization Status

Commercialized by M/s Ducom Instruments, Bangalore

Techno-economics

Cost: Rs. 25-30 Lakh/unit depending upon nos. of attachment.

Technology Readiness Level (TRL)

TRL:7





DPI009

Annealing Simulator Device

Salient Features

A reactor chamber enables controlled process environment and controlled heating and cooling rates. The device parameters are as follows:

Annealing Parameter

Temperature : 1000°C Maximum

Slowest Heating rate : 10°C/hr

Highest Heating rate : 500°C/min or Higher

Annealing environment : H₂& N₂ mixture, N₂, or any other gas

Cooling rate : 200°C/s with gases

Medium of cooling : Air, H₂& N₂ mixture, N₂, Atomized water

Power Requirement : 230V, 50Hz, 200VA

Control, Display and Analysis : External laptop /notebook/ PC

Environmental Consideration

Not Applicable

Major Raw Materials

NA

Major Plant Equipment/Machinery

Furnace, Hot & cold chamber, Gas mixing system, Data acquisition & analysis system

Technology Package

(a) Details of equipment, (b) Operating Manual and (c) Application notes and d) Operating Training

Uses

- Varieties of unique annealing simulations can be made easier using this device
- The device can be applied for batch as well as continuous annealing of steel samples.
- Flexibility of heat treatment under controlled atmosphere as and when required.
- Precise control on the heating & cooling rate in annealing simulation.
- Flexible control on the soaking time during annealing simulation.
- Several specimens can undergo annealing simulation in one go.
- Faster data acquisition device for temperature recording for entire cycle of annealing simulation.
- Precision environmental control on annealing simulation.

Scale of Development

Commercial model

Commercialization Status

Commercialized by M/s Krisjan India, Jamshedpur

Techno-economics

Cost: 50 Lakh/basic units. Additional cost: high end model

Technology Readiness Level (TRL)

TRL:6





DPI010

Energy Efficient coke based Brass and Bell Metal Melting Furnace

Salient Features

The existing traditional brass melting furnaces are fuel inefficient. The operators are exposed to toxic flue gases and the flue contains high suspended particulate matter (SPM) resulting serious health hazard for the artisans. These also contribute to atmospheric pollution.

The features of the developed furnace are:

- ~ 20% reduction in coke consumption
- ~ 80% less suspended particulate matter (SPM) and Zn vapour in flue
- Reduction in melting cycle resulting ~t 25% increase in productivity
- Minimum alteration of existing operating practices of traditional brass melting furnace
- Construction by using locally available materials

Environmental Consideration

Less CO₂ emission, less SPM and less effect on Zn vapour on human body as well as on environment.

Major Raw Materials

For furnace construction: Locally available Bricks, Mud and Steel grate.

For operation: Brass / Bell metal and coke

Major Plant Equipment/Machinery

Shaded area of about 3m X 3m along with a ¼ HP air blower

Technology Package

(a) Process-Know-how, (b) Details of furnace construction, (c) Plant Layout and (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

Melting of brass/ bell metal, suitable for artisans engaged in producing brass and bell metal artifacts

Scale of Development

Per batch melting capacity 3-10 kg.

Commercialization Status

Technology transferred to:

- Moradabad Industrial Development Company, Moradabad, UP
- Technical Training Institute, Balasore, Odisha
- In process with West Bengal Khadi & Village Industries Board on behalf of MSME & T Department, Govt. of W.B

Techno-economics

Cost of the new furnace is around Rs. 10,000/ which is only Rs. 5,000/- extra to the traditional brass melting furnace presently is being used by artisans. This extra cost can be recouped within 30 days of furnace operation.

Technology Readiness Level (TRL)

TRL:8





Uses

Closed loop corrosion test rig is developed as an equipment to study the electrochemical and corrosion behavior of metallic materials under flow simulated media with controlled dissolved oxygen and different flow rate at a constant temperature. This study is required for the pipeline material evaluation specifically dealing with oil, marine water and other liquid media.

