NML Technology Handbook

CSIR-National Metallurgical Laboratory

Jamshedpur - 831007, 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

FOREWORD

For any R&D organisation, the Intellectual property generated and the technologies developed can be considered to be the main asset creations. Licensing the IP and commercialising 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 commercialisation. 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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ANALYTICAL CHEMISTRY

ANC DIVISION

ANC 001

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. NML is applying for NABL accreditation for its CRM programme.

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 equipment 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 100 g 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.

Uses

Treatment of arsenic contaminated groundwater to make it suitable for the purpose of drinking

Scale of Development

The process is standardized for 7-10 L batch with 2.5 LPH throughput

Commercialization Status

Ready for commercialization

Techno-economics

Filtered water cost is 3-5 paisa per litre covering all possible recurring expenditure. The hardware cost is Rs. 600/- per unit (one time)

ANC 002

Arsenic Removal from Groundwater

Salient Features

It is an adsorption technique. A naturally occurring ferruginous manganese ore (FMO) is used as adsorbent for iron and arsenic in contaminated groundwater and may be applied at both domestic and community level. A domestic three compartment filtration unit employing this technique has been developed at NML. It works for both As(III) and As(V) without any pre-treatment. At domestic level the hardware does not require electricity. The process comes with a sludge management protocol.

Environmental Consideration

The process generates arsenic bearing sludge which must be contained and passivated before disposal. The FMO as such is non-toxic. The filtered water must be monitored for secondary manganese contamination.

Major Raw Materials

Ferruginous manganese ore.

Major Plant Equipment/Machinery

For domestic level it is a three container water filter. For community level plant equipment and machinery may be designed for the client as per scale.

Technology Package

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

ANC 003

Coal Mine Water Reclamation

Salient Features

Coalmine water reclamation process developed at NML has three modules arranged sequentially. It separates suspended particulate matters using appropriate flocculants, negotiates dissolved contaminants including heavy metal ions with a nanometric aqueous suspension developed that kills harmful micro-organisms through ozonation. The finished product is suitable for the purpose of drinking.

Environmental Consideration

The process is environment friendly and does not involve any hazardous or toxic reagents. In fact, it addresses a major environmental issue arising out of coal mining.

Major Raw Materials

Underground coal mine water

Major Plant Equipment/Machinery

Flocculation tank, reaction tank, clarifier, filter, ozonator

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

Treatment of coalmine groundwater and make it suitable for the purpose of drinking

Scale of Development

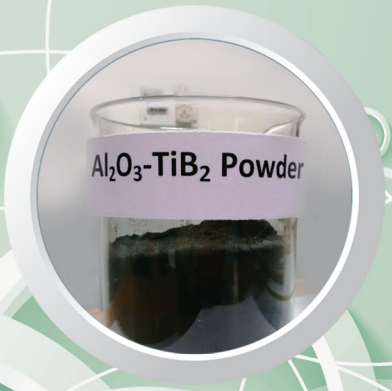
Continuous mode @ 4000-5000 LPH that can operate for 20 hours per day.

Commercialization Status

A 4000-5000 LPH plant has been successfully installed and commissioned jointly with CIMFR, Dhanbad in the Putki colliery of BCCL. It is ready for commercialization in other sites

Techno-economics

Available on demand. The purified water cost works out to be less than 20 paisa per litre.



CORROSION & SURFACE ENGINEERING

CSE DIVISION

CSE 001

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, 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 (1-2µm)

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

Patent No : IN 245388

Environmental Consideration

No significant environmental issues

Major Raw Materials

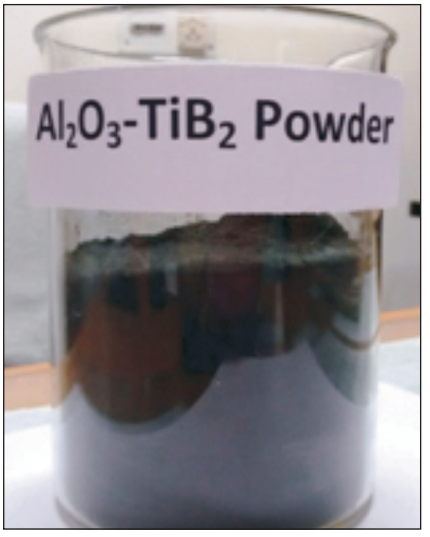
Oxides of zirconium, Titanium and Boron and elemental Al powder.

Major Plant Equipment/Machinery

Equipment for reaction and in-situ densification of the composite

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 Lakhs

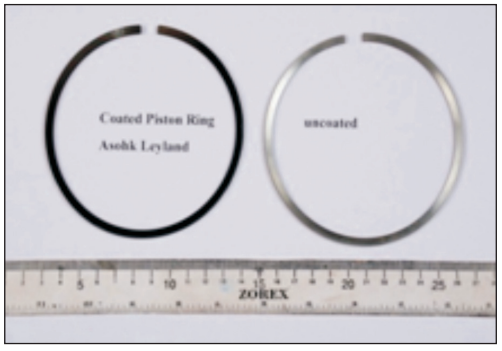


Image : Piston ring coated with nano-composite TiSiBC hard coatings

Uses

Wear and oxidation resistant coatings, Cutting tool, recording device, Automobile components (Pistion, 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 Lakhs.

CSE 002

Nano-Composite Hard Coating

Salient Features

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 800°C.

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

Patent Application No : 0770DEL2010

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 1

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)

CSE 003

Zirconium Boride and Titanium Boride Powder by single step Carbothermal 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 :

XRD analyses : TiB_2 or ZrB_2 phase in the product

Purity : > 95%

Average particle size : 10µm

Patent Application Filed. Number Awaited

Environmental Consideration

CO and CO_2 evolution

Major Raw Materials

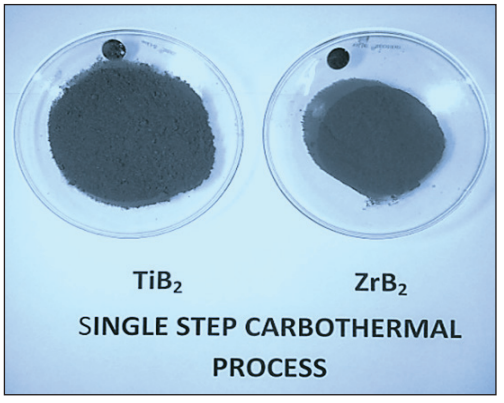
Oxide powders of Zirconium, Titanium and Boron, and carbon powder. Inert gas (Argon)

Major Plant Equipment/Machinery

High temperature graphite furnace, Ball Milling facility

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

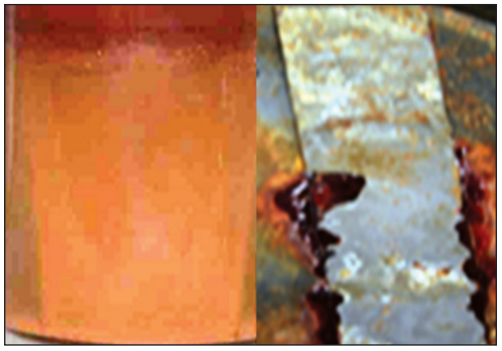
200 gm per batch

Commercialization Status

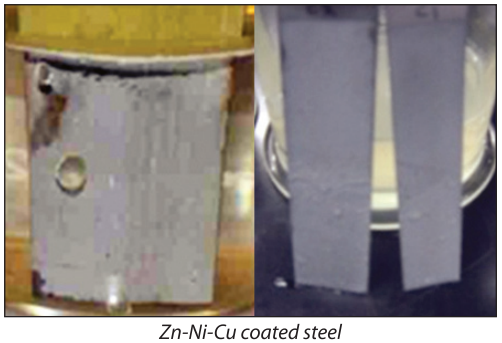
Technology for ZrB_2 and TiB_2 powder production is transferred to M/S Aum Techno Ceramics, Gujarat

Techno-economics

For current level investment is only furnace and milling equipment. It will be around Rs. 60 Lakhs



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 materiels. It will be around Rs. 20 Lakhs

CSE 004

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.

