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 " . 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

Forword

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

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

Director
CSIR-National Metallurgical Laboratory
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CSIR-NML has emerged as one of the major players in metallurgical and materials research, backed up by a substantial share of intellectual

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MNP001

COLUMN FLOTATION TECHNOLOGY

Uses

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

Scale of Development

Laboratory – Pilot – Commercial scale flotation columns.

Commercialization Status

The technology is fully commercialized for both, laboratory and industrial columns. The installed capacity range from 150 TPD to 1000 TPD.

Techno-economics

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

Technology Readiness Level (TRL)

TRL: 9

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

a) Process and reagent development in collaboration with M/s Somu Organo Chem Pvt. Ltd., Bengaluru,

b) Flotation Column design, engineering, erection, commissioning, stabilization and training in collaboration with M/s McNally Sayaji Engineering Limited., Bengaluru.

INW009

RECOVERY OF GOLD FROM WASTE MOBILE PHONES AND SCRAPS OF VARIOUS EQUIPMENT

Salient Features

A process is developed for the selective dissolution of gold metal from the PCBs of waste mobile phone, small parts of various equipments containing gold on outer layer. The gold was leached in suitable lixivient. The gold bearing leach liquor was contacted with activated carbon to adsorb the gold on the surface of charcoal. 99.99% Gold was recovered from the leach liquor using adsorption/ cementation with subsequent heat treatment.

Environmental Consideration

Waste water/Effluent generated is further treated and recycled to the close-loop process in industry. The solid waste/ residue containing other metals is further treated for its recovery as value added product.

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) Technology demonstration

d) Training

e) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

Tgold 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 100 Kg (Lab , Scale-up/Pilot)

Commercialization Status

Transferred to 02 Indian Industries and commercialized.

Techno-economics

- Capital Cost ~ 50 Lakh
- Recurring Cost ~ 12 Lakh/ Year
- ROI> 30%

Technology Readiness Level (TRL)

TRL:6

INW010

CLOSE LOOP TECHNOLOGY TO RECOVER LITHIUM, COBALT, MANGANESE, COPPER, NICKEL AS METALS/SALTS, SALEABLE PLASTICS AND RE-USABLE GRAPHITE FROM LIBS, NICKEL METAL HYDRIDE (NI-MH) AND LITHIUM IRON PHOSPHATE (LFP) BATTERIES.

Uses

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

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL: 9

Salient Features

The technology comprises of physical pre-treatment, beneficiation, hydro- followed by electro-metallurgy is developed to recycle LIBs to produce Lithium, Cobalt, Manganese, Copper, Nickel as Metals/Salts, Saleable plastics and re-usable Graphite. In physical pre-treatment and beneficiation three fractions 1. Mixed metals 2. Plastics and 3. Black powder of cathodic materials were obtained. Leaching of the metals from the black mass was made with suitable lixiviants at optimized conditions. Leach liquor generated containing metals was further processed through solvent extraction, precipitation, crystallization/ electro-winning techniques to recover various metals as salt/ pure metal. The technology is also well validated for the recycling of Electric vehicle (EVs) rechargeable batteries i.e. Nickel Metal Hydride (Ni-MH) and Lithium Iron Phosphate (LFP) batteries.

Environmental Consideration

Waste water/Effluent generated is further treated and recycled to the close-loop process in industry. The solid waste/ Residue containing other metals is further treated for its recovery as value added product.

Major Raw Materials

Discarded Lithium Ion Batteries (LIBs), Ni-MH, LFP, Acids, Alkali, Organic extractant, modifier, diluents, etc.

Major Plant Equipment/Machinery

Scutter-crusher, Pulverizer, Spiral, Flotation set-up, leaching reactors, 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) Technology demonstration

d) Training

e) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

INW011

RECOVERY OF NEODYMIUM AS A VALUE ADDED PRODUCT FROM WASTE HARD DISK OF PERSONAL COMPUTERS

Salient Features

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

Environmental Consideration

Waste water/Effluent generated is further treated and recycled to the close-loop process in industry. The solid waste/ Residue containing Iron is utilized for the recovery as value added product.

Major Raw Materials

Discarded hard disk/Nd-Fe-B Magnets, Acids, Alkali, 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) Technology demonstration

d) Training

e) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

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

Scale of Development

1 Kg discarded hard disk magnets

Commercialization Status

Ready for commercialization

(International Sponsored activity)

Techno-economics

- Scale 50 Kg
- Capital Cost ~ 50 Lakh
- Recurring Cost ~ 10 Lakh/ Year

Technology Readiness Level (TRL)

TRL:6

INW010

CLOSE LOOP TECHNOLOGY TO RECOVER GOLD, COPPER, NICKEL, ALUMINIUM, LEAD AND TIN FROM PERSONAL COMPUTER PCBS

Uses

Gold, Aluminium, Copper, Lead, Tin etc have wide applications in various sectors such as electric and electronic sectors, making alloys, electroplating, etc.

Scale of Development

10 kg to 50 Kg (Scale-up and Pilot)

Commercialization Status

Already transferred technology to 06 Indian industries and Commercialised..

Techno-economics

For 2 Ton/ Day recycling

Capital Cost ~ 300 Lakh

Recurring Cost ~ 24 Lakh/ Year

ROI > 20%

Technology Readiness Level (TRL)

TRL: 6

Salient Features

The technology comprises of physical pre-treatment, beneficiation, hydro- followed by electro-metallurgy of PCBs is developed to recover Aluminium, Lead, Tin, Copper and gold as metals/salts. Small devices from the PCBs are depopulated by desoldering it at particular temperature. Aluminium recovered as Heat exchanger, which are made-up of pure aluminium. ICs and MLCCs are separated for further processing to get gold. Selective dissolution of gold metal from depopulated materials of PCBs i.e. ICs and MLCCs was made using suitable lixiviant. The gold bearing leach liquor was contacted with activated carbon to adsorb the gold on the surface of charcoal. 99.99% Gold was recovered from the leach liquor using adsorption/ cementation with subsequent heat treatment. Copper from the PCBs was recovered by physical pre-treatment followed by hydro-electro-metallurgy.

Environmental Consideration

Waste water/Effluent generated is further treated and recycled to the close-loop process in industry. The solid waste/ Residue containing other metals is further treated for its recovery as value added product.

Major Raw Materials

Printed Circuit Bords (PCBs) of Computers, Acids, Alkali, Organic extractant, modifier, diluents, etc.

Major Plant Equipment/Machinery

Scutter-crusher, Pulverizer, Spiral, Flotation set-up, Leaching reactors, 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) Technology demonstration

d) Training

e) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

INW013

RECOVERY OF PRECIOUS METALS AU, AG, PD, PT FROM SMALL ELECTRONIC DEVICES, MLCCS, KEYBOARDS, ICS ETC

Salient Features

The technology comprises of physical pre-treatment, beneficiation, hydro- followed by electro-metallurgical is developed to recycle small electronic devices, MLCCs, Keyboards, ICs etc to produce Au, Ag, Pd, Pt. Leaching of the metals from the above materials was made with suitable lixiviants at optimized conditions. Leach liquor generated was further processed through solvent extraction, precipitation, crystallization/ electro-winning techniques to recover various metals as salt/ metal. The technology is also well validated.

Environmental Consideration

Waste water/Effluent generated is further treated and recycled to the close-loop process in industry. The solid waste/ Residue containing other metals is further treated for its recovery as value added product.

Major Raw Materials

Discarded small electronic devices, MLCCs, Keyboards, ICs, Acids, Alkali, Organic extractant, modifier, diluents, etc..

Major Plant Equipment/Machinery

Scutter-crusher, Pulverizer, Spiral, Flotation set-up, Leaching reactors, 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) echnology demonstration

d) Training

e) Quality Assurance Methods. Assistance in setting up the plant on separate terms.

Uses

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

Scale of Development

1 Kg discarded hard disk magnets

Commercialization Status

Ready for commercialization

(International Sponsored activity)

Techno-economics

- Scale 50 Kg
- Capital Cost ~ 50 Lakh
- Recurring Cost ~ 10 Lakh/ Year

Technology Readiness Level (TRL)

TRL:6

MNP005

RECOVERY OF CHROMITE VALUES FROM TAILINGS / SLIMES PRODUCED BY CHROMITE ORE BENEFICIATION PLANT

Uses

For recovering of chromite values from tailings/slimes generated by chromite ore beneficiation plant.

Scale of Development

Pilot Scale

Commercialization Status

Ready for Implementation.

Techno-economics

Techno-economically favourable.

Technology Readiness Level (TRL)

TRL: 6

Salient Features

The technology exploits the difference in density of the chromite ore and the associated gangue minerals for their separation using fine gravity separator. The technology was developed at bench scale and subsequently validated through pilot scale trials. It produces marketable chromite concentrate with final tailings assaying< 10 % Cr_2O_3 meeting IBM guidelines for disposal of tailings. It has several advantages *viz.*

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

Environmental Consideration

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

Major Raw Materials

Tailings/Slime produced by chromite ore beneficiation plant.

Major Plant Equipment/Machinery

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

Technology Package

a) Process know how covering process flow-sheet with material balance, equipment/process parameters.

b) Assistance in setting up of plant on separate terms and conditions.

MNP006

SEPARATION OF QUARTZ & FELDSPAR

Salient Features

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

Environmental Consideration

Installation of tailings and effluent disposal systems is needed.

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

a) Process knowhow

b) Details of equipment

c) Quality Assurance Methods.

d) 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

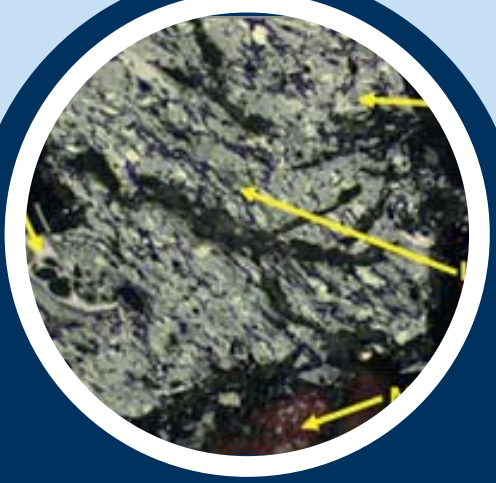
Ready for commercialization

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL: 6



MNP007

DRY BENEFICIATION OF NON COKING COAL FOR APPLICATION IN THERMAL POWER AND DRI

Uses

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

Scale of Development

Pilot Scale at 10 TPH scale

Commercialization Status

It is to be commercialized with the support of user industries

Techno-economics

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

Technology Readiness Level (TRL)

TRL: 7

Salient Features

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

Environmental Consideration

Conserves water, no process water generated which prevents water pollution

Major Raw Materials

Thermal coal

Major Plant Equipment/Machinery

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

Technology Package

a) Process know and equipment details,

b) Technological process flowsheet with mass balance

c) Assistance in setting up the plant on separate terms and conditions.