Scale of Development

Already equipment is fabricated and tested for performance

Commercialization Status

Ready for commercialization

Techno-economics

Technology Readiness Level (TRL)

TRL:5

DPI011

Closed Loop Corrosion Test Rig - Equipment for Flow Assisted Corrosion Study

Salient Features

Closed loop corrosion test rig is indigenously designed by CSIR-NML for the first time. Equipment has the facility to control and monitor dissolved oxygen (50-5000ppb), flow rate of the media during experiment. Provision for extra sensors for monitoring other parameters. Equipment is attached with two type of test rig for metallic coupon exposure as well as electrochemical studies using on line potentiostat under flow condition.

Environmental Consideration

No significant environmental issues

Major Raw Materials

SS316 used for fabrication. Equipment consists of SS316 submersible pump, digital oxygen and temperature sensor, flow meter and integrated online data accusing facility.

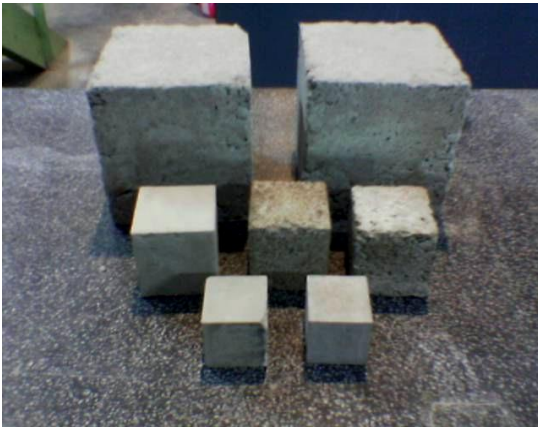
Major Plant Equipment/Machinery

SS fabrication facility as per provided design with software integration for computer controlled operation.

Technology Package

Complete equipment design and performance demonstration. As it is new equipment so initial phase NML will help the license in design modification and discussion as per customer need.





INW001

Geopolymer Cement

Salient Features

Geopolymer cement is new type of alumino-silicate binder and considered alternative to Portland cement. During synthesis, the alumino-silicates present in feedstock undergo polymerization and polycondensation resulting into hard ceramic like material with good longevity.

- Meet the properties of Portland pozzolana cement as mentioned in IS 1489: 1991
- These cements are ~10% more durable than OPC and are fire resistant upto 900°C
- Uses ambient temperature synthesis and generates 70% less CO₂ than Portland cement

Environmental Consideration

The product meets USEPA 1311 specification for toxicity. Also due to 70% low CO₂ emission and 25-35% less embodied energy than Portland cement, it falls in the category of green. Due to use of waste and byproduct, it qualifies for 1 point in LEED certification for green building.

Major Raw Materials

- Fly ash conforming to IS 3812
- Ground granulated blast furnace slag conforming to IS 12089:1987
- Chemical admixture as per IS 9103
- Commercial grade Alkali hydroxide/ silicate

Major Plant Equipment/Machinery

4 bin Inline hopper with pneumatic/mechanical feeding system, batch weighing system, high energy mixer, packaging unit, alkali preparation tank

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout and (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

The geopolymer cement is used as binder material, main ingredient in precast concrete blocks, fire resistant and insulated panels, decorative stone artefacts, building materials, cast ceramic tiles, and immobilization of toxic wastes.

Scale of Development

Pilot Scale at 5 tons/day capacity

Commercialization Status

The process has been demonstrated at pilot scale and ready for up-scaling

Techno-economics

Minimum viable plant size: 100 tons/day
 Capital cost: Rs. 120 Lakh (Excluding land and building)
 Cost of product: Rs. 5000/ ton

Technology Readiness Level (TRL)

TRL:8





INW002

Paving Blocks from Fly Ash, Blast Furnace Slag, Steel Slag, etc

Salient Features

These Paving blocks are produced from the geopolymerisation of industrial waste such as fly ash, granulated blast furnace slag, steel slag, and red mud in different combinations.