Patent Application No : 1401/KOL/2012

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)

CSE 005

Fine Zirconium Diboride Powder by SHS

Salient Features

The developed technology for the production of single phase Zirconium Diboride powder by self-propagating high temperature synthesis route is economical as it uses low cost raw materials and does not require high temperature furnaces and the process is easy to scale up. The process also takes less time (less than 2h per batch), where only synthesis time is only 5 minutes.

The important characteristics of the produced powder are :

Purity : $\geqslant 95\%$

Particle sizes : 200 nm -2 µm

XRD analyses : Single phase of ZrB_2

Powder Sinterability : Excellent

Patent No : IN 244014

Environmental Consideration

(i) No significant issues except generation of ultrafine MgO powder

(ii) Acid leached residue generation

Major Raw Materials

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

Major Plant Equipment/Machinery

SHS reaction chamber and byproduct leaching set up

Technology Package

- Detailed knowhow of the powder production process
- Demonstration at the scale of 100-200 gm per batch.
- 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)

Uses

Ultra high temperature components, thermocouple sleeves, electrode for Al-extraction (Hall Heroult), Hypersonic aero-engine components, evaporation boats, sputtering targets, rocket nozzles, Re-entry vehicle component etc

Scale of Development

100-200 gm per batch

Commercialization Status

Ready for commercialization

Techno-economics

For current level investment will be around Rs. 15 Lakhs

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

- M/S. 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

CSE 006

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^{0} : 65-70	Hardness : 2H
Film Thickness : 2-5 micron	Coverage : 15-20 m2/litre	Dry : 10 min.
VOC : 750-800 g/L	Acid resistance : Pass	Lead < 1 ppm
Alkali resistance : Pass	Salt Spray Test : 500 hrs	Cd < 1 ppm

Patent Application No : 3445DEL2012

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, 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.

CSE 007

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 formulationis 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.

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 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

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

CSE 008

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 formulationis 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

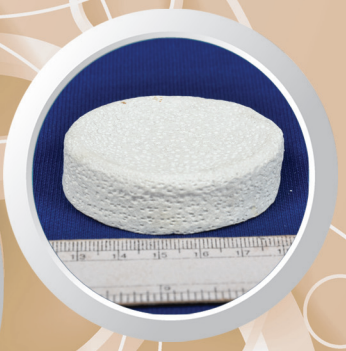
Sodium Carbonate, thiourea, surfactants

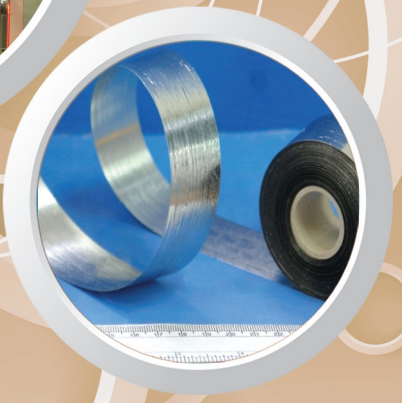
Major Plant Equipment/Machinery

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.





MATERIALS SCIENCE & TECHNOLOGY

MST DIVISION

MST 001

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 1kg (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

Patent Application No: 352/DEL/2007

Environmental Consideration

No hazardous gas emitted.

Major Raw Materials

(I) Fe, Co, Ni, Cr, Nb, Cu, Si,B, Al, Mn, Ga depending on the type of alloys to be produced

(ii) Excel grade argon gas

(iii) 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 reactors, 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

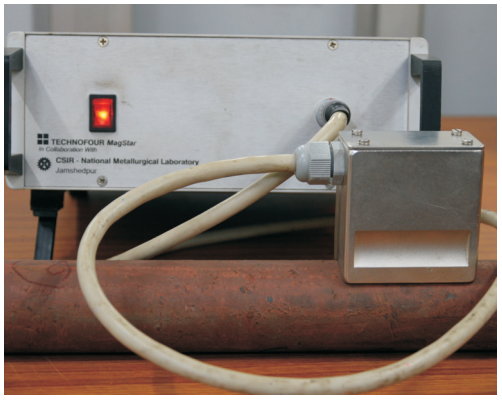
Licensed for manufacturing to M/s Vacuum Techniques Pvt. Ltd., Bangalore, on non-exclusive basis

Techno-economics

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

MST 002

MagStar: A portable magnetic hysteresis and Barkhausen emissions based electromagnetic device for non-destructive evaluation of steel structure/component



Uses

(I) Evaluation of microstructural changes during heat-treatment/ ageing,

(ii) Determination of ferrite volume fraction,

(iii) Evaluation of ferromagnetic phases and its correlation with mechanical properties and

(iv) 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

Techno-economics

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

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 200Hz
Excitation	:	0-1500 Oe
Wave Shape	:	Sinusoidal / Triangular

Magnetic Barkhausen Emissions (MBE) measurement

Frequency Range	:	10Hz to 200 Hz
Excitation	:	Up to 1500 Oe

Number of cycles 3 to 10

Gain 0 to 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/ personal computer

Patent Application No: 2545DEL2006

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.

MST 003

HINDMET : High Induction Nanostructured Ferromagnetic Metallic Ribbons

Salient Features

FeCoSiBNb nanostructured alloy system is prepared by melt spinning technique in the form of ribbons with Curie temperature >1000K and saturation Induction ~ 1.75T. Ribbon thickness ~ 25-35 micron.

Patent Application No: 0893DEL2006

Environmental Consideration

No hazardous gas emitted.

Major Raw Materials

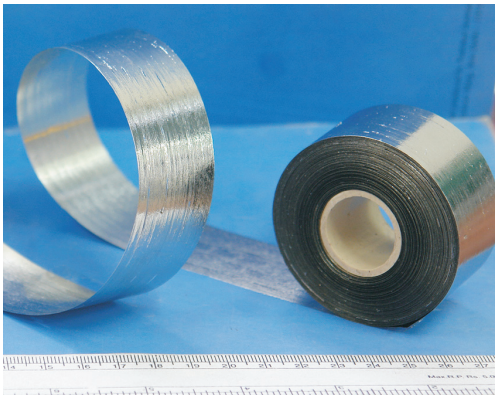
1. Iron, Cobalt, Silicon, Boron and Niobium (purity ~99.9%)
2. Excel grade argon gas
3. Chilled water

Major Plant Equipment/Machinery

Electric Arc Furnace, melt spinning system

Technology Package

Complete flow-sheet, Equipment details, process description, cost estimation & product specification. Assistance in setting up the plant on separate terms.