MNP008

BENEFICIATION OF DUMPED LOW-GRADE IRON ORE FINES FOR IRON AND STEEL MAKING

Salient Features

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

Environmental Consideration

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

Major Raw Materials

Low-grade dumped iron ore fines.

Major Plant Equipment/Machinery

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

Technology Package

a) Process knowhow with details of equipment

b) Technological process flow-sheet with material balance

c) Quality Assurance Methods.

d) 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 approximately Rs. 300 crores.

Technology Readiness Level (TRL)

TRL: 7

MNP009

PHOSPHATE CONCENTRATE

Salient Features

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

Environmental Consideration

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

Major Raw Materials

Rock phosphate, flotation reagents.

Major Plant Equipment/Machinery

Crushers, Gridding mills, Flotation and dewatering units.

Technology Package

a) Process knowhow with equipment details

b) Technological process flow-sheet with material balance

c) Assistance in setting up the plant on separate terms and conditions.

Uses

For the manufacture of phosphoric acid and phosphatic fertilizers.

Scale of Development

200 kg/h

Commercialization Status

Ready for commercialization

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL: 7

MNP0010

DE-ASHING OF HIGH NON-COKING 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.

d) Assistance in setting up the plant on separate terms and conditions.

Uses

Clean coal fines for injection in blast furnace

Scale of Development

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

Commercialization Status

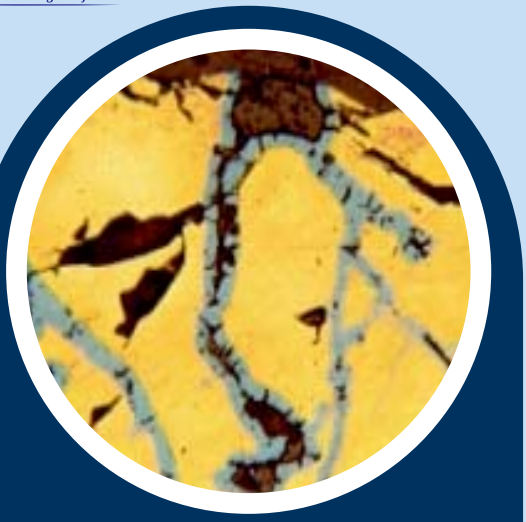
Ready for commercialization

Techno-economics

Available on demand

Technology Readiness Level (TRL)

TRL: 6



MNP011

COPPER CONCENTRATE FROM COPPER ORES

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 CSIR-NML flowsheet.
(2) 6000 TPD Malanjkhand copper project is based on CSIR-NML flowsheet.

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL: 8

Salient Features

The process is based on forth 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 tailings.

Major Raw Materials

Copper Ore; Flotation Reagents.

Major Plant Equipment/Machinery

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

Technology Package

a) Process knowhow with technological process flow-sheet and material balance

b) Details of equipment

c) Assistance in setting up the plant on separate terms and conditions.

MNP012

TECHNOLOGY FOR BENEFICIATION OF LOW-GRADE LIMESTONE CONTAINING FINELY DISSEMINATED SILICA GRAINS FOR UTILIZATION IN CEMENT MAKING INDUSTRY

Salient Features

Based on the detailed studies on characterization with respect to physical, chemical, mineralogical and beneficiation characteristics flotation based process technology has been developed for beneficiation of low grade limestone sample with fine grained silica as the impurity. The important technical features of the technology include the following:

- Separation of fine grained silica from calcite.
- Reduction of silica content in the sample from 19% to 11%.
- High recovery of CaO of 96%.
- Validation of laboratory result at pilot scale.
- The technology is suitable for beneficiation of low grade limestone for use in cement making

Environmental Consideration

Environmentally friendly. Suitable measures are to be taken for disposal of tailings

Major Raw Materials

limestone, flotation reagents.

Major Plant Equipment/Machinery

Crusher, Vibratory screen, Ball mill, Hydrocyclone, Flotation cells, Thickener, Filter.

Technology Package

a) Process flow sheet with material balance.

b) List of chemicals

c) List of equipment

d) Quality control procedure

Uses

- Meeting the requirement of construction industry in view of growing infrastructure needs.
- Effective utilization of low-grade limestone deposits and conservation of resources.
- Usage of limestone concentrate in cement making industry

Scale of Development

150 kg/hr

Commercialization Status

Ready for commercialization

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL: 6

MNP013

TECHNOLOGY FOR PRODUCTION OF TUNGSTEN METAL POWDER FROM PLANT TAILINGS/ WASTE SAMPLE

Salient Features

Tungsten is a strategic metal and has critical applications in defense, mining and other sectors. Indian tungsten demand is mostly met through imports. Chinese monopoly in global tungsten supply, fluctuating international prices places us in situation where development of indigenous technology for production of tungsten from domestically available resources (lean grade ores/ tungsten containing mine/plant waste) becomes imperative. Based on the characterization, laboratory and pilot scale studies technology was developed for production of tungsten metal powder from plant tailings/rejects with extremely low concentration of tungsten (0.02 WO_3).

The important technical features are the followings:

- Novel route for beneficiating extremely fine grained and low tungsten assaying plant tailings/waste material to a product suitable for extraction of tungsten.
- Hydrometallurgical extraction of tungsten from pre-concentrate involving alkali leaching, solvent extraction & crystallization of ammonia para-tungstate (APT).
- Production of high purity (99.9%) tungsten metal powder from high temperature reduction of APT.

Environmental Consideration

Environmentally friendly. Suitable measures are to be taken for disposal of tailings

Major Raw Materials

Gold ore Tailings, chemicals such as Alamin-336, Iso-decanol, Kerosene, Conc. Sulphuric acid, ammonia and NaOH.

Major Plant Equipment/Machinery

Falcon concentrator, magnetic separator, screens, ball mill, chemical reactor, precipitators, Mixer settlers, crystallizer, furnace etc.

Technology Package

a) Equipment
b) Results
c) Process flowsheet for pre-concentration of tailings/rejects with material balance
d) Process flow sheet for extraction of tungsten from pre-concentrate
e) Details of Process parameters

Uses

- Equipment used in the developed process is easy to operate
- Chemicals such as Alamin-336, Iso-decanol, and Kerosene will be recycled in the process.
- Useful for production of tungsten metal powder from industrial waste with low tungsten concentration /lean grade ore

Scale of Development

Pilot Scale

Commercialization Status

Ready for commericalization

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL: 7

MNP014

AN APPARATUS AND METHOD FOR DRY SEPARATION OF MATERIALS BASED UPON THEIR DENSITY DIFFERENCE

Salient Features

The developed dry separator technology is used in any field which separates materials/minerals based on their density difference without using any chemicals, water. The efficiency of Pneumatic pulsated separators in density-wise separation of particles is enhanced and dead zones are minimized. No usage of chemicals, water leads to reduction in slurry discharge into water bodies there by enhancing environmental safety and reducing dewatering processes will add to economical advantages.

Angle of Fluidization adjustment from 0-90 degrees resulting in change in force balance of particles.

Dry density separation of materials ranging from 500 kg/m^3 - 7000 kg/m^3. This range of density separation can be enhanced by enhancing the fluidization which can done in the fabricated dry separator.

The pulsation frequency of air is in between 0-60 Hz

Environmental Consideration

Environmentally friendly. Suitable measures are to be taken for disposal of tailings

Major Raw Materials

Coal, Iron ore etc.

Major Plant Equipment/Machinery

Not Applicable

Technology Package

a) Equipment

b) Results

c) Process flowsheet for pre-concentration of tailings/rejects

e) Details of Process parameters

Uses

- Bubbling is reduced
- Forces balance on the particle changes, as fluidization forces are at an angle, which resulted in decrease in the minimum fluidization velocity of particles
- Dead zones are minimized due to inclined fluidization as air traces larger path reaching long lengths of separator

Scale of Development

80 kg per batch (1 batch = 12 minutes,5 batches in hour =400 kg/hr)

Commercialization Status

Ready for commericalization

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL: 3

MNP015

PREPARATION OF COKE FROM SEMI-COKING AND NON-COKING COALS

Uses

- The cost of the process of coke making will be significantly reduced by reducing the use of hard coking coal
- Yield % of active coking component in coking coal is one of the important parameter to understand the coal quality for coke making

Scale of Development

7 kg

Commercialization Status

Ready for commericalization

Techno-economics

Capital expenditure : Rs. 40-50 lakhs

Operational cost : Rs. 40-50 lakhs

Technology Readiness Level (TRL)

TRL: 6

Salient Features

- Preparation of metallurgical grade coke using semi-coking and non-coking coals
- Determination of coal blend composition for coke making.
- The coke will have a CSR of more than 60 % and CRI of less than 25%
- Indian coking coals and semi-coking coals can be used for coke making
- Identification of active coking component in hard coking coal and soft coking coal
- Estimation of % yield of the active coking component in soft coking coal as well as hard coking coal
- Determination of blending composition of coal using non-coking coal (20% or more) to achieve quality coke for blast furnace application.

Environmental Consideration

Environmentally friendly.

Major Raw Materials

Coal

Major Plant Equipment/Machinery

Coke Oven, CSR/CRI equipment, Proximate Analyzer, Ultimate analyzer

Technology Package

a) The know-how transferred to industry

b) List of Chemicals

c) List of Equipment

d) Process flow sheet

e) Quality control procedure

MMA001

HIGHLY PURE TITANIUM-BASED MAX PHASE

Salient Features

- Ti_3AlC_2 development of MAX phase of high purity and its corresponding Ti_3C_2 MXene for the promising uses as a specialty chemical in various sectors including energy generation and storage.
- Indigenous process has been developed for producing high quality Ti based Ti_3AlC_2 MAX powder via pressureless sintering method.
- Produces high purity of 98-99%.
- Processing conditions has been optimized thoroughly to make the process simple.
- Different Ti, Al and C raw material sources have been investigated to make the process affordable and control the purity.
- The process majorly involves milling and sintering under inert atmosphere.
- The process is scalable and economical

Environmental Consideration

Environment friendly

Major Raw Materials

Commercially available Ti, Al and C based chemicals

Major Plant Equipment/Machinery

Ball mill and furnace with inert gas purging facility.

