Some recent technological achievements of CSIR–National Metallurgical Laboratory

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Recent technological advancements at CSIR–NML are highlighted with special reference to magnesium technology, strategic metals (tungsten and sodium), column flotation, potash from feldspar and, utilization of iron ore fines and slimes. Notable developments pertaining to annealing simulator and, lacquer and energy efficient furnaces for brassware artisans are brought to focus.

Keywords: Annealing