Uses

Core materials for high frequency power transformers and space power systems which encounters high temperature during operation.

Scale of Development

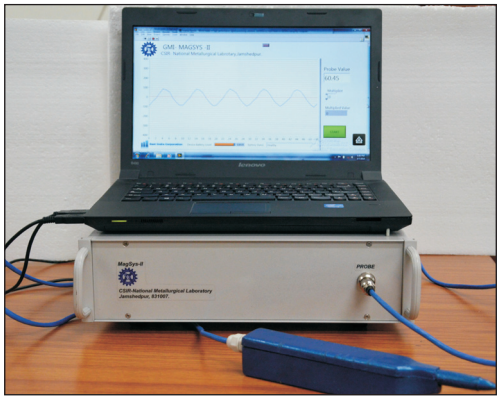
Process demonstrated 500g/ batch Scale

Commercialization Status

Ready for transfer

Techno-economics

For 50 kg/month capacity plant : (Capital Rs. 1 Crore (excluding land & shed) & Recurring Expenditure Rs. 15 Lakhs/month.



Uses

- In petrochemical industries where properties of stainless steel based component changes due to carburization
- Detection of presence of 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

Ready for commercialisation

Techno-economics

Cost: Rs. 15 Lakh/unit Including sensor

MST 004

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

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/ personal computer

Patent Application No: 0651/DEL/2011

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.

MST 005

MagStric: Magnetostrictive sensing device using nanostructured soft magnetic materials for pipeline inspection

Salient Features

The developed magnetostrictive sensing device is capable of measuring defects in ferrous and non-ferrous pipes.

- The equipment comprises of nanostructured magnetostrictive sensing element, typically Fe-Si-B alloy in the form of ribbons which can be easily pasted on the pipe under inspection.
- An alternating current (50 - 100 kHz) for excitation of magnetic field is supplied to the sensing coil in the presence of direct current bias magnetizing field.
- The element due to magnetostriction generates mechanical waves propagating through the test pipe. The backwall echoes are picked up by the same sensing element and the sensing coil systems. The additional reflected signals indicate the presence of defects in the pipes.
- Power requirement: 220V, 50Hz

Patent Application Filed. Number Awaited

Environmental Consideration

Not applicable

Major Raw Materials

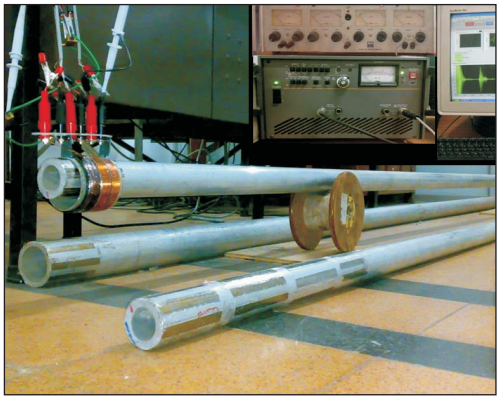
Melt Spun ribbons, Electronic components, magnetizing and sensing copper coils

Major Plant Equipment/Machinery

100 kHz power source, amplifier, data acquisition & analysis system

Technology Package

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



Uses

Identification of defect location in long range ferrous and non-ferrous pipes by keeping the sensing element at one end.

Scale of Development

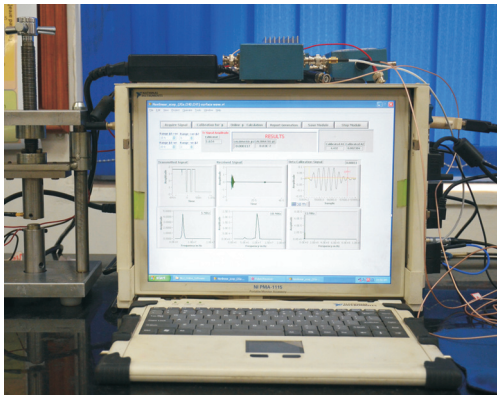
Prototype laboratory based device and scope for making portable for field application

Commercialization Status

Ready for commercialization

Techno-economics

Equipment Cost: Rs. 50 Lakh/unit and melt spun ribbon cost : Rs. 1 Lakh/kg.



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. 35Lakhs

MST 006

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.

- Pulser 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)

Patent application No : 2618/Dec/2013

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

MST 007

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 - 2.5 mm
- Operating frequency: 10 Khz
- Depth Resolution: 200 µm
- Drawing line speed: up to 12 m/s
- LCD display
- Software for data logging to identify defect location
- Interfacing through LAN
- Analog output for further signal analysis
- Alarm: LED & Buzzer
- 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, craw feet etc. detection in wires during cold drawing

Scale of Development

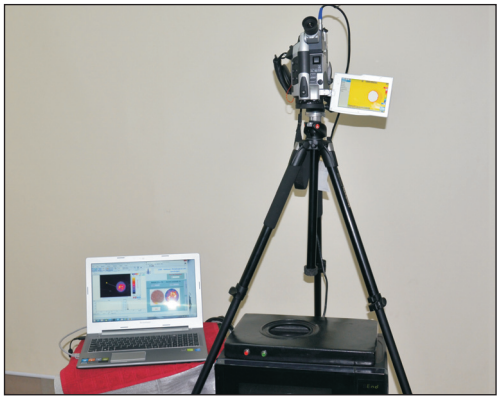
Prototype developed

Commercialization Status

Ready for commercialization

Techno-economics

Capital Cost:~ Rs. 5Lakhs



Uses

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

Commercialization Status

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

Techno-economics

Capital Cost:~ Rs. 5 Lakhs

MST 008

Microwave-IR SORT: A rapid, reliable, non-invasive technology 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^{o}C
- Microwave power: 650 - 700 Watt
- Iron ore size: -10mm
- Time of estimation: 30 secs/sample

Patent Application No: 854/KOL/2014

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

MST 009

Development of Biphasic Calcium Phosphateblocks

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.

Patent Application 2009DEL2013

Environmental Consideration

Not applicable

Major Raw Materials

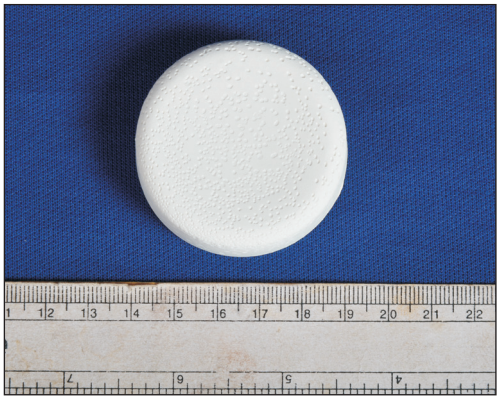
Calcium salt and phosphate salts ammonium solution NH_3, Distilled water, polymer

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 Lakhs (excluding land & shed)

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 Lakhs (excluding land & shed)

MST 010

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.

Patent Application No: 3438DEL2014

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.

MST 011

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% .