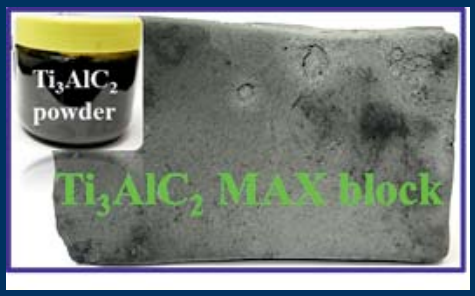
Technology Package

a) List of Chemicals

b) List of Equipment

c) Process flow sheet

d) Quality control procedure



Uses

- Process developed for production of Ti_3AlC_2 MAX phase.
- High purity of 98-99% purity.
- Cost-effective than imported Ti_3AlC_2.
- Produces good quality Ti_3C_2 Mxene.
- Can be used for various energy applications

Scale of Development

The process demonstrated at 200 gm/batch scale

Commercialization Status

The know-how transferred industry.

Techno-economics

Raw material cost – Rs. 8000/100 g

Processing cost – Rs. 900/100 g

Technology Readiness Level (TRL)

TRL: 5

MMA002

HIGH CARBON HIGH CHROMIUM WHITE CAST IRON WITH IMPROVED WEAR RESISTANCE FOR GRINDING MEDIA APPLICATIONS

Salient Features

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

Environmental Consideration

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

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

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

Uses

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

Scale of Development

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

Commercialization Status

Transferred to industry after successful field trials.

Techno-economics

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

Technology Readiness Level (TRL)

TRL: 6

MMA003

INDIGENOUS SODIUM METAL PRODUCTION TECHNOLOGY

Salient Features

- No commercial production/ technology is presently available in India; hence total Indian demand is met by import only.
- CSIR-NML has successfully designed, fabricated and operated 500A closed sodium cell and produced sodium metal by molten salt electrolysis of sodium chloride.
- Based on the expertise a 3000A pilot scale closed sodium cell was designed, fabricated and demonstrated for industry. The pilot plant was operated successfully for at least a month and produced significant amount of sodium metal.
- The purity of the metal was between 99.9 to 99.83% and the cell efficiency was about 83%.
- The indigenously developed cell design was successfully proven.
- Based on the success of the pilot scale operation the commercialization/ industrialization of sodium metal production technology is under progress at the industry up to a capacity of 144000A which includes 12000A of 12 cells aiming to produce 700MT per annum

Environmental Consideration

The generated chlorine gas will be used to convert it as sodium hypo chloride, which is a marketable product. No other environment hazard can be noticed during the cell operation.

Major Raw Materials

Sodium chloride, Calcium Chloride, Barium Chloride. Lithium Chloride, Sodium hydroxide, N_2 Gas, etc.

Major Plant Equipment/Machinery

Electrolytic cell, Melter, AC power source, Rectifier, Dryers, Chlorine gas scrubber, etc.

Technology Package

a) Design and drawing of the sodium cell

b) List of Chemicals

c) List of Equipment

d) Process flow sheet

e) Plant Operating procedure

Uses

- Indigenous technology to produce sodium metal first time in India.
- The electrolytic cell is designed to produce up to 99.9% pure sodium metal with a cell efficiency of 83%.
- The cell was designed to operate continuously for longer time and its capacity was 3000A.
- The sodium metal can be used for making sodium hydride, which has large pharmaceutical uses.
- Commercialization/ industrialization is under progress

Scale of Development

Pilot plant of 3000A capacity was setup and successfully demonstrated at industry.

Commercialization Status

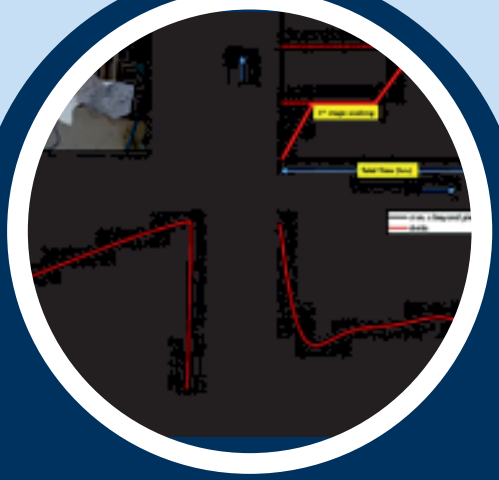
3000A sodium cell has been commissioned at industry

Techno-economics

- Raw material cost for sodium metal production: Rs. 150/ kg
- Processing cost for sodium metal production: Rs. 100/ Kg
- Total production cost of sodium metal: Rs 250/ kg
- Market price Sodium Metal cost: Rs 500/kg

Technology Readiness Level (TRL)

TRL: 8



MMA004

LOW COST WORK HARDENABLE HADFIELD STEEL FOR HEAVY IMPACT GOUGING WEAR RESISTANT APPLICATION

Uses

- Cr containing Grade 3 Mn steel for primary crushing applications
- Enhanced castability ensuring sound casting of thick sectioned components.
- Elimination of grain boundary carbide induced embrittlement prominent in thick components made up of Grade 3 Mn steel.
- Prolonged heat treatment duration for carbide dissolution in thick sections not required.
- Enhanced impact toughness with similar strength levels as of Cr containing Mn steel grade

Scale of Development

1000Kg

Commercialization Status

Ready for commercialization

Techno-economics

- Raw material cost: Rs. 40,000/ton
- Processing cost: Rs. 50,000/ton
- Total cost of a 1-ton component: Rs 90,000
- Average Wear rate of the developed steel: 13.58g/Mt of limestone crushing (with 15% SiO2 and 4% Al2O3)

Technology Readiness Level (TRL)

TRL: 5

Salient Features

- Si containing Hadfield steel is a suitable alternative for Cr containing Grade 3 Mn steels generally used as thick sectioned components in primary crushers of run of mines. Addition of Si enhances fluidity which is essential for sound castings and absence of Cr eliminates the problem of grain boundary carbide induced embrittlement in thicker sections.
- Si based modification of the composition leads to cheaper Hadfield steel variant
- Elimination of Cr renders the alloy suitability for heavy section castings.
- Enhanced fluidity due to higher Si content leads to sound castings
- Yield Strength: 440 ± 5 MPa, UTS: 810 ± 20 MPa and % Total Elongation: 30 ± 2%
- Hardness: 220 ± 10 HV30, Charpy Impact Toughness: 150 ± 10

Environmental Consideration

Environment friendly.

Major Raw Materials

Mild Steel scrap, ferro-manganese, ferro-silicon.

Major Plant Equipment/Machinery

Induction Melting Furnace, Heat Treatment furnace, water bath for quenching.

Technology Package

a) Alloy composition

b) Casting Practice

c) Heat Treatment schedule

CAL001

ANTI-TARNISHING LACQUER FOR SILVER AND COPPER-BASED ALLOYS

Salient Features

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

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

Appearance: Transparent | Gloss @20°: 65-70 Hardness :2H

Film Thickness: 2-5 micron| Coverage: 15-20 m^2/litre|Dry: 10min.

VOC: 750-800 g/L | Acid resistance: Pass | Lead < 1 ppm

Alkali resistance: Pass | Salt Spray Test: 500 hrs | Cd<1ppm

Environmental Consideration

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

Major Raw Materials

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

Major Plant Equipment/Machinery

Reflux unit, Stirring unit, Filtering unit

Technology Package

a) Process-Know-how,

b) Details of equipment,

c) Plant Layout

d) Quality Assurance Methods.

e) Assistance in setting up the plant on separate terms.

Uses

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

Scale of Development

500 litres/batch

Commercialization Status

Product Commercialized by industry in Odisha and West Bengal

Techno-economics

Capital cost: Rs. 10 Lakh

Unit price: Rs. 400/litre

Technology Readiness Level (TRL)

TRL: 8

CAL002

DIP CLEANER CUM BRIGHTENER FOR GOLD AND DIAMOND

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 industry at Odisha

Techno-economics

Capital cost: Rs. 2 Lakh

Unit price: Rs. 300/litre

Technology Readiness Level (TRL)

TRL: 8

Salient Features

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

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

e) Assistance in setting up the plant on separate terms.

CAL003

DIP CLEANER/TARNISH REMOVER FOR SILVER

Salient Features

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

Environmental Consideration

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

Major Raw Materials

Sodium Carbonate, thiourea, surfactants

Major Plant Equipment/Machinery

Stirring unit

Technology Package

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

Uses

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

Scale of Development

100 litres/batch

Commercialization Status

Product Commercialized by industry

Techno-economics

Capital cost: Rs. 2 Lakh

Unit price: Rs. 250/litre

Technology Readiness Level (TRL)

TRL: 9

Uses

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

Scale of Development

Product is prepared on the scale of 50 liters

Commercialization Status

Ready for commercialization

Techno-economics

Rs. 300/litre

Technology Readiness Level (TRL)

TRL: 7

CAL004

ANTI-CORROSIVE CHEMICAL FOR STEEL SHEET, REBAR AND WIRE

Salient Features

An anti-corrosive chemical has been developed for the corrosion prevention of steel sheet, rebar and wire. The developed chemical has the following 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°C for 5 min
- Cured coated products at 250° C give golden and brown colors with 5 and 10 min curing time, respectively
- Cured product gives good lustre
- Coating forms a good adhesion on a surface
- Can also be applied on a surface using brush and spray

Environmental Consideration

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

Major Raw Materials

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

Major Plant Equipment/Machinery

Magnetic stirrer for mixing of chemicals, Container of 100 litres

Technology Package

a) Process-Know-how,

b) Details of equipment

c) Quality Assurance Methods.

d) Assistance in setting up the plant on separate terms.

CAL005

CYANIDE FREE PROCESS FOR LEACHING AND RECOVERY OF GOLD

Salient Features

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

Environmental Consideration

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

Major Raw Materials

Commercially available iodine chemicals, hydrogen peroxide

Major Plant Equipment/Machinery

Plastic tanks, filter unit, Centrifuge

Technology Package

a) Process know how

b) Details of equipment & machinery

c) Plant layout

d) Quality assurance methods.

e) Assistance in setting up of plant on separate terms.