- Meets IS 15658:2006 specification
- Can be produced in different shapes and sizes with properties equivalent to M15 – M35 grade concrete.
- Uses ambient temperature synthesis and generates 30% less
- CO₂, 35% low embodied energy than conventional equivalent product

Environmental Consideration

The product meets USEPA 1311 specification for toxicity. Also due to 35% low CO₂ emission and 35% less embodied energy, it falls in the category of green.

Major Raw Materials

- Fly ash conforming to IS 3812, and/or
- Ground granulated blast furnace slag conforming to IS 12089:1987, and/or Steel slag with low free lime and metallic iron
- Chemical admixture as per IS 9103
- Commercial grade Alkali hydroxide/ silicate

Major Plant Equipment/Machinery

Hopper, Batch weighing system, Pan mixer, Vibro-hydraulic press, Curing tanks, Conveyor belt, Dust collection systems, etc.

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout, & (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

The process produces pavement blocks of different shapes and sizes, and different colours and designs. These paving blocks can be used in pavement, patio, lounge, garden, park, petrol pumps, etc and are suitable for light to medium load.

Scale of Development

10 tons/day

Commercialization Status

Technology transferred and commercialized.

Techno-economics

Minimum viable plant size: 50 tons/day
Capital cost: Rs. 50 Lakh (Excluding land and building)
Cost of product: Rs. 400/ square meter

Technology Readiness Level (TRL)

TRL:8





INW003

Yellow Tungsten Oxide (YTO) and W-powders from WC-hard Metal Scraps

Salient Features

Recovery of high pure products (YTO, W-metal powders & other metal salts/powders) from waste/end-of-life WC-hard metal tool bits/drill bits/inserts etc. and heavy metal alloy scraps/swarf. The salient features of the process are:

- Purity of YTO & W-powder is >99.9%
- High pure cobalt salt is a by-product
- Process recovers all the metals from WC scraps with >95% recovery efficiency.
- Processing cost ~ Rs. 400/kg of tungsten powder (excluding scrap cost).

Environmental Consideration

- No solid/liquid effluent generated.
- ~0.25MT of CO₂/MT of W-powder.
- Storage & handling of flammable H₂ gas.

Major Raw Materials

(i) WC scraps, (ii) commercial mineral acids, (iii) EXCEL Grade N₂& H₂ gases.

Major Plant Equipment/Machinery

(i) FRP/rubber-lined leaching reactors with heating & condensation facilities, (ii) high temperature oxidation furnace (~1000°C Max), (iii) Filter press with PP/FRP MOC with suitable slurry handling pumps, (iv) Pusher type reduction furnace (~1000°C Max), and (v) Drying oven (150°C, Max).

Technology Package

Complete flow-sheet with mass balance, Equipment details, Process description, Equipment flow-diagram, Cost estimate & Product specification. Assistance in setting up the plant on separate terms.

Uses

Tungsten has numerous critical applications in defense, energy, mining etc. sectors

Scale of Development

Process demonstrated at 1 kg/batch scale

Commercialization Status

The process has been licensed to
(i) M/s Bharat Futuristic Corporation, Bangalore and
(ii) M/s Minestone Minerals Ltd., Mangalore

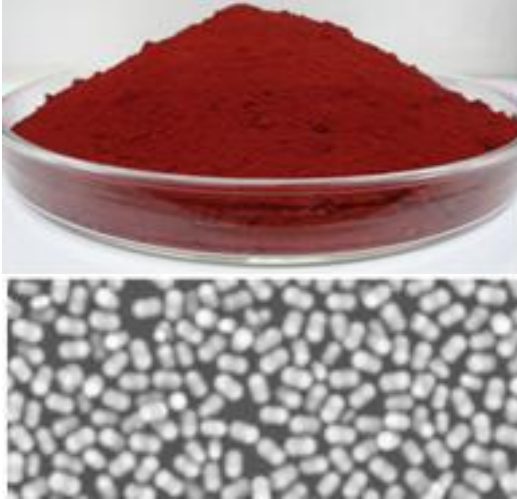
Techno-economics

For a 5MT/month capacity plant; Capital 85.0 Lakh (excluding land & shed) & Recurring Expenditure Rs. 18.0 Lakh/month (excluding scrap cost).