Patent Application No: 3566DEL2013

Environmental Consideration

Eco friendly process. No high temperature, pressure requirements

Major Raw Materials

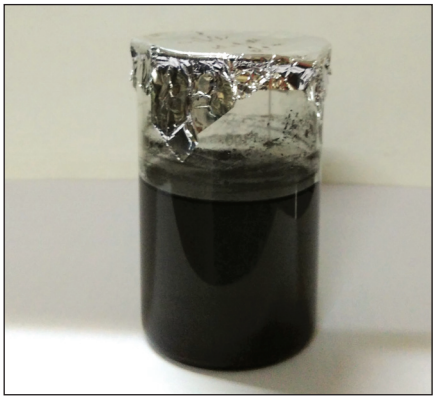
Natural Graphite, Collagen and PVA, analytical grade

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

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 investment:Rs. 5 Lakhs.

Production cost: Rs 1000/-/litre

MST 012

Aqueous Ferro-fluids

Salient Features

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

Magnetite : 01 - 0.3 % by Vol
Size : $\leq$ 6 nm
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 (^{o}F) - 212^{o}F
Magnetization : Fluid : 0.23 emu/gm,
dried power : 43.34 emu/gm
Colloidal stability :
Zeta Pl : -15-18 mv
Hydrodynamic dia : ~150-175 nm
Polydispersity index : 0.1 - 0.2

Patent Application No: 0672DEL2010

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.

MST 013

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

Patent Application No: 0549DEL2012

Environmental Consideration

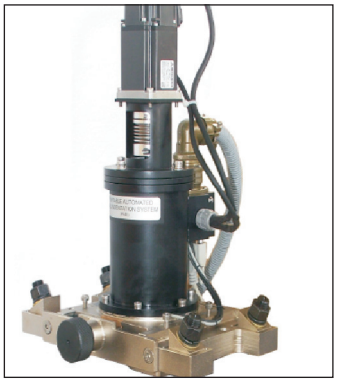
Not applicable

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 Lakhs/unit depending upon nos. of attachment.

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: Rs. 50 Lakh basic unit. Additional cost: high end model

MST 014

Annealing Simulator

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^{o}C Maximum
Slowest Heating rate	:	10^{o}C/hr
Highest Heating rate	:	500^{o}C/min or Higher
Annealing environment	:	H2& N2 mixture, N2, or any other gas
Cooling rate	:	200^{o}C/s with gases
Medium of cooling	:	Air, H_2& N_2 mixture, N_2, Atomized water
Power Requirement	:	230V, 50Hz, 200VA
Control, Display and Analysis	:	External laptop /notebook/ personal computer
Patent Application No	:	1308KOL2013

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, (c) Application notes & d) Operating Training

MST 015

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

Patent Application No: 2653DEL2011

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.

After 90 days at the power plant

Uses

Underwater turbine components

Scale of Development

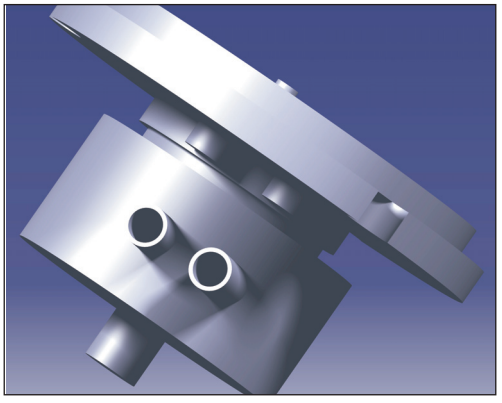
40 kg in lab scale; component of ~100kg was prepared in actual and was tested at hydelpower plant during monsoon

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 Lakhs



Uses

Production of Bulk Glassy / Amorphous Alloys

Scale of Development

Laboratory based Suction Casting Assembly which can be retrofitted to any Ar-arc melting furnace.

Commercialization Status

Ready for commercialization

Techno-economics

Cost of suction casting assembly: Rs. 20 Lakh (with 4 Nos of Cu moulds and 2 Nos of meting pots). Additional cost per Cu-mould: Rs. 25,000/- , Melting pot : Rs. 10,000/-

MST 016

Suction Casting Assembly for the preparation of Bulk Metallic Glass

Salient Features

- The developed suction casting assembly (SCA) is capable of producing BMG. This SCA can be retrofitted to any commercially available arc melting furnace.
- Major components of SCA are melting pot, copper-stainless steel sandwich (CSSS), Cu-mould and mould chamber.
- Melting pot of the SCA is designed and positioned in the CSSS in order to enhance the heat transfer from the melting pot to the CSSS and to minimize the heat transfer from melting pot to the casting mould.
- Inclination of the melting pot, orifice of the melting pot, alignment of the Cu-mould and positioning of melt flow stopper ensures successful BMG castings.
- This SCA allows fast, easy and hassle-free melt flow during suction casting to produce laboratory scale BMG.

Patent Application Filed. Number Awaited

Environmental Consideration

Not Applicable

Major Raw Materials

Electrolytic grade Copper & SS-304 for suction casting assembly, Pure elements for preparation of BMG

Major Plant Equipment/Machinery

Ar-arc melting furnace with water circulation facility

Technology Package

(a) Design of suction casting assembly for Ar-arc melting furnace, (b) Detailed operating procedure and (c) Demonstration of BMG preparation by suction casting assembly.

MST 017

Copper Based Ductile Bulk Metallic Glass

Salient Features

- A process for the preparation of Cu-based bulk metallic glass with good strength and comparatively high plastic strain / ductility using the indigenously developed suction casting assembly. This process produced materials exhibiting reasonable plastic strain without diminution of their strength at room temperature through minor addition, thereby overcoming the major drawback of BMG to a reasonable extent. Chances of their abrupt failures will be minimal and hence these materials would be useful for structural applications requiring high strength and ductility.
- Cu-based BMG of the present invention has excellent mechanical properties; such as high compressive strength (2200 Mpa), reasonable ductility (20 %), and hence can be considered potential materials for developing small machine components.

Patent Application Filed. Number Awaited

Environmental Consideration

Environment friendly

Major Raw Materials

Pure elements

Major Plant Equipment/Machinery

Ar-arc melting furnace, Water circulation system with cooling facility, Suction casting assembly developed by NML

Technology Package

(a) Process-Know-how, (b) Equipment details, (c) Assistance in setting up the facility and (d) Preparation of ductile BMG

Uses

Structural Material

Scale of Development

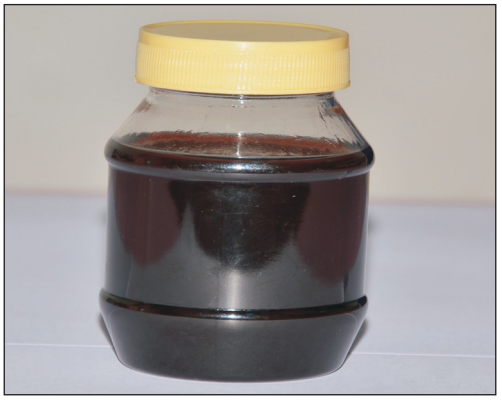
Lab scale: 1gm to 30 gms per batch; 8 to 10 batches per day. BMG rods: 1 mm to 6 mm diameter and of 70 mm length. BMG Plates: 1 mm to 1.5 mm thick, 8 mm width and 70 mm length

Commercialization Status

Ready for commercialization

Techno-economics

For creating facility for melting and suction casting; Capital Rs. 50.0 Lakhs
Recurring cost : Rs. 5.0 Lakhs per kg



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 10 liters

Commercialization Status

Ready for commercialization

Techno-economics

Rs. 300/litre for commercial grade chemicals

MST 018

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 silent 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^{o}C for 5 min
- Cured coated products at 250^{o} 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

Patent Application Filed.