Uses

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

Scale of Development

Pilot scale (100 liters/batch)

Commercialization Status

Process implemented in industry

Techno-economics

Capital cost: 10 lakhs

Chemical cost: As per scale of operation

Technology Readiness Level (TRL)

TRL:6

CAL006

CYANIDE FREE ALKALINE ELECTROLYTE AND ELECTROCHEMICAL PROCESS FOR RUST REMOVAL FROM PLAIN CARBON STEEL COMPONENTS

Uses

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

Scale of Development

Pilot scale (25 liters/batch)

Commercialization Status

Process implemented in industry

Techno-economics

- Capital cost: 10 lakhs
- Chemical cost: As per scale of operation

Technology Readiness Level (TRL)

TRL:6

Salient Features

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

Environmental Consideration

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

Major Raw Materials

Commercially available alkaline chemicals, sulfur containing chemicals.

Major Plant Equipment/Machinery

Rectifier, Plastic tanks, mixing unit

Technology Package

a) Process know how

b) Details of equipment & machinery

c) Plant layout

d) Quality assurance methods

e) Assistance in setting up of plant on separate terms.

CAL007

ZN-NI-CU COATINGS FOR ANTI-BACTERIAL AND FUEL TANK APPLICATIONS

Salient Features

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

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

Environmental Consideration

No significant environmental issues with the process or coatings

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

a) Detailed knowhow for the deposition of Zn-Ni-Cu coatings.

b) Demonstration at the scale of 30 cm x 20 cm scale.

c) CSIR-NML can help in Scaling up the process on request.

d) Assistance or guidance at different stages of process implementations and product evaluation on separate terms.

Without coated

Zn-Ni-Cu Coated Steel

Uses

Coated steel for : Anti-bacterial applications (ACs, Refrigerators, Windows, Air coolers), Automobile fuel tank.

Scale of Development

30 cm X 20 cm steel substrates

Commercialization Status

Ready for commercialization

Techno-economics

For current level, investment is only HVOF unit and then major raw materials. It will be around Rs. 20 Lakh

Technology Readiness Level (TRL)

TRL:5

CAL008

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^{o}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
- Stable up to 700-800^{o}C
- Good corrosion resistance: accelerated salt spray test showed no degradation for 900 hr exposure.

Uses

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

Scale of Development

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

Commercialization Status

Ready for commercialization

Techno-economics

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

Technology Readiness Level (TRL)

TRL:5

Environmental Consideration

No significant environmental issues

Major Raw Materials

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

Major Plant Equipment/Machinery

Magnetron sputtering system

Technology Package

a) Detailed knowhow of the deposition process including the target preparation.

b) Demonstration at the scale of 75mm x 75mm scale

c) CSIR-NML can help in Scaling up the process on request.

d) Assistance or guidance at different stages of process implementation and product evaluation (on separate terms)

CAL009

SELF-HEALING ANTICORROSIVE COATING FOR STEEL

Salient Features

The self-healing coating can be used for long term maintenance free corrosion protection of steel structures.

- Polymer based composite self-healing coating
- Autonomous self-healing is triggered in presence of water/moisture
- Coating passes 1000 hours of salt spray test after breakage of coating
- Adhesion strength: > 10 Mpa
- Hardness: 190 HB, Modulus: 4 Gpa

Environmental Consideration

No significant environmental issues

Major Raw Materials

Polymer resin, commercially available inorganic chemicals

Major Plant Equipment/Machinery

Ball mill, Blending unit

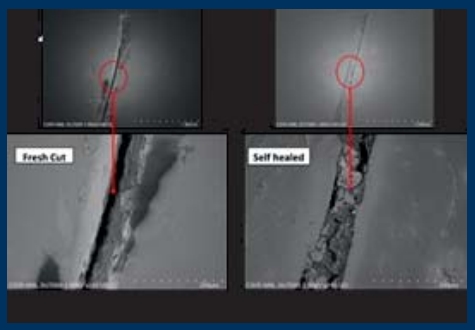
Technology Package

a) List of Chemicals

b) List of Equipment

c) Process flow sheet

d) Quality control procedure



Uses

- Autonomous self-healing triggered by water
- Can be applied by brushing or spraying
- Coating cures in ambient conditions in 24 hours
- Suitable for onsite application
- Scalable and Economical

Scale of Development

1 kg scale

Commercialization Status

Ready for commercialization

Techno-economics

Raw material cost: Rs. 450-500/liter

Processing cost: Rs. 50/liter

Coverage area of the coating: 140-160 sq. feet per liter

Technology Readiness Level (TRL)

TRL:4

CAL010

PROCESS TO CLEAR BALL JAM IN BALL PEN TIPS

Uses

- Clears the jam in ball pen tips
- Restores the shine and writing functionality of jammed tips
- Improves the corrosion resistance and performance of tips

Scale of Development

1 kg scale

Commercialization Status

Tested successfully on jammed tips at industry

Techno-economics

- Raw material cost – Rs. 250/liter
- Processing cost – Rs. 50/liter
- Surface coverage: 1 liter/1 kg of ball pen tips

Technology Readiness Level (TRL)

TRL:6

Salient Features

The jam in ball pen tips made of copper alloys due to corrosion can be cleared using the chemical treatment process to make the damaged tips functional. Chemical treatment of jammed ball pen tips made of copper alloys to clean the corrosion products and make the tips functional.

- The chemical treatment of the jammed ball pen tips is done in batch process to clear the jam and restore the tip functionality.
- The treatment process involves contacting the jammed ball pen tips with the treatment solution for duration of 1-2 minutes by dipping.
- The chemical treatment is done at ambient conditions in an ultrasonic bath.
- The chemical treatment removes the corrosion products around the jammed ball and form a conversion coating of less than 10 nm thickness on the tip surface to protect it from further corrosion.
- The chemical treatment process improves the appearance of the tips and does not alter the writing performance of the ball pen tips.
- The process is scalable and economical

Environmental Consideration

No significant environmental issues

Major Raw Materials

Commercially available chemicals

Major Plant Equipment/Machinery

Tank, Ultrasonic bath

Technology Package

a) List of Chemicals

b) List of Equipment

c) Process flow sheet

d) Quality control procedure

CAL011

PROCESS TO IMPROVE CORROSION RESISTANCE OF STEEL REBAR

Salient Features

Rusting of steel rebar during transport and storage is prevented through chemical treatment process.

- The chemical treatment can be done offline or online in rebar production line.
- The treatment process involves contacting the rebar surface with the treatment solution for duration of 1-2 seconds by spraying or dipping.
- The chemical treatment can be done at ambient conditions or at elevated temperatures of up to 600 °C.
- The chemical treatment results in formation of an invisible conversion coating of less than 1 µm on the rebar surface.
- The chemical treatment process does not impact the bond strength of rebar with concrete.
- The process is scalable and economical

Environmental Consideration

No environmental issues are involved in this technology

Major Raw Materials

Commercially available chemicals

Major Plant Equipment/Machinery

Reactor, Mixer, Filter

Technology Package

a) List of Chemicals

b) List of Equipment

c) Process flow sheet

d) Quality control procedure

Uses

- Prevents rusting of rebar during transport and storage
- Improves customer acceptance of rebar
- Improves life of concrete

Scale of Development

10 Kg.

Commercialization Status

Ready for commercialization.

Techno-economics

- Raw material cost – Rs. 40/liter
- Processing cost – Rs. 10/liter
- Surface coverage: 2 liter/1 ton of 10 mm rebar.

Technology Readiness Level (TRL)

TRL:6

ISM001

CERTIFIED REFERENCE MATERIALS

Salient Features

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

Environmental Consideration

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

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

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

Uses

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

Scale of Development

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

Commercialization Status

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

Techno-economics

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

Technology Readiness Level (TRL)

TRL:8

ISM002

EROSION RESISTANT STEEL

Salient Features

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

Environmental Consideration

Not Applicable

Major Raw Materials

Low carbon steel scrap, low carbon ferro alloys

Major Plant Equipment/Machinery

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

Technology Package

a) Process-Know-how

b) Details of equipment

c) Plant Layout

d) Quality Assurance Method

e) Assistance in setting up the plant on separate terms.

After Casting

After 90 days trial at the hydel power plant

Uses

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

Scale of Development

40 kg in lab scale; component of ~100kg was prepared in actual and was tested at 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 Lakh

Technology Readiness Level (TRL)

TRL:5

ISM003

GRAPHENE COATED STEEL

Salient Features

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

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 % H2, steel and quartz substrates.

Technology Package

a) Process-Know-how,

b) Details of equipment &

c) Quality Assurance Methods.

d) 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 industry.

Commercialization Status

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

Techno-economics

Rs.10-20 for A4 size substrate

Technology Readiness Level (TRL)

TRL:5

ISM004

SYNTHETIC FLUX AND A PROCESS FOR DE-PHOSPHORIZATION OF STEEL IN INDUCTION FURNACE

Salient Features

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

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

Environmental Consideration

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

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

Includes

a) Process Know-How

b) Quality Assurance Methods

c) Assistance in setting up the flux making plant on separate terms

Uses

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

Scale of Development

(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.

Technology Readiness Level (TRL)

TRL:7

ISM005

FERROSILICON FROM BHQ, BHJ & LOW REACTIVE COAL

Uses

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

Scale of Development

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

Commercialization Status

Ready for commercialization

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6

Salient Features

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

Environmental Consideration

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

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

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

ISM006

PRODUCTION OF DIRECTLY REDUCED IRON (DRI)

Salient Features

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

Environmental Consideration

(I) Environmental friendly as generation of coal char is only 100-150 kg per ton of DRI

(ii) No liquid effluent generated.

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

a) Know-How

b) Complete flow-sheet with mass balance

c) Equipment details, process description, product specification

d) Assistance in setting up the plant as per organization terms and conditions

Uses

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

Scale of Development

Laboratory scale: 1 to 5 kg

Commercialization Status

Ready for commercialization

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6

ISM007

HIGHLY METALLISED LOW SULPHUR DIRECTLY REDUCED IRON (DRI) FROM IRON ORE SLIME AND REJECTED/MIDDLING COAL

Salient Features

The process utilizes ~100% waste raw materials to yield a value added product. This invention is useful for converting steel plant wastes 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. The DRI produced from these waste raw materials is suitable as a substitute of scrap for induction furnace, electric arc furnace and basic oxygen furnace for steel making.