Technology Readiness Level (TRL)

TRL:9





INW004

Ferrite and Pigment grade high purity Monodispersed iron Oxide from Waste Chloride Pickle Liquor and other Iron Rich Sources

Salient Features

A simple process is developed at CSIR-NML for production of highly dispersed red iron oxide of uniform size and shape from variety of waste sources including chloride pickle liquor. The major processing steps consist of oxidation of ferrous iron followed by conversion to desired grade iron oxide.

The developed process takes care of the impurity present in the starting material and can produce high purity iron oxide suitable for various other high end applications in making soft ferrites, catalysts, sensors etc.

The process produces very uniform size iron oxide in the range 100-2000 nm of different shapes and color. Due to highly dispersed and very uniform nature of the particles, the produced iron oxide gives very high color purity and matches with the color of different standard grade high end iron oxide available in the market.

Environmental Consideration

The liquid effluent generated from is treated for regeneration of alkali and recovery of marketable grade salt. Only about 50 kg of non toxic residue is generated per ton of iron oxide production.

Major Raw Materials

Waste Chloride Pickle liquor, Blue dust, scrap iron, High Iron containing waste

Major Plant Equipment/Machinery

Oxidation column/leaching reactor (optional) Precipitation Reactors, Filter press, storage tanks, alkali regeneration setups, evaporator/crystallizer

Technology Package

(a) Process-Know-how, (b) Details of equipment, (c) Plant Layout and (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

Hematite has variety of application as photosensitive material, catalyst, high quality pigments, and cosmetics besides its major use as magnetic materials mainly for producing both soft and hard ferrites

Scale of Development

Developed and demonstrated on 1 kg Scale

Commercialization Status

Transferred to
M/s Tata Pigments Ltd.
M/s Rang Sarjan Chemicals

Techno-economics

Preliminary techno-economics available on demand

Technology Readiness Level (TRL)

TRL:8





INW005

Recovery of Lead from Zinc Plant Residue

Salient Features

Subsequent to zinc extraction with sulphuric acid from various zinc secondaries, insoluble lead in the form of sulphate remained in the leached residue. The residue containing appreciable amount of lead is treated as hazardous waste and is presently being dumped inside the plant premises. A complete flow-sheet is developed with following key features:

- Overall recovery is >96% of lead and simultaneously recovers >70% of both Cu & Zn present in the residue
- Recovered lead as lead chloride, lead oxide, or cement lead
- Operates in a close loop without generation of any toxic effluents
- The final residue containing <0.2% lead can be safely dumped.

Environmental Consideration

No toxic liquid effluent generated as the process operates in close loop. The leached residue containing <0.2% Pb is generated, which is suitable for dumping. All other streams are recycled or treated for metal recovery.

Major Raw Materials

Secondary zinc plant residue, other lead containing residue

Major Plant Equipment/Machinery

Leaching reactor, filter press, storage tanks, transfer pumps

Technology Package

Process know-how, complete flow-sheet with mass balance, equipment details, process description, equipment flow-diagram, cost estimate, product specification Plant Layout and quality assurance methods. Also assistance in setting up the plant on separate terms.

Uses

Lead is used for making lead acid batteries, rolled extrusion, ammunition, cable sheathing, soldering etc.