Environmental Consideration

No issue of environment, as it does not release any gases and used chemicals are non- toxic and non- hazardous.

Major Raw Materials

Plant extract, ISO-propanol and cross linker

Major Plant Equipment/Machinery

Magnetic stirrer for mixing of chemicals

Technology Package

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

MST 019

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 silent 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

Patent Application No: PCT/IN2014/000310

Environmental Consideration

H_2O and CO_2 gases release during heating

Major Raw Materials

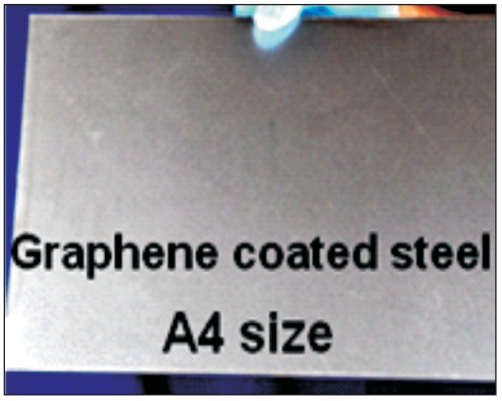
Shellac biopolymer and Iso-propanol

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 % H_2, 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

METAL EXTRACTION & FORMING

MEF DIVISION

MEF 001

Production of Ferronickel from Spent Nickel Catalyst

Salient Features

A simple smelting process is developed for recovery of nickel as ferronickel of various grades from different nickel catalysts containing nickel in the range, 8 - 18%. By controlling the parameters and the process techniques, ferronickel of 20 - 75% Ni grade have been produced with > 90% Ni recovery. The process consists of mixing the spent catalyst with additives, heating and reducing the mixture to get ferro-nickel

Environmental Consideration

Per ton of spent catalyst smelting would produce about 250 kg of CO_2 gas. The slag generated is non-toxic and can be dumped.

Major Raw Materials

Spent nickel catalyst, mill scale (iron oxide), coke etc.

Major Plant Equipment/Machinery

Grinding and palletizing, Smelting furnace,

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 and condition.

Uses

The main use of Ferronickel is the manufacture of steel.

Scale of Development

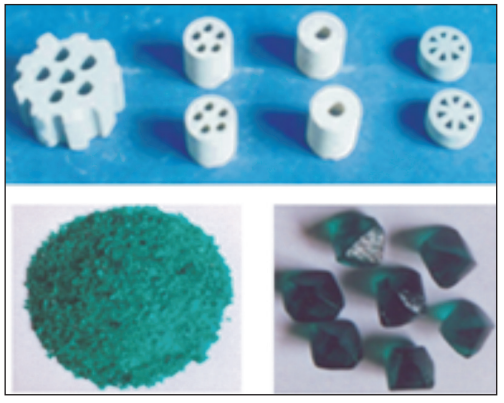
10 kg spent catalyst per batch smelting

Commercialization Status

Ready for commercialization

Techno-economics

For a 10 MT/month capacity plant; Capital cost is ~90 L (excluding land & shed) Recurring Expenditure -Rs. 4.0 Lakhs/month (excluding the cost of spent catalyst).



Uses

Nickel sulphate is extensively used in electroplating, organic chemical synthesis, metal coloring, dye mordant, manufacturing other nickel salts, Ni-Cd battery

Scale of Development

Process developed on 1 kg scale with overall recovery of 96% nickel

Commercialization Status

Process demonstrated on 1 kg scale and transferred to M/s SMC Technology, Malaysia

Techno-economics

For a 10 MT/month capacity plant; Capital cost is ~Rs.75 Lakhs (excluding land & shed). Recurring Expenditure - Rs. 3.5 Lakhs/month (excluding spent catalyst cost).

MEF 002

Production of Nickel Sulphate 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.

Environmental Consideration

Only CO_2 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

Major Plant Equipment/Machinery

Roaster, Grinding and sieving apparatus, leaching reactors, promoter, filtration unit, pumps, crystalliser etc.

Technology Package

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

Assistance in setting up the plant on separate terms and condition.

MEF 003
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 remains in the leach residue. The residue containing appreciable amount of lead is treated as hazardous waste. A complete flow-sheet for recovery of lead is developed with following key features:

- Overall recovery is >96% of lead and simultaneously recovers >70% of both Cu & Zn present in the residue
- Recovers 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.

Patent Application No: 1589DEL2010

Environmental Consideration

No toxic liquid effluent is generated as the process operates in close loop. About 500 - 600 kg of 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

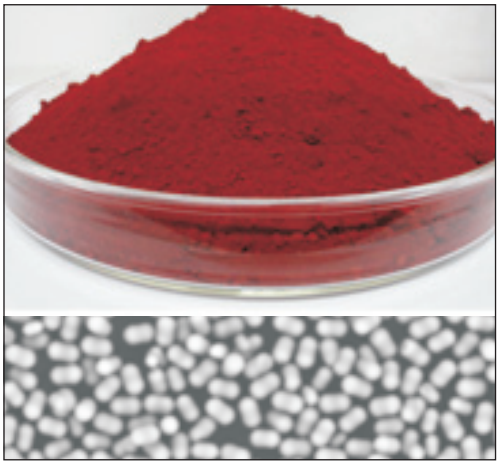
Developed and demonstrated on 1 Kg scale

Commercialization Status

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

Techno-economics

Chemical requirement cost is about Rs. 7,000 /- against product cost of about Rs. 30,000/- per ton of lead residue processing (Pb in residue ~15%)



MEF 004

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

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.

Techno-economics

Chemical requirement cost is about Rs. 30,000 against product cost of about Rs. 1,25,000 per ton of iron oxide production.

Salient Features

High purity mono dispersed hematite particles of very uniform sizes and shapes have been produced by low temperature aqueous synthesis route in large quantities with a yield of almost 100% starting from very inexpensive and impure iron sources such as blue dust, scraps, pickle liquors, crude iron oxide, high iron containing residues etc. Low temperature aqueous synthesis method produce very uniform size and shapes of iron oxide from very inexpensive and impure iron sources. The mono dispersed hematite particles of different shapes such as cubic, spindle, ellipsoidal, spherical, peanut type particle can be produced by this method. Different shapes of uniform size mono dispersed hematite particles of size ranging from 200 - 2000 nm can be produced.

Environmental Consideration

The liquid effluent generated from is treated for regeneration of alkali and recovery of marketable grade salt. Only about 50 kg of nontoxic 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.

MEF 005

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 CO_2/MT of W-powder.
- Storage & handling of flammable H_2 gas.

Major Raw Materials

(i) WC scraps, (ii) commercial mineral acids, (iii) EXCEL Grade N_2& H_2 gasses.