Environmental Consideration

Less than conventional DRI processes

Major Raw Materials

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

Major Plant Equipment/Machinery

Tunnel kiln, saggers, pelletizer etc.

Technology Package

a) Process Know-how

b) Details of equipment

c) Plant Layout and

d) Assistance in setting up the plant as per CSIR-NML norms

Uses

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

Scale of Development

Commercial Tunnel Kiln: 12 to 18 TPD

Commercialization Status

Ready for commercialization

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6

ISM008

PROCESS FOR PRODUCTION OF HIGHLY METALLISED DIRECTLY REDUCED IRON CYLINDERS (DRIC) FROM LEAN GRADE RAW MATERIALS

Salient Features

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

Environmental Consideration

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

Major Raw Materials

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

Major Plant Equipment/Machinery

Tunnel Kiln, saggars/crucibles, pressing machine etc.

Technology Package

a) Process-Know-How

b) Details of equipment

c) Plant layout

d) Quality assurance methods and

e) Assistance in setting up the plants as per CSIR-NML norms

Uses

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

Scale of Development

Laboratory scale: 4 to 6 kg

Commercialization Status

Ready for commercialization

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6

ISM009

HIGHLY METALLISED DIRECTLY REDUCED IRON (DRI) FROM MILL SCALE AND LEAN GRADE NON COKING COAL IN TUNNEL KILN

Uses

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

Scale of Development

Pilot Plant in Commercial Tunnel Kiln: 18 TPD

Commercialization Status

Transferred to industry and available for implementation to user industries.

Techno-economics

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

Technology Readiness Level (TRL)

TRL:9

Salient Features

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

Environmental Consideration

Negligible compared to the conventional process of DRI making.

Major Raw Materials

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

Major Plant Equipment/Machinery

Tunnel kiln, Saggers, Ball Mill, Pelletizer etc.

Technology Package

a) Process Know-how

b) Details of equipment

c) Plant Layout and

d) Assistance in setting up the plant as per CSIR-NML norms

ISM010

COLD BONDED CARBON COMPOSITE PELLETS FOR UTILIZATION OF IRON ORE MICRO-FINES AND CARBON BEARING FINES

Salient Features

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

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

Uses

Iron and Steel industries

Scale of Development

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

Commercialization Status

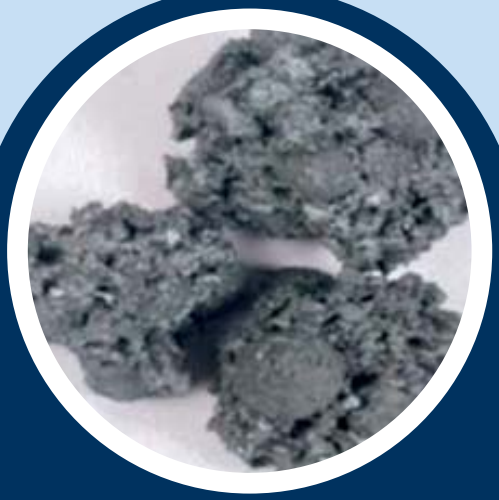
Up-scaling is required

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6



Uses

Iron Making

Scale of Development

12 kg/batch

Commercialization Status

Up-scaling is required

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6

ISM011

PELLET-SINTER COMPOSITE AGGLOMERATE (PSCA) OF IRON OXIDE FINES FOR USE IN BLAST FURNACE

Salient Features

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

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

Environmental Consideration

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

Major Raw Materials

Iron ore fines, LD Sludge, BF-Blue Dust

Major Plant Equipment/Machinery

Pelletizer, Conventional sintering facility, charging system

Technology Package

a) Process-Know-how,

b) Details of equipment

c) Quality Assurance Methods

d) Assistance in up-scaling and setting up the plant on separate terms.

ISM012

FLUXED SINTER THROUGH MICRO-PELLETIZATION

Salient Features

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

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

Environmental Consideration

No harmful/hazardous effect on environment

Major Raw Materials

LD Sludge, BF-Blue Dust and Lime Fines

Major Plant Equipment/Machinery

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

Technology Package

a) Process flowchart and details,

b) Details of equipment

c) Quality Assurance Methods

d) Assistance in up-scaling and setting up the plant on separate terms.

Uses

Iron and steel making

Scale of Development

10 kg / batch

Commercialization Status

Up-scaling is required

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6

ISM013

BRIQUETTING OF ORE FINES

Salient Features

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

Environmental Consideration

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

Major Raw Materials

Ore fines, Binder, Fluxes, Metallurgical Wastes

Major Plant Equipment/Machinery

Mixing unit, Briquetting Machine

Technology Package

a) Process knowhow

b) Assistance in setting up the plant on separate terms.

Uses

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

Scale of Development

500 kg/day; Scale-up is possible

Commercialization Status

Ready for commercialization

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL:6

ISM014

KNOW-HOW FOR PREPARATION OF HYDROGEN STANDARD (CRM) IN STEEL

Salient Features

Availability of certified reference material (CRM) for determination of hydrogen in steel by hot fusion technique is cumbersome in terms of both cost and time, as it is an imported product to India. CSIR-NML has successfully developed an indigenous hydrogen standard (CRM) in steel. The uncertainty in the developed product has been protected better than the available market by adopting suitable techniques during the standard sample preparation process.

- Cautious selection of raw material considering the metallurgical aspects
- Improved uncertainty and stability
- Controlled heat treatment practice to achieve the desired hydrogen level
- Ni coating to improve the luster as well as the shelf life
- Product developed as per ISO Guide 17034: 2016
- 15 numbers of lab participated in round robin/inter lab (RRT) test

Environmental Consideration

This is a green technology. No damage to the environment.

Major Raw Materials

304 stainless steel and 410 stain steel plates/wires

Major Plant Equipment/Machinery

i) Unidirectional heating annealing furnace for hydrogen diffuse annealing heat treatment

ii) Cutting machine (wire to pin sample cutter or EDM cutter to draw pin samples from plates)

iii) Surface cleaning and Ni coating unit

Technology Package

a) Steel grade selection guide

b) Heat treatment and coating practices and related process parameters

c) Process flow sheet

Uses

- Indigenous development of Certified Reference Material (CRM) for gases (Hydrogen) in steels as an import substitution (Make in India)
- ≈50% reduced cost than imported product

Scale of Development

100 bottles (100 pins/bottle)

Commercial scale

Commercialization Status

Ready for commercialization

Techno-economics

Raw material cost: Rs. 250 – 350 /kg of SS

Processing cost: Rs. 25,000 /batch of heat treatment

Sample preparation cost: From wire: capital investment of wire cutter Rs. 5 lakhs

From plate: Rs. 60 /pin sample through EDM cutter

Coating cost: Rs 5 /pin sample

RRT and Certification: Rs 1.5 lakhs

Technology Readiness Level (TRL)

TRL:8

DPI001

WIDE METALLIC GLASS RIBBON PROCESSING UNIT

Salient Features

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

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

Environmental Consideration

No hazardous gas emitted.

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

a) Equipment details,

b) Process description,

c) Cost estimation

d) product specification.

e) Assistance in setting up the plant on separate terms.

Uses

Rapidly solidified material processing unit for

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

Scale of Development

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

Commercialization Status

Licensed for manufacturing to industry on non-exclusive basis.

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6

DPI002

MAGSTAR: A PORTABLE MAGNETIC HYSTERESIS AND BARKHAUSEN EMISSIONS BASED ELECTROMAGNETIC DEVICE FOR NON-DESTRUCTIVE EVALUATION OF STEEL STRUCTURE/COMPONENT

Salient Features

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

Magnetic Hysteresis Loop (MHL) measurement

Frequency Range	:	20mHz to 200mHz
Excitation	:	0-1500 Oe
Wave Shape	:	Sinusoidal / Triangular

Magnetic Barkhausen Emission (MBE) measurement

Frequency Range	:	10Hz to 200 Hz
Excitation	:	Up to 1500 Oe
Number of Cycles	:	3 to 10
Gain	:	0 - 20 dB (in steps of 1 dB)

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

Power Requirement	:	230V, 50Hz, 200VA
Weight	:	3.25Kg
Control, Display and Analysis	:	External laptop/notebook/ PC

Environmental Consideration

Not Applicable

Major Raw Materials

Electronic components, Soft magnetic core materials

Major Plant Equipment/Machinery

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

Technology Package

a) Details of equipment,

b) Operating Manual and

c) Quality Assurance Methods.

Uses

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

Scale of Development

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

Commercialization Status

Licensed for manufacturing to industry non-exclusive basis. Device has been procured by industry, R&D units and Academia.

Techno-economics

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

Technology Readiness Level (TRL)

TRL:8

DPI003

MAGSYS: A PORTABLE GIANT MAGNETO-IMPEDANCE (GMI) BASED MAGNETIC SENSING DEVICE FOR NDE APPLICATIONS

Uses

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

Scale of Development

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

Commercialization Status

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

Techno-economics

Cost: Rs. 15 Lakh/unit Including sensor

Technology Readiness Level (TRL)

TRL:7

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 : 2 kg
- Control, Display and Analysis: External laptop / notebook/ PC

Environmental Consideration

Not applicable

Major Raw Materials

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

c) Quality Assurance Methods

d) Nanostructured GMI wire to be supplied by NML along with the technology package.