Scale of Development

Developed and demonstrated on 1 Kg scale

Commercialization Status

Transferred to M/S Cinkom Lead Zinc Metal Mining Co., Turkey

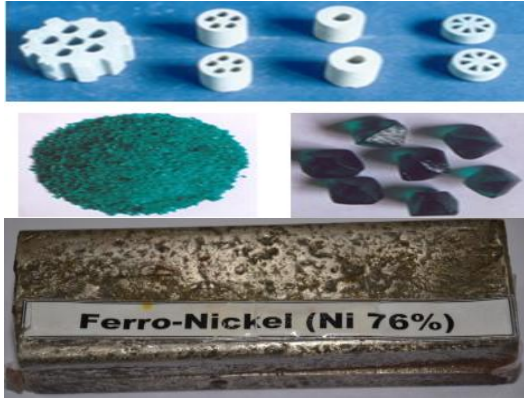
Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL:7





INW006

Recovery of Nickel from Spent Nickel Catalyst

Salient Features

Nickel catalysts used in various operations become spent after several cycles of use, for which a very simple and innovative process is developed at NML for recovery of nickel. The processing step consists of direct acid leaching in presence of a promoter followed by impurity removal to produce nickel salt/metal. The novelty of the process is that, it gives very high nickel recovery (99%) under the moderate conditions in presence of a little quantity of a promoter without which it is found to be very poor even at higher temperature and acid concentration. High purity alumina is produced from the process as a part of leached residue.

A smelting process is also developed for recovery of nickel as ferronickel from variety of spent catalyst containing nickel in the range 8-25%. Various grades of ferronickel with nickel content in the range 20% to 80% have been produced.

Environmental Consideration

Only CO₂ is produced from the process if the catalyst is contaminated with oil/ghee and the quantity will depend on the organic content in the spent catalyst. About 10-20 kg per ton of iron hydroxide residue is generated.

Major Raw Materials

Spent nickel catalyst, sulphuric acid, alkali, Promoter. Mill scale (iron oxide), coke etc

Major Plant Equipment/Machinery

Roaster (optional), Grinding and sieving apparatus, leaching reactors, promoter, filtration unit, pumps, crystalliser etc. Grinding and palletizing facility, Smelting furnace.

Technology Package

(a) Process-Know-how, (b) Mass Balance, (c) Details of equipment, (d) Plant Layout and (e) Quality Assurance Methods.

Uses

Nickel sulphate is extensively used in electroplating, organic chemical synthesis, metal coloring, dye mordant, manufacturing other nickel salts, Ni-Cd battery. The main use of Ferronickel is the manufacture of steel.

Scale of Development

Process developed on 1 kg scale with overall recovery of 96% nickel
Smelting process is developed on 10 kg scale per batch spent catalyst with 90% Ni recovery

Commercialization Status

Sulphate process developed and demonstrated on 1 kg scale and transferred to M/s SMC Technology, Malaysia

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL:6





**Fe-Ni/Co
Mo alloy**



**Calcia-alumina
slag**

Uses

The main use of Fe-Ni/Co-Mo alloy in the manufacture of special grade alloy steels and calcium aluminate slag for cement making.

Scale of Development

Developed on 10 kg spent catalyst smelting per batch

Commercialization Status

Ready for transfer and commercialization

Techno-economics

Available on request.

Technology Readiness Level (TRL)

TRL:5

INW007

Production of Fe-Ni/Co-Mo Metallic Alloy & Saleable Alumina Rich Slag from Ni-Mo/Co-Mo Spent Catalysts

Salient Features

Hydrometallurgical treatment of spent hydro-refining catalysts generates residues containing significant amount of Ni (2-5%), Co (2-5%) and Mo (0.5-1%). These residues are presently dumped or underutilized in construction related industries. The pyrometallurgical process developed at CSIR-NML is able to recover more than 90% of these metals as saleable alloys, besides generating calcium aluminate type slag.

A process also developed to treat spent HDS catalyst containing 4-18 % Mo, 1-10 % Ni, 1-18 % W, 0.5-5% Co, 30-35% Al and minor amount of S, P and Si to produce a Co/Ni, Mo-W-Fe alloy with P less than 0.1% and alumina rich slag as building material.