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 1kg/batch scale

Commercialization Status

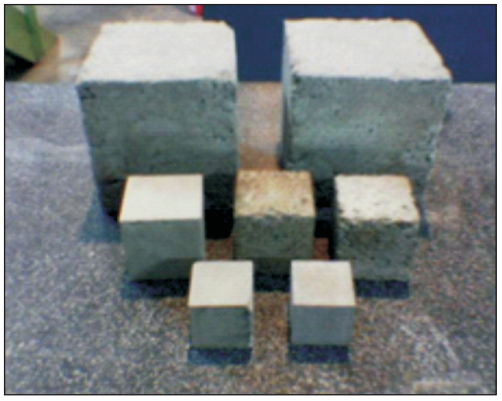
The process has been licensed to

(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 Lakhs (excluding land & shed) & Recurring Expenditure Rs. 18.0 Lakhs/month (excluding scrap cost).



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. 70 Lakhs (Excluding land and building)

Cost of product: Rs. 4200/ ton

MEF 006

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 undergoes 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 CO_2 than Portland cement

Patent No: IN251997

Environmental Consideration

The product meets USEPA 1311 specification for toxicity. Also due to 70% low CO_2 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, & (d) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

MEF 007

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 CO_2, 35% low embodied energy than conventional equivalent product

Patent Application No: 1509/KOL/2011

Environmental Consideration

The product meets USEPA 1311 specification for toxicity. Also due to 35% low CO_2 emission and 35% less embodied energy, 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, and/or
- Ground granulated blast furnace slag conforming to IS 12089:1987, and/orSteel 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. 40 Lakhs (Excluding land and building)

Cost of product: Rs. 320-400/ square meter

Uses

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

Scale of Development

(i) Flux has been produced in 200 Kg capacity pilot scale furnace

(ii) 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.

MEF 008

Development of 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

MEF 009

Ferrosilicon from BHQ, BHJ & Low Reactive Coal

Salient Features

The most remarkable feature of this process is the 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.

Patent Application No: 1393/KOL/2012 & 1076/KOL/2012

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

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 Tonnes): 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.

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.

MEF 010

Production of Directly Reduced Iron (DRI)

Salient Features

The process uses ~100% waste material and this invention is useful for converting steel plant wastes / mining waste iron ore and coal in to a high quality value added product (DRI) suitable for electric furnace, BOF and induction furnace for steel making.

Patent Application No: 1190/KOL/2012

Environmental Consideration

- Generation of 100-150 kg of coal char per ton of DRI
- No liquid effluent generated.

Major Raw Materials

(i) Waste / lean iron ore fines such as iron ore slime (ii) waste / lean grade coal.

Major Plant Equipment/Machinery

(I) Muffle furnace or Tunnel Kiln, (ii) Ceramic crucibles, (iii) Pelletizer etc.,

Technology Package

Complete flow-sheet with mass balance, Equipment details, Process description, Cost estimate and Product specification. Assistance in setting up the plant as per organization terms and conditions

MEF 011

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

Salient Features

The process utilises ~100% waste materials to yield a value added product. This invention is useful for converting steel plant wastes fines / mining waste fines such as iron ore slime/fines, middling and rejected coal containing more than 25 % ash into a highly metallised (Metallisation > 96%) low Sulphur (0.006%S) DRI suitable for induction furnace, electric arc furnace and blast furnace for iron and steel making.

Patent Application No: 1320/KOL/2013 & 1345/KOL/2013

Environmental Consideration

- Generation of 150-200 kg of coal char per ton of DRI
- No liquid effluent generated.

Major Raw Materials

(i) Waste / lean iron ore fines such as iron ore slime (ii) Waste / lean grade coal containing 25 to 65% ash such as Middling Coal, Rejected Coal and likewise.

Major Plant Equipment/Machinery

(i) Muffle furnace or Tunnel Kiln, (ii) Ceramic crucibles, (iii) Pelletizer etc.,

Technology Package

Complete flow-sheet with mass balance, Equipment details, Process description, Cost estimate and Product specification. Assistance in setting up the plant as per organization terms and conditions

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

Laboratory scale: 1 to 5 kg

Commercialization Status

Ready for commercialization

Techno-economics

Cost of the DRI produced to be approximately Rs. 13,000 / ton.

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

Pilot scale: 1 - 10 tones

Commercialization Status

Ready for commercialization

Techno-economics

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

MEF 012

A Process for Production of Highly Metalised Low Sulphur Directly Reduced Iron (DRI) in Tunnel Kiln

Salient Features

The process utilises ~100% waste raw materials (iron ore fines, slimes and likewise and coal fines such as middling coal, rejected coal, non coking coal, jhama coal and likewise) generated during mining and processing of raw materials for preparation of blast furnace burden. The DRI produced from this process is highly metallised (Metallisation > 96%) with low Sulphur (0.006%S) and can be used as substitute of scrap /feed material for induction furnace, electric arc furnace and Basic Oxygen Furnace (BOF) for steelmaking.

Patent Application No: 1220/KOL/2014

Environmental Consideration

- Generation of 100-150 kg of coal char per ton of DRI
- No liquid effluent generated.

Major Raw Materials

(i) Waste iron ore fines or slime and likewise, (ii) waste coal containing 15 to 35% ash such as Jhama Coal, Middling Coal and likewise.

Major Plant Equipment/Machinery

(i) Tunnel Kiln, (ii) Ceramic crucibles/Saggers, (iii) Pelletizer etc.,

Technology Package

(a) Process-Know-how, (b) Details of the equipments with specification, (c) Plant Layout and (d) Methods for Quality Assurance. Assistance in setting up the plant as per CSIR-NML norms.

MEF 013

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

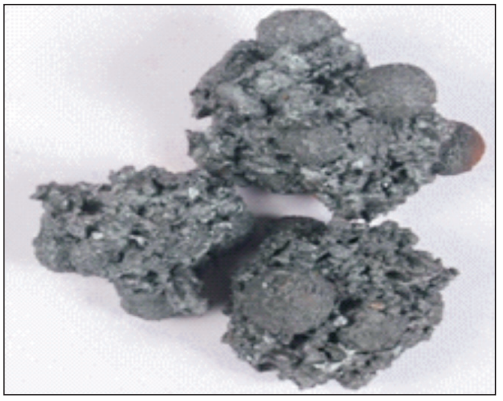
Iron ore fines, LD Sludge, BF-Blue Dust

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

In Blast Furnace Iron Making

Scale of Development

12 kg / batch

Commercialization Status

Ready for commercialization

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.

Uses

Iron and Steel industries

Scale of Development

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

Commercialization Status

Ready for commercialization

Techno-economics

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

MEF 014

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
- CO_2 in steel plant's waste gas is utilized in strengthening of pellet

Environmental Consideration

No harmful effect on environment, it will decrease CO_2 emission since, CO_2 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, CO_2 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.