DPI004

FLAWGUARD: A COST EFFECTIVE DEVICE FOR DEFECT DETECTION IN WIRES DURING COLD DRAWING

Salient Features

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

- Test material diameter: 1.5 mm – 13 mm
- Operating frequency: 10 – 250 kHz
- Depth Resolution: 100 µm
- Drawing line speed: up to 12 m/s
- LCD display
- Alarm: LED & Buzzer
- Graphical representation, data logging and post processing
- Defect characterization: defect location and severity
- Real time data in ASCII format
- Interfacing through LAN
- Customized software for smart monitoring & control, real time data through IOT, SMS & E-mail facility
- Standalone as well as laptop based.
- Power Requirement: 220V/50Hz
- Weight: 1.5 kg; Dimension: 300 x 300 x 100 (all in mm)

Environmental Consideration

Not applicable

Major Raw Materials

Electronic components, enameled copper wire, cables and accessories

Major Plant Equipment/Machinery

Sensing probe, power source, data acquisition & analysis software

Technology Package

a) Process-Know-how,

b) Details of equipment

c) Quality Assurance Method

d) 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, implemented at one of the biggest wire mills in India

Commercialization Status

Ready for commercialization

Techno-economics

Capital Cost: Approximately Rs. 7 Lakh

Technology Readiness Level (TRL)

TRL:7

DPI005

ULTRA-B: A PORTABLE NONLINEAR ULTRASONIC DEVICE

Uses

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

Scale of Development

Portable device is ready

Commercialization Status

Ready for commercialization

Techno-economics

Capital Cost:- Rs. 35Lakh

Technology Readiness Level (TRL)

TRL:6

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)

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

DPI006

ULTRASONIC FLOW GAUGE: A DEVICE FOR FLUID FLOW RATE MEASUREMENT THROUGH A NARROW TUBE

Salient Features

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

Environmental Consideration

NA

Major Raw Materials

Electronic items

Major Plant Equipment/Machinery

NA

Technology Package

a) Process-Know-how

b) Details of equipment

c) Software

d) Assistance in setting up the plant on separate terms

Uses

- Onboardpropellant gauging of space craft
- as a gas flow meter
- as a liquid flow meter

Scale of Development

Prototype Developed

Commercialization Status

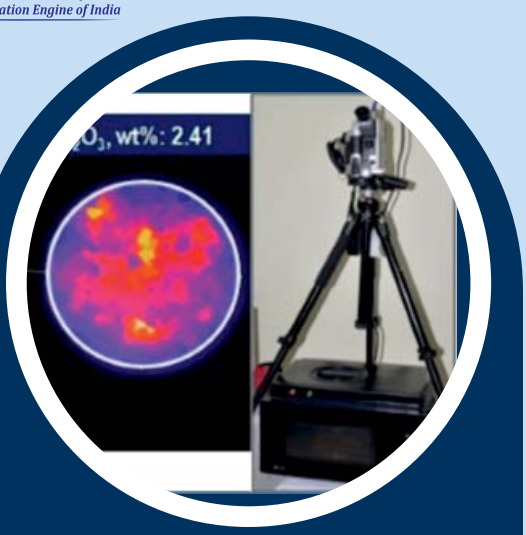
Technology transferred

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL:6



DPI007

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 °C
- Microwave power: 650 - 700 Watt
- Iron ore size:-10mm
- Time of estimation: 30s

Uses

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

Scale of Development

Fully Developed

Commercialization Status

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

Techno-economics

Capital Cost:- Rs. 5 Lakh

Technology Readiness Level (TRL)

TRL:6

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) Software

d) Assistance in setting up the plant on separate terms

DPI008

PABI: PORTABLE AUTOMATED BALL INDENTATION SYSTEM

Salient Features

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

Environmental Consideration

Not applicable

Major Plant Equipment/Machinery

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

Technology Package

a) Details of equipment,

b) Operating Manual,

c) Quality Assurance Methods,

d) Training

e) Data for validating the systems

Uses

To evaluate key mechanical properties of metallic components/ materials

Scale of Development

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

Commercialization Status

Commercialized by Industry

Techno-economics

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

Technology Readiness Level (TRL)

TRL:7

DPI009

ANNEALING SIMULATOR DEVICE

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 industry

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6

Salient Features

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

Annealing Parameter

Temperature	:	1000°C Maximum
Slowest Heating rate	:	10°C/hr
Highest Heating rate	:	500°C/min or Higher
Annealing environment	:	H_2 & N_2 mixture, N_2, or any other gas
Cooling rate	:	200°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/ PC

Environmental Consideration

Not Applicable

Major Raw Materials

NA

Major Plant Equipment/Machinery

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

Technology Package

a) Details of equipment,

b) Operating Manual

c) Application notes

d) Operating Training

DPI010

ENERGY EFFICIENT COKE BASED BRASS AND BELL METAL MELTING FURNACE

Salient Features

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

The features of the developed furnace are:

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

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

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 industries in Uttar Pradesh, Odisha

Techno-economics

Cost of the new furnace is marginally higher, which can be recouped with in 30 days of operation.

Technology Readiness Level (TRL)

TRL:8

DPI011

"CLOSED LOOP CORROSION TEST RIG" EQUIPMENT FOR FLOW ASSISTED CORROSION STUDY

Uses

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

Scale of Development

Already equipment is fabricated and tested for performance and ready for demonstration

Commercialization Status

Ready for commercialization

Techno-economics

Available on request.

Technology Readiness Level (TRL)

TRL:5

Salient Features

"Closed loop corrosion test rig" is indigenously designed by CSIR-NML for the first time. Equipment has the facility to control and monitor dissolved oxygen (50-5000ppb), flow rate and temperature (10 to 50 degree centrigade) the media during experiment. Provision for extra sensors for monitoring other parameters. Equipment is attached with two type of test rig for metallic coupon exposure as well as electrochemical studies using on line potentiostat under flow condition. Flow media: water, sea water and oil.

Environmental Consideration

No significant environmental issues

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

a) Complete equipment design and performance demonstration.

b) As it is new equipment so initial phase NML will help the license in design modification and discussion as per customer need on separate terms

DPI012

ZINCOMETER: A SENSING DEVICE FOR REAL-TIME ZINC COATING WEIGHT MEASUREMENT OF STEEL WIRES IN THE GALVANISED LINE

Salient Features

The Zincometer is an encircling coil based technology for real-time Zinc coating weight measurement of moving wires in the commercial pad wiping (thin) as well as nitrogen wiping (thick) galvanized lines. It is a low cost, Make-In-India device which can assure uniform coating weight across the length of wire in the production line. This sensing device is applicable for wire diameters ranging from 1.6 mm to 13 mm with ± 5-10 GSM variation. The entire system is coupled with data processing, feed forward control mechanism along with real time data saving option.

Environmental Consideration

No significant environmental issues

Major Raw Materials

Electronic device components (BOM will be supplied)

Major Plant Equipment/Machinery

No major plant equipment is required

Technology Package

a) Complete equipment design and performance demonstration.

b) As it is new equipment so initial phase NML will help the license in design modification and discussion as per customer need on separate terms.

Uses

Zincometer is an indigenously developed device for real time zinc coating weight measurement of steel wires in the pad wipping as well as Nitrogen wipping galvanized lines

Scale of Development

Technology has been completely developed, performance evaluated, implemented at one of the renowned wire mills in India

Commercialization Status

Ready for commercialization

Techno-economics

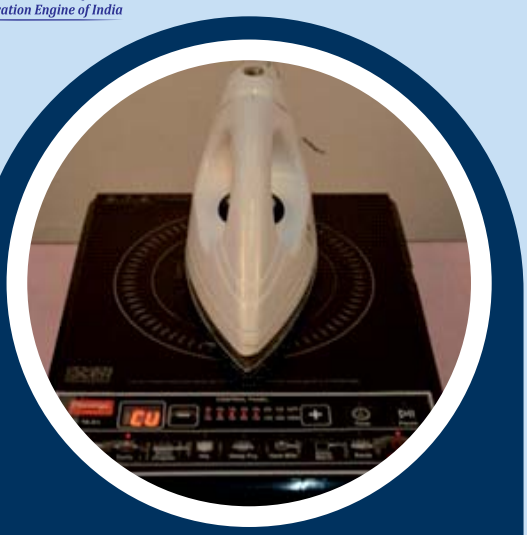
Available on request.

Technology Readiness Level (TRL)

TRL:7

DPI013

INDUCTION ACTIVE SOLE PLATE FOR IRON PRESS



Uses

Energy saving

Scale of Development

Prototype has been made

Commercialization Status

Ready for commercialization

Techno-economics

Sole plate cost ~ 100 / piece (machine cost is not considered)

Technology Readiness Level (TRL)

TRL:7

Salient Features

The developed sandwiched sole plate has the following features;

- 3 mm thick Al plate (non-ferrous) can be used at the bottom of the sandwiched plate, which is unique in the design
- Heat retention capacity is high, heat loss < $5^{o}C$ /min
- ~50 % energy saving compared to electro-heating iron press

Environmental Consideration

No significant effect on environment.

Major Raw Materials

Steel 304 series, Al plate, High heat capacity metal oxide powder

Major Plant Equipment/Machinery

Plate cutting machine

Technology Package

a) Process-Know-how

b) Details of construction

c) Quality Assurance Methods.

DPI014

FOBOP: FIBRE OPTIC BASED BREAK OUT PREDICTION TECHNOLOGY FOR BILLET CASTER

Salient Features

The present technology offers a real-time, temperature sensing system for monitoring the cold face temperature of a billet mould along its length and to predict breakout in a live billet caster well in advance. This technology uses Fibre Bragg Grating (FBG) as a temperature sensor. Multiple sensors were written on a single optical fibre and embedded along the length of a billet mould. The "interrogation" of these sensors allowed for temperatures to be obtained along the length of the mould from a single strand of the optical fibre. In addition to the development of the packaged FBG sensor array, its installation in the harsh conditions (high temperature, high pressure, restricted space) of an operating caster has called for considerable engineering ingenuity. This too has been successfully accomplished. Technology has already been implemented at one of the casters in a renowned steel industry and break out has been successfully detected in one strand in a live caster. FOBOP consists

I. Array of 5 FBG sensors in an optical fibre

ii. Proper encapsulation of fibre with array of FBGs

iii. Machining of the mould as the design

iv. Installation of encapsulated fibre on the machined Cu-mould

v. Test of output signals from the sensors on fixing of the mould in the caster.

vi. Software for analyzing data to detect breakout and trigger for prevention.

Environmental Consideration

No significant effect on environment.

Major Raw Materials

Optical fibre, Interrogator, Splicer, Various connectors, DAQ, Fibre with FBGs

Major Plant Equipment/Machinery

Billet Mould

Technology Package

a) Process-Know-how

b) Details of construction

c) Quality Assurance Methods.

Uses

Preventive action can be taken to avoid break out to happen in a billet caster. This technology will help to avoid long outages, which involve laborious equipment cleaning with lancing and gas cutting and/or change of mould assembly/segments all together in a caster.

Scale of Development

Commercially deployed in Industry

Commercialization Status

Ready for commercialization. Technology Transferred to Industry.

Techno-economics

Available on request.

Technology Readiness Level (TRL)

TRL:8

DPI015

MAGNETOIMPEDANCE (MI) BASED ARRAY SENSING DEVICE FOR DETECTION OF CARBURISATION AND DEFECTIVE WELDS: MAGRAYS

Uses

- It is light weight
- Battery operated
- Array of sensors provide larger foot print
- Can be remotely controlled

Scale of Development

Successfully transferred to industry

Commercialization Status

Ready for commercialization. Technology Transferred to industry.