Environmental Consideration

Economic recovery of strategic metals Ni, Co and Mo from waste source of processed spent hydro-refining catalysts. The slag generated is non-toxic and will be completely used in cement making.

Major Raw Materials

Spent hydro-refining catalysts, iron source, lime, coke etc.

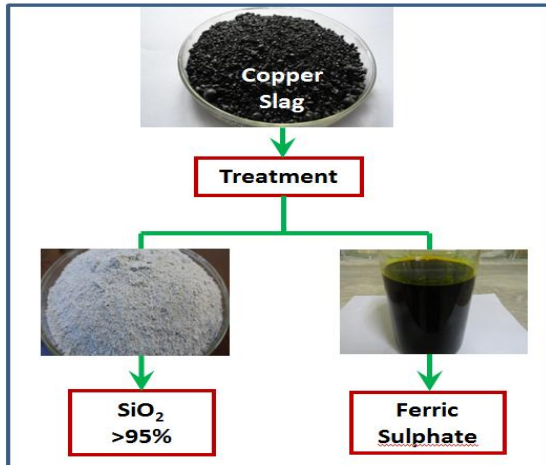
Major Plant Equipment/Machinery

Grinding and pelletizing facility, Electric arc reduction smelting furnace.

Technology Package

(a) Process-Know-how (b) Details of equipment (c) Plant Layout (d) quality assurance methods.
Assistance in setting up the plant on separate terms and condition.





INW008

Production of ferric sulphate from copper slag for arsenic removal

Salient Features

About 2.2 ton of waste copper slag is generated for every tonne of copper produced which is currently being dumped near the plant site. CSIR-NML developed a very unique process by which the slag is converted to two commercial products such as ferric/ferrous sulphate and silica powder. About 5 kL of ~35% ferric sulphate solution and ~300 kg SiO₂ powder for every tone of slag treated. Ferric sulphate is an important ingredient for arsenic removal from toxic waste stream of copper industries and silica produced from the process is useful for phosphoric acid plant. Implementation of the process will not only take care of environmental norms but also will make the industry independent on availability of chemicals for critical operation of treating effluents.

Environmental Consideration

The process does not generate any solid or liquid effluent.

Major Raw Materials

Copper slag, sulphuric acid

Major Plant Equipment/Machinery

Grinding facility, Leaching set-up, filtration unit, drying facility.

Technology Package

Technology will be transferred with details of process description, operating parameters, equipment list with specification, mass balance, preliminary cost estimation etc

Uses

Ferric sulphate is an important ingredient for arsenic removal and also utilized as raw material for production of red pigment. Silica powder is useful for phosphoric acid production.

Scale of Development

Developed and demonstrated on Kilogram scale. Being piloted to 1MT per batch scale.

Commercialization Status

Transferred to M/s Sterlite Copper, Vedanta.

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL:5



INW009



Scrap containing gold



Gold pellets & strips

Uses

Gold is a versatile metal and is used for various purposes like in jewellery, electrical and electronic equipments, dentistry, medical diagnosis, aerospace, glassmaking etc.

Scale of Development

1 Kg to 10 Kg (Lab Scale)

Commercialization Status

Transferred to M/s ADV Metal Combine Pvt. Ltd., New Delhi

Techno-economics

Capital Cost ~ 20 Lakh
Recurring Cost ~ 02 Lakh/ Year

Technology Readiness Level (TRL)

TRL:6

Recovery of Gold from Waste Mobile Phones and Scraps of various Equipment

Salient Features

A process is developed for the dissolution of metal from the PCBs of waste mobile phone, small parts of various equipments containing gold on outer layer. Chemical leaching followed by adsorption/ cementation with subsequent heat treatment was used to recover 99% gold.

Environmental Consideration

20 to 25 L effluent generated is recycled after proper treatment. The solid residue will be utilized as non hazardous filling material in various applications.