MEF 015

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, CO_2 treatment facility, Sinter Plant, charging system of micro-pellets

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

Steel making as suitable flux

Scale of Development

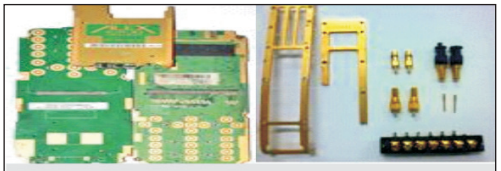
10 kg / batch

Commercialization Status

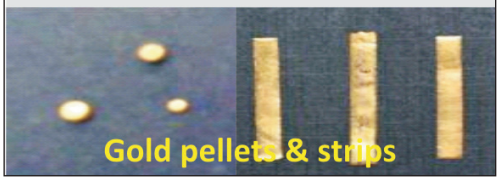
Ready for commercialization

Techno-economics

Capital cost for the Pelletizer, CO_2 treatment facility depends upon amount of up scaling.Conventional sinter strand will be used. Raw materials used are wastes.



Scraps containing gold



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 ~Rs. 10 Lakhs

Recurring Cost ~Rs. 2 Lakhs/ Year

MEF 016

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.

MEF 017

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 ~10 Lakhs

Recurring Cost ~2Lakhs/ Year

Neodymium Fluoride

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 ~ 10 Lakhs

Recurring Cost ~ 02 Lakhs/ Year

MEF 018

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, H_2SO_4, 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.

MEF 019

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 in ~25% increase in productivity
- Minimum alteration of existing operating practices of traditional brass melting furnace
- Construction by using locally available materials

Patent Application No. : 0596DEL2013

Environmental Consideration

Less CO_2 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:

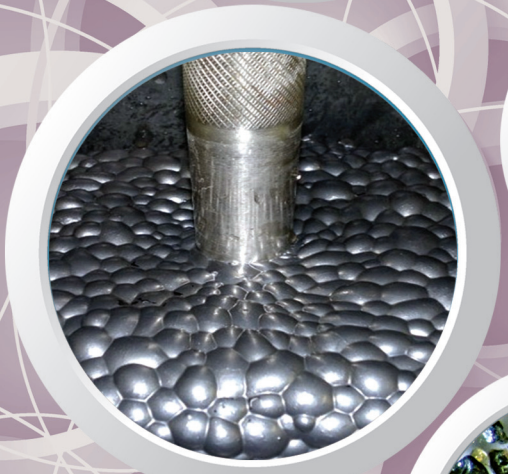
I) M/S Moradabad Industrial Development Company, Moradadad, UP

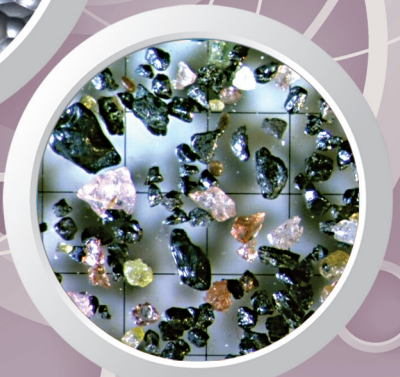
ii) M/S Technical Training Institute, Balasore, Odisha

ii) 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/- more than the traditional brass melting furnace presently is being used by artisans. This extra cost can be recouped within 30 days of furnace operation.





MINERALS PROCESSING

MNP DIVISION

MNP 001

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

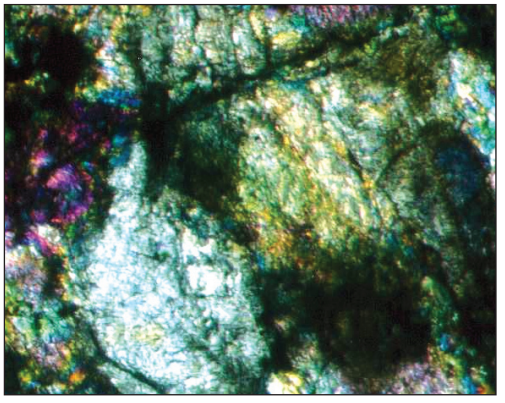
Low-grade baryte ores, Flotation reagents.

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.



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

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

MNP 002

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 and magnetic separation, dewatering.

Technology Package

a) Process knowhow with details of equipment

b) Process flow-sheet with material balance

c) Assistance in setting up the plant on separate terms

MNP 003

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 and 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. Assistance in setting up the plant on separate terms.

Uses

The technology is for beneficiation 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

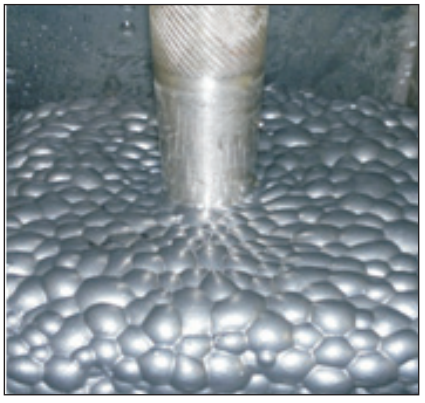
Beneficiation: 0.5 tph raw ore Extraction: 5 kg concentrate, scale-up possible

Commercialization Status

Ready for commercialization

Techno-economics

Available on demand



Uses

For metallurgical use (coking), for direct reduction of iron ore, coal dust injection in blast furnace (non-coking).

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

MNP 004

Clean Coal from Coking/Non-Coking coals/ Coal slurry

Salient Features

The technology is based on flotation of raw coals of coking/non-coking, or coal slurry of the washing circuit to produce a clean coal of 12-17% ash from a feed of 22-30% ash.

Environmental Consideration

Installation of tailings disposal units shall be needed.

Major Raw Materials

Raw coals/slurry, flotation reagents.

Major Plant Equipment/Machinery

Comminution equipment if necessary, Flotation banks, Conditioning tank, Thickeners, Filters

Technology Package

(a) Process knowhow, (b) Details of equipment & (c) quality assurance methods. Assistance in setting up the plant on separate terms.

MNP 005

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.

Environmental Consideration

There should be well planned disposal of wastes and effluents.

Major Raw Materials

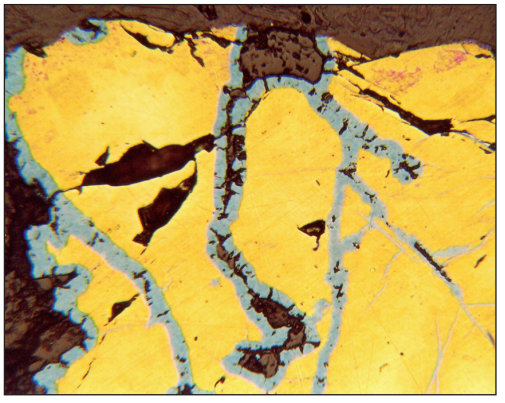
Copper Ore; Flotation Reagents.

Major Plant Equipment/Machinery

Crushers, Grinding mill and 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) Quality assurance methods. Assistance in setting up the plant on separate terms.



Uses

The copper concentrate is used for extraction of metal by pro-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 NML flowsheet. (2) 6000 tpd Malanjkhand copper project is based on NML flowsheet.

Techno-economics

Available on demand.

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

MNP 006

De-ashing of high-ash Thermal Coal

Salient Features

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.

MNP 007

High Quality Magnesite

Salient Features

The Process is based on multiple stage froth flotation of milled feed followed by dewatering and pelletisation / briquetting of magnesite concentrate. The product is suitable for use in refractory industries.

Environmental Consideration

Installation of tailings disposal system is needed.

Major Raw Materials

Magnesite ore, Flotation reagents.