Techno-economics

Cost per unit Device

Device cost: ₹ 10,00,000

Sensor material: ₹ 30,000

Technology Readiness Level (TRL)

TRL:7

Salient Features

Giant Magneto-impedance based array sensor for detection of carburization in austenitic steels/components used in petrochemical refinery units.

Display and data logging includes

- Frequency, Current can be altered
- Each of 16 element sensor output
- Average value sensor output
- Desired locations can be scanned

Environmental Consideration

No significant effect on environment.

Major Raw Materials

Electronic components, Nanostructured ferromagnetic wires

Major Plant Equipment/Machinery

Sensing probe, Unit comprising of electronic circuit, power source and display system

Technology Package

a) Process-Know-how

b) Details of construction

c) Device

INW001

GEOPOLYMER CEMENT

Salient Features

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

- Meet the properties of Portland pozzolana cement as mentioned in IS 1489: 1991
- These cements are ~10% more durable than OPC and are fire resistant upto 900^{o}C
- Uses ambient temperature synthesis and generates 70% less CO_2 than Portland cement

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

Uses

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

Scale of Development

Pilot Scale at 5 tons/day capacity

Commercialization Status

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

Techno-economics

Minimum viable plant size: 100 tons/day

Capital cost: Rs. 120 Lakh (Excluding land and building)

Cost of product: Rs. 5000/ ton

Technology Readiness Level (TRL)

TRL:8

Uses

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

Scale of Development

10 tons/day

Commercialization Status

Technology transferred and commercialized.

Techno-economics

Minimum viable plant size: 50 tons/day

Capital cost: Rs. 50 Lakh (Excluding land and building)

Cost of product: Rs. 400/ square meter

Technology Readiness Level (TRL)

TRL:8

INW002

PAVING BLOCKS FROM FLY ASH, BLAST FURNACE SLAG, STEEL SLAG, ETC

Salient Features

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

- Meets IS 15658:2006 specification
- Can be produced in different shapes and sizes with properties equivalent to M15 – M35 grade concrete.
- Uses ambient temperature synthesis and generates 30% less
- CO_2, 35% low embodied energy than conventional equivalent product

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.

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

a) Process-Know-how,

b) Details of equipment,

c) Plant Layout,

d) Quality Assurance Methods

e) Assistance in setting up the plant on separate terms.

INW003

YELLOW TUNGSTEN OXIDE (YTO) AND TUNGSTEN(W) METAL POWDER FROM W-CARBIDE/ALLOY SCRAPS

Salient Features

Recovery of high pure products (YTO, W-metal powders & other metal salts/powders) from waste/end-of-life W-Carbide(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 ~ 40% less than the conventional process.

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 1 kg/batch scale

Commercialization Status

The process has been licensed to industries.

Techno-economics

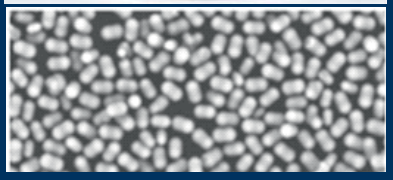
For a 5MT/month capacity plant; Capital 85.0 Lakh (excluding land & shed) & Recurring Expenditure Rs. 18.0 Lakh/month (excluding scrap cost).

Technology Readiness Level (TRL)

TRL:9

INW004

FERRITE AND PIGMENT GRADE HIGH PURITY MONODISPERSED IRON OXIDE FROM WASTE CHLORIDE PICKLE LIQUOR AND OTHER IRON RICH SOURCES



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 Piloted on 50 kg Scale

Commercialization Status

Transferred to two industries

Techno-economics

Preliminary techno-economics Available on request

Technology Readiness Level (TRL)

TRL:8

Salient Features

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

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

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

Environmental Consideration

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

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

a) Process-Know-how,

b) Details of equipment

c) Plant Layout

d) Quality Assurance Methods

e) Assistance in setting up the plant on separate terms.

INW005

RECOVERY OF LEAD FROM ZINC PLANT RESIDUE

Salient Features

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

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

Environmental Consideration

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

Major Raw Materials

Secondary zinc plant residue, other lead containing residue

Major Plant Equipment/Machinery

Leaching reactor, filter press, storage tanks, transfer pumps

Technology Package

a) Process know-how, complete flow-sheet with mass balance, equipment details, process description, equipment flow-diagram, cost estimate, product specification Plant Layout

b) Quality assurance methods

c) 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 on 1 Kg scale

Commercialization Status

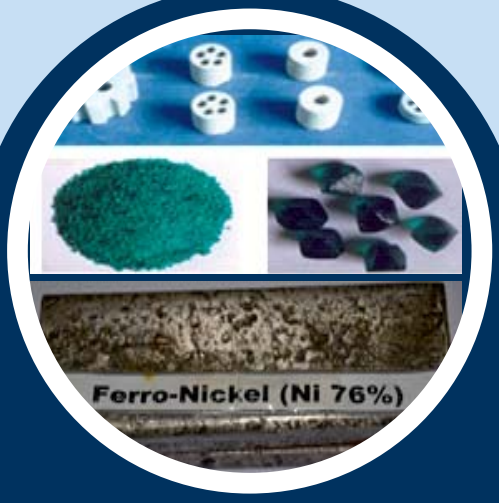
Demonstrated and Transferred to overseas company

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL:7



INW006

RECOVERY OF NICKEL FROM SPENT NICKEL CATALYST

Uses

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

Scale of Development

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

Commercialization Status

Sulphate process developed and demonstrated on 1 kg scale and transferred to a overseas company

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL:6

Salient Features

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

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

Environmental Consideration

Only 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. Mill scale (iron oxide), coke etc

Major Plant Equipment/Machinery

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

Grinding and palletizing facility, Smelting furnace.

Technology Package

a) Process-Know-how

b) Mass Balance

c) etails of equipment

d) Plant Layout and

e) Quality Assurance Methods.

INW007

PRODUCTION OF FE-NI/CO-MO METALLIC ALLOY & SALEABLE ALUMINA RICH SLAG FROM NI-MO/CO-MO SPENT CATALYSTS

Salient Features

CSIR-NML has developed a pyro-metallurgical based carbothermic reduction process route to treat roasted spent catalyst (containing 12-16 % MoO_3, 2-3 % NiO, 0.5-1.0% CoO, 50-55 % Al_2O_3 and minor amount of S, P) to produce a saleable Fe-Mo-Ni/Co alloy for making special grades of steels and alumina rich slag to be useable as building/ refractory material in an electric arc furnace.

Treating one MT of spent catalyst with reductant produced 300 kg of Fe-Mo-Ni/co alloy and 1200 kg of Calcia-alumina slag. Final Fe-Mo-Ni/Co alloy has 21-24% Mo, 10-12% Ni, 1.5-2.5 % Co, 0.08-0.12% P, 0.09- 0.15% S, 0.18 - 0.20 C, 65-69% Fe. Slag has chemical composition as 50-55% Al_2O_3, 35-40% CaO, 2-3% FeO, 0.1-0.2% Mo, 0.02-0.06% Ni, 0.01-0.02% Co, 0.1-0.2% S, 0.00- 0.002% P.

Environmental Consideration

Economic recovery of strategic metals like Ni, Co and Mo from spent refinery catalysts. The slag generated is non-toxic and will be completely used as construction material.

Major Raw Materials

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

Major Plant Equipment/Machinery

Grinding and pelletizing facility, Electric arc reduction smelting furnace.

Technology Package

a) Process-Know-how

b) Details of equipment

c) Plant Layout

d) quality assurance methods

e) Assistance in setting up the plant on separate terms and condition

Uses

The main use of Fe-Ni/Co-Mo alloy in the manufacture of special grade alloy steels and calcium aluminate slag as raw material for building/ceramic material production.

Scale of Development

Developed on 100 kg spent catalyst smelting per batch

Commercialization Status

Ready for transfer and commercialization

Techno-economics

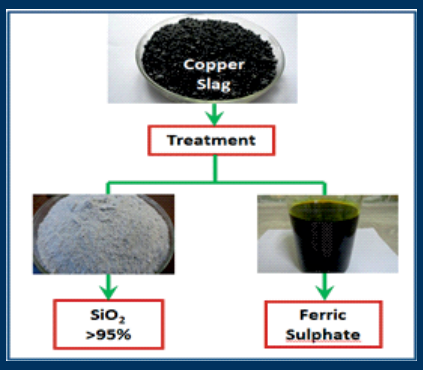
Available on request.

Technology Readiness Level (TRL)

TRL:6

INW008

PRODUCTION OF FERRIC/FERROUS SULPHATE AND SILICA POWDER FROM COPPER SLAG



Uses

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

Scale of Development

Developed on Kilogram scale.

Commercialization Status

Demonstrated and Transferred for commercialization to industry.

Techno-economics

Available on request

Technology Readiness Level (TRL)

TRL:5

Salient Features

About 2.2 ton of waste copper slag is generated for every tonne of copper produced which is currently being dumped near the plant site. CSIR-NML developed a very unique process by which the slag is converted to two commercial products such as ferric/ferrous sulphate and silica powder.

About 5 kL of ~35% ferric sulphate solution and ~300 kg SiO_2 powder is produced for every tone of slag treated. Ferric sulphate is an important ingredient for arsenic removal from toxic waste stream of copper industries and silica produced from the process is useful for phosphoric acid plant. Implementation of the process will not only take care of environmental norms but also will make the industry independent on availability of chemicals for critical operation of treating effluents.

Environmental Consideration

The process does not generate any solid or liquid effluent.

Major Raw Materials

Copper slag, sulphuric acid

Major Plant Equipment/Machinery

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

Technology Package

Technology is available for transfer with details of process description, operating parameters, equipment list with specification, mass balance, preliminary cost estimation etc

INW009

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

d) Assistance in setting up the plant on separate terms.

Uses

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

Scale of Development

1 Kg to 10 Kg (Lab Scale)

Commercialization Status

Transferred to industry.