Major Raw Materials

Mobile phone PCBs, scrap parts of various equipments, leachant, adsorbent, etc.

Major Plant Equipment/Machinery

Leaching reactor, hood, filter press, pH meter, balance, glassware, safety appliances, etc.

Technology Package

(a) Process-Know-how (b) Details of equipment (c) Quality Assurance Methods. Assistance in setting up the plant on separate terms.





INW010

Recovery of Cobalt from Discarded Li-ion Batteries of Mobile Phone

Salient Features

A process is developed for the dissolution of metals from discarded lithium ion batteries (LIBs) of mobile phone. Diluted sulfuric acid in presence of an oxidant was used to leach out ~70-80% cobalt along with other metals in 60 min at elevated temperature. Leach liquor generated was further processed through solvent extraction, precipitation, crystallization/ electro-winning techniques to recover cobalt as salt/ metal.

Environmental Consideration

About 1 to 10 L of acidic effluent is generated which is further treated to recover acid. The solid waste containing other metals is further treated for its recovery as value added product.

Major Raw Materials

Discarded mobile phone batteries, H_2SO_4 , organic extractant, modifier, diluents, etc.

Major Plant Equipment/Machinery

Scutter-crusher, Flotation set-up, Leaching reactor, Filtration unit, Solvent extraction equipment (Mixer settler unit), Evaporator, Crystallizer, Electro-winning cell, rectifier, etc.

Technology Package

(a) Process-Know-how (b) Details of equipment (c) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

Cobalt as a metal is used for making permanent magnets, alloys, electroplating, etc. Cobalt salts have been used to produce colours in paint, porcelain, glass, pottery and enamels. Radioactive cobalt-60 is used to treat cancer and, in some countries, to irradiate food to preserve it.

Scale of Development

100g to 5 Kg (Lab Scale)

Commercialization Status

Ready for commercialization

Techno-economics

Capital Cost ~ 20 Lakh
Recurring Cost ~ 02 Lakh/ Year

Technology Readiness Level (TRL)

TRL:6





INW011

Recovery of Neodymium as a Value Added Product from Waste Hard Disk of Personal Computers

Salient Features

A process is developed for the recovery of neodymium as value added product from magnets of discarded hard disk. Under optimized condition, sulfuric acid leaches 98% Nd, 97% Fe, 60% Ni and 7.5% B. Acid leaching was followed by selective precipitation of Nd and leaching of the precipitate with 5-20% HF solution.

Environmental Consideration

1-5 L effluent generated is recycled after proper treatment. The solid residue will be utilized as non hazardous filling material in various applications.

Major Raw Materials

Discarded hard disk, H₂SO₄, NaOH, HF, precipitants, etc.

Major Plant Equipment/Machinery

Dismantling set-up, Leaching reactor, Stirring speed controller, glass condenser, Settler, solid-liquid separation unit i.e. centrifuge, filter press/vacuum filter, Oven, etc.

Technology Package

(a) Process-Know-how (b) Details of equipment (c) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

For production of scintillation detectors, magnets, laser materials rare earth fluoride crystal glass optical fiber, aviation magnesium alloy for metallurgical industry and electrolytic production of metal additives.

Scale of Development

50-200 g magnets / 10 Kg discarded hard disk (Lab scale).

Commercialization Status

Ready for commercialization

Techno-economics

Capital Cost ~ 20 Lakh
Recurring Cost ~ 02 Lakh/ Year

Technology Readiness Level (TRL)

TRL:6



IP SEARCH AND ANALYSIS SERVICES

CSIR-National Metallurgical Laboratory provides IP search and analysis services to its clients. We have a dedicated team, cutting edge tools and database resources for delivering such jobs on time. Our highly qualified research team builds interactive tools and widgets which help fill the void between quality analysis and representation of conclusive results.