Major Plant Equipment/Machinery

Crushers, Milling units, Flotation banks, Thickeners, Filters, Dryers, Pelletising/Briquetting machine.

Technology Package

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

Uses

Wide ranging uses of magnesite in refractories, glass and foundry industries.

Scale of Development

The process has been developed at 25 tpd pilot plant level. Further scale-up possible.

Commercialization Status

Ready for commercialization

Techno-economics

Available on demand

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.

MNP 008

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

Phosphate rock, flotation reagents.

Major Plant Equipment/Machinery

Crushers, Gridding mills, Flotation and dewatering units.

Technology Package

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

MNP 009

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 iron ore

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

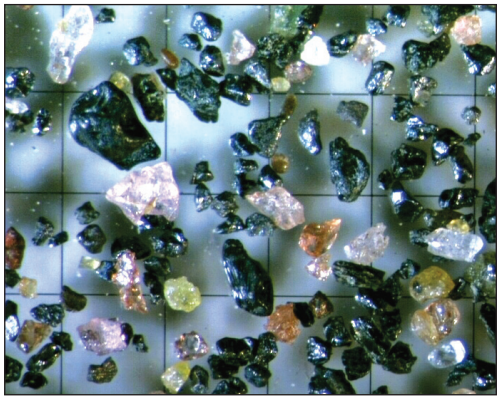
0.5 tph. Further scale-up is possible.

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.



Uses

For manufacture of value added products from ilmenite, garnet, zircon, sillimanite and monazite for various industrial uses.

Scale of Development

0.5 tph; Further scale-up possible.

Commercialization Status

Ready for commercialization

Techno-economics

Available on demand.

MNP 010

Beach Sand Heavy Minerals

Salient Features

This process technology enables separation and purification of valuable beach sand minerals to produce high purity ilmenite, garnet, zircon, sillimanite and monazite. The separation process exploits the difference in physical and physico-chemical properties of constituent minerals and uses gravity, magnetic, high-tension and flotation techniques.

Environmental Consideration

The process is environmental friendly. In case of recovery of sillimanite by froth flotation, arrangement for disposal of tailings is to be made.

Major Raw Materials

Beach sand heavy minerals, Flotation reagents.

Major Plant Equipment/Machinery

Gravity, Magnetic, HT separation Units, Flotation cells, Dewatering/Drying units.

Technology Package

(a) Process knowhow with flow-sheet, (b) Details of equipment & (c) Quality assurance methods. Assistance in setting up the plant on separate terms.

MNP 011

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

Uses

Technology is utilized to make pellets from iron ore fines for iron and steel making.

Scale of Development

5 kg batch Further scale-up possible.

Commercialization Status

Ready for commercialization

Techno-economics

Available on demand.

MNP 012

Pelletisation of Iron Ore Fines

Salient Features

This Technology is utilized for pelletisation of iron ore fines using suitable binder/s. Pellets can be used for iron and steel making after induration

Environmental Consideration

The process is environment friendly.

Major Raw Materials

Iron Ore fine(~63% Fe), Binder, Fluxes

Major Plant Equipment/Machinery

Grinding mill, Pelletiser, Induration unit

Technology Package

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

MNP 013

Sintering of Iron Ore with high percentage of Micro-Fines

Salient Features

This technology produces iron ore sinter for iron and steel making. Iron ore containing high amount of micro-fines can be utilized for iron making through micro-pelletisation cum sintering without curing.

Environmental Consideration

Induration process is eliminated through Micro-pelletisation cum sintering.

Major Raw Materials

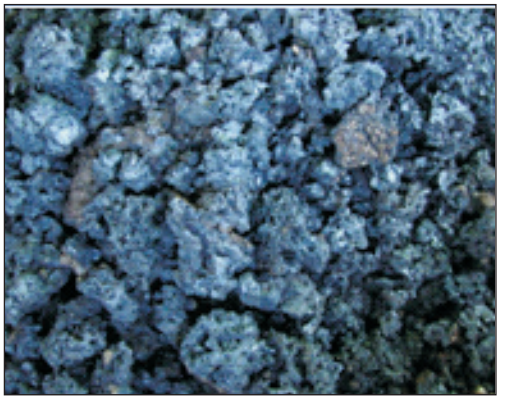
Iron ore concentrate, binder, flux, coke breeze, mill scale, flue dust

Major Plant Equipment/Machinery

Mixing unit, Pelletiser, Sintering Unit.

Technology Package

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



Uses

Iron ore sinter is used for iron and steel making.

Scale of Development

Capacity: 35-150 kg/batch

[Bed height = 400 - 740 mm]

Commercialization Status

Ready for commercialization

Techno-economics

Available on demand

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

MNP 014

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.

CSIR NML – Madras Centre

NMC 001

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

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., Bangalore, (ii) Flotation Column design, engineering, erection, commissioning, stabilization and training in collaboration with M/S McNally Bharat Engineering Co. Ltd., Kolkata

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

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 lakhs (approx.)

Uses

Value addition to low grade ores by flotation.

Scale of Development

Demonstrated at plant scale

Commercialization Status

Regents available commercially from M/S. Somu Organics. Commercially being supplied to JSW Steels for the beneficiation of iron ore tailings and to Andhra Barite Corpn for the beneficiation of low-grade barite waste dumps.

Techno-economics

Depends on reagent typically Rs. 250 - 300 /kg

MNC 002

Specific, Selective & Green Reagents for the Beneficiation of Ores, Minerals and Coal

Salient Features

The performance of flotation technique greatly depends on the surfactants/collector reagents used to create hydrophobic character specific & selectively on the particle surface to be floated. Hence, development of effective and specific reagents for the ores and coal is essential. CSIR NML developed such reagents in collaboration with M/s Somu Organo-Chem Pvt. Ltd., Bangalore. The following specific reagents are available:

1. Reagent for the beneficiation of Iron Ore Fines/Tailings by reverse flotation process.
2. Reagent for the beneficiation of low-grade Barite and Limestone by reverse flotation process
3. Single reagent for the flotation of Coal fines (replacing diesel & frother)

- All the reagents are environmental friendly bio-degradable.
- All the reagents are proven successful industrially.
- Reagents for Iron ore and Barite are being supplied regularly to JSW Steels and Andhra Barite Corpn.
- These reagents are economical & cost effective

Environmental Consideration

The reagents are synthesized from vegetable oils and hence are completely bio-degradable.

Major Plant Equipment/Machinery

N A

Technology Package

Reagents will be supplied by M/S Somu Organo-Chem Pvt. Ltd., Bangalore, on request.

IP Analytics Services

CSIR-National Metallurgical Laboratory started providing IP search and analysis services to its clients in the area of minerals, metals and materials. The Laboratory offers patent analytics services that enable clients to take an eagle's eye view of the current and future trends of their respective technologies and develop ideas around such technologies. The analytical reports of CSIR-NML is intended to provide its clients with insights, which aid them to strategize and plan their business approach in a better manner. CSIR-NML has in-depth expertise in IP search and analysis to assist its clients in specific areas of patent research. With vast experience in the area of patinformatics/patent analytics, CSIR-NML provides the following IP services

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 Knowledge**[SM], Questel **QPAT**
- Software : VantagePoint

For more information please contact

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