Techno-economics

Capital Cost ~ 20 Lakh

Recurring Cost ~ 02 Lakh/ Year

Technology Readiness Level (TRL)

TRL:6

Uses

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

Scale of Development

100g to 5 Kg (Lab Scale)

Commercialization Status

Ready for commercialization

Techno-economics

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

Technology Readiness Level (TRL)

TRL:6

INW010

RECOVERY OF COBALT FROM DISCARDED LI-ION BATTERIES OF MOBILE PHONE

Salient Features

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

Environmental Consideration

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

Major Raw Materials

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

Major Plant Equipment/Machinery

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

Technology Package

a) Process-Know-how

b) Details of equipment

c) Quality Assurance Methods

d) Assistance in setting up the plant on separate terms.

NW011

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

d) Assistance in setting up the plant on separate terms.

Uses

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

Scale of Development

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

Commercialization Status

Ready for commercialization

Techno-economics

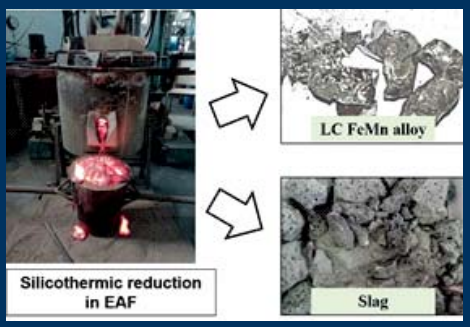
Capital Cost ~ 20 Lakh
Recurring Cost ~ 02 Lakh/ Year

Technology Readiness Level (TRL)

TRL:6

INW012

ENERGY EFFICIENT PRODUCTION OF LOW/MEDIUM CARBON FERROMANGANESE



Uses

Coke fines generated in coke processing can be used for roasting of manganese ore Off-gas from a SiMn furnace may be used for heating the rotary kiln

Scale of Development

100 Kg

Commercialization Status

Ready for commercialization

Techno-economics

To produce 1 ton LC-FeMn

Raw materials cost: ₹ 90000

Energy and overhead: ₹ 25000

Technology Readiness Level (TRL)

TRL:7

Salient Features

This process manufactures the low carbon and medium carbon ferro manganese in an electric arc furnace melting and reduction of charge mix occur simultaneously. The roasted manganese ore in this process is made to react with silico manganese alloy acting as reductant.

- Carbothermic roasting of manganese ore ensures reduction of higher manganese oxides into lower manganese oxide, and iron oxide to metal iron
- Simultaneous charging of roasted manganese ore, flux and silicomanganese in EAF
- Very fast metallothermic reactions inside EAF complete within 5-20 min
- Tap-to-tap high throughput volume
- IS grade specification of low-/medium-carbon ferromanganese can be achieved

Environmental Consideration

As per Government rules for ferroalloy industry.

Major Raw Materials

Manganese ore, lime and silicomanganese.

Major Plant Equipment/Machinery

Crusher, rotary kiln, electric arc furnace

Technology Package

a) Process know-how

b) List of equipment

c) Demonstration

INW013

CONVERSION OF HEMATITE FINES TO MAGNETITE USING COMPRESSED NATURAL GAS (CNG)

Salient Features

Conversion of hematite fines to magnetite using Compressed Natural Gas (CNG) Will be used in for heavy media separation in coal washeries. Heavy media separation material in coal industries will save huge amount of money for import of the material.

- Salient Technical Features are as follows:
- Magnetite content more than 90%
- All Particle size is less than 100 micron
- 90% of the particle size is less than 45 micron
- Magnetic saturation is more than 75 emu/gm

Environmental Consideration

No significant damage to environment.

Major Raw Materials

Hematite fines available in iron and steel industries as by product/ waste product.

Major Plant Equipment/Machinery

Reduction Unit and Cooling unit

Technology Package

a) List of Raw Materials

b) List of Equipment

c) Process flow sheet

d) Quality control procedure

Uses

- Steel Plant waste can be utilized
- Highly beneficial for coal, iron and steel industries

Scale of Development

10 Kg

Commercialization Status

Ready for commercialization

Techno-economics

Raw material cost: Rs. 5000/ton

Processing cost: Rs. 3000/ton

Technology Readiness Level (TRL)

TRL:5

INW014

RECOVERY OF VANADIUM AS AMMONIUM METAVANADATE AND VANADIUM PENTAOXIDE FROM SPENT SULFURIC ACID CATALYSTS

Uses

Technology can save landfill costs for this hazardous waste and earn green certifications apart from monetary benefits of producing this high cost strategic element in most desired marketable form.

Scale of Development

25 Kg

Commercialization Status

Ready for commercialization

Techno-economics

Available for 1ton catalyst processing per day

Technology Readiness Level (TRL)

TRL:7

Salient Features

>98-99% pure vanadium as ammonium metavanadate (AMV) and vanadium pentaoxide (V_2O_5), with <0.9% impurity as per international high pure grade specifications. Commercial value of 128USD/lb for AMV and 380USD/lb for V_2O_5. With acid leaching using 20-30% solids, 96-98% V could be extracted. The leach liquor was subjected to selective sequential precipitation route to extract 98.6% pure vanadium as ammonium metavanadate and >99% pure as vanadium pentaoxide (V_2O_5). High pure silica is a derivative product of the process.

- Low cost acid leaching and low temperature process
- Easily replicable on large scale
- Closed loop recycling of reagents
- Low Incubation time and high returns
- High pure (>98%) vanadium product(s) like AMV, SODIUM VANADATE
- 99.98% pure V_2O_5
- High pure (>99%) silica is a by-product

Environmental Consideration

100% closed loop recycling of all reagents and by products

Major Raw Materials

Spent/used catalyst, sulfuric acid, ammonia, cheap oxidizing agents

Major Plant Equipment/Machinery

Leaching reactors/tank, pH meter, precipitation tanks, Filter press, drier, vacuum oven

Technology Package

Available on 25-100kg scale with complete equipment deign and performance demonstration.

INW015

RECYCLING OF SPENT/USED/DISCARDED LITHIUM IRON PHOSPHATE (LFP) BATTERIES FOR RECOVERY OF LITHIUM, IRON AND PHOSPHORUS

Salient Features

>90-95% pure lithium as lithium carbonate/lithium hydroxide and 98% pure iron phosphate, as per battery grade and fertilizer specifications. LCE is 18000 USD per ton in Oct 2021 with a rise of 30% as compared to 2020. With acid leaching using 10-20% solids, 98-100% Li, Fe and P could be extracted. The leach liquor was subjected to selective sequential precipitation route to extract 90-95%% pure lithium as lithium carbonate/lithium hydroxide and 98% pure iron phosphate. Purified graphite was a derivative in the process.

- Low cost acid leaching and low temperature process
- High pure (>90-95%) lithium product(s)
- High pure 98% iron phosphate
- 85% pure graphite is a by-product
- Easily replicable on large scale
- Closed loop recycling of reagents
- Low Incubation time and high returns

Environmental Consideration

100% closed loop recycling of all reagents and by products

Major Raw Materials

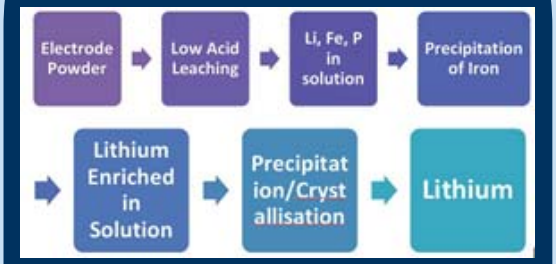
Spent/used LFP batteries, sulfuric acid, sodium hydroxide, cheap oxidizing agents and complexation reagents.

Major Plant Equipment/Machinery

Leaching reactors/tank, pH meter, precipitation tanks, Filter press, drier, vacuum oven.

Technology Package

Available on 10kg scale with complete equipment deign and performance demonstration.



Uses

Technology can extract critical elements like Lithium, Cobalt and Nickel apart from manganese as salts in most desired marketable form, with holistic recycling to result in reusable graphite.

Scale of Development

50 Kg Battery Scale

Commercialization Status

Ready for commercialization

Techno-economics

Available for 50kg spent LIBs with NMC, NCA, LCO, LMO, NCA chemistries.

Technology Readiness Level (TRL)

TRL:5

INW016

RECOVERY OF LITHIUM, NICKEL, COBALT, MANGANESE AND GRAPHITE FROM SPENT/USED/DISCARDED LITHIUM-ION BATTERIES OF MIXED CHEMISTRIES

Uses

Technology can extract critical elements like Lithium, Cobalt and Nickel apart from manganese as salts in most desired marketable form, with holistic recycling to result in reusable graphite.

Scale of Development

50 Kg Battery Scale

Commercialization Status

Ready for commercialization

Techno-economics

Available for 50kg spent LIBs with NMC, NCA, LCO, LMO, NCA chemistries.

Technology Readiness Level (TRL)

TRL:5

Salient Features

>96-99.9% multiple variant pure salts of lithium, nickel, cobalt and manganese as per battery grade specifications. For generic value, an estimate of 100kg of spent laptop LIBs gives 25kg electrode material, from which 5.7 kg Cobalt sulfate, 0.69 kg Lithium Hydroxide, 0.51 kg Nickel Carbonate, 5.4 kg Manganese Carbonate, 0.5 kg Alumina Powder and 12 kg graphite powder can be separated. With acid leaching using 20-30% solids, 94-96% Li, Co, Ni and Mn, was extracted. The leach liquor was subjected to selective sequential multistage solvent extraction and precipitation route to extract >96-99.9% multiple variant pure salts of lithium, nickel, cobalt and manganese. High pure graphite is a derivative product of the process. The process enables recovery of acid and reagents.

- Low cost acid leaching and low temperature process
- Complete separation among Li, Ni, Co and Mn
- Chemistry of Batteries Tested: LCO, LCA, LMO, NMC, NCA in single or mixed chemistries
- 96-99.9% pure multiple variant salts as products
- No impurity of Fe, Al and Cu in any critical metal product
- Aluminium, Copper: 99% recovery
- Total recycling of reagents with 85% recovery of acid
- Residual carbon is converted to High Pure Graphite
- Easily replicable on large scale
- Low Incubation time and high returns

Environmental Consideration

100% closed loop recycling of all reagents and by products

Major Raw Materials

Spent/used lithium based batteries of LCO, LCA, LMO, NMC, NCA chemistries, sulfuric acid, cheap oxidizing agents, cheap organic reagents, cheap precipitation reagents.

Major Plant Equipment/Machinery

Leaching reactors/tank, pH meter, solvent extraction system, precipitation tanks, Filter press, drier, vacuum oven.

Technology Package

Available on 100kg battery feed scale with complete equipment deign and performance demonstration.