IP SERVICES

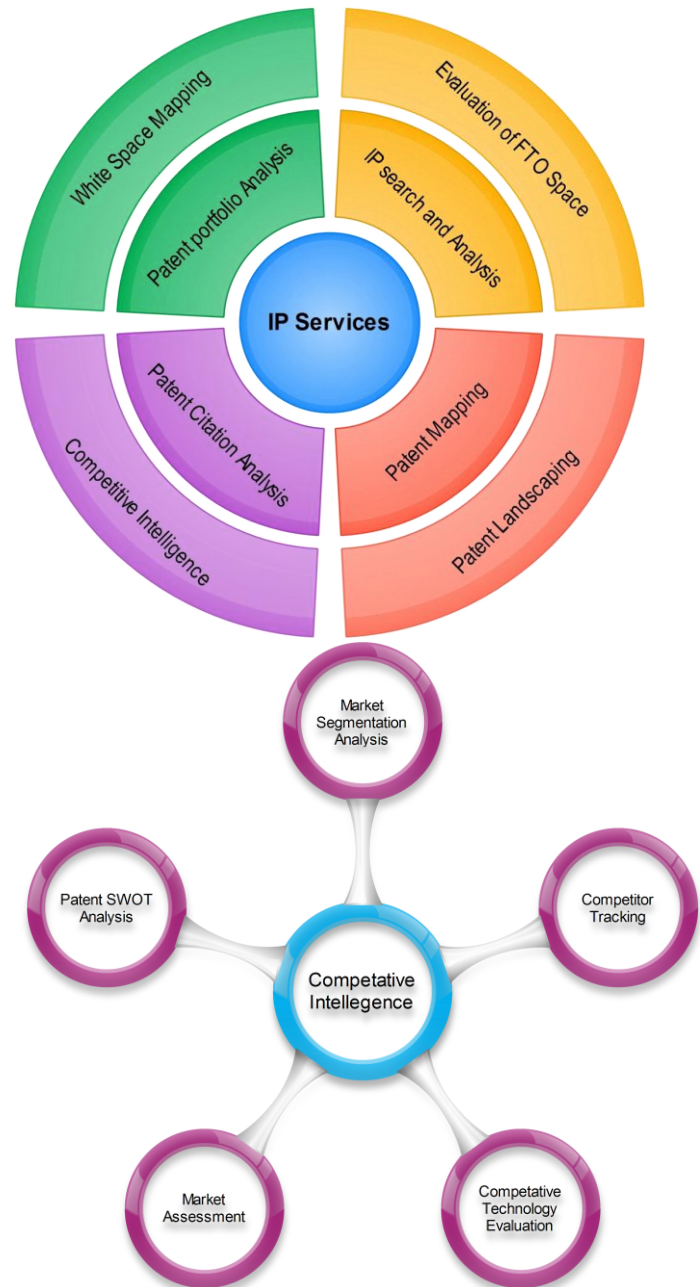
- IP search and Analysis
- Evaluation of FTO Space
- Patent Landscaping
- Patent portfolio Analysis
- Patent Mapping
- Patent Citation Analysis
- White Space Mapping
- Competitive Intelligence.

WE OFFER COMPETITIVE INTELLIGENCE IN

- Competitor Tracking/Profiling
- Comparative Technology Evaluation
- Market Assessment Studies
- Strategic Grouping/Collaboration
- Patent SWOT Analysis
- Patent Claim Analysis
- Market Segmentation Analysis.

RESOURCES

- ❖ Database: Thomson Reuters **Web of KnowledgeSM**, **Questel QPAT**
- ❖ Software: **VantagePoint**



For further details please contact:

Director
 CSIR-National Metallurgical Laboratory
 Jamshedpur-831007, India
 Phone: 91 657 2345202, 2345205 Fax: 91 657 2345213
 e-mail: director@nmlindia.org





CSIR-National Metallurgical Laboratory

Jamshedpur-831007, India

Tel:91-657-2345000/001, Fax: 91-657-2345213

Email:director@nmlindia.org,

Website:www.nmlindia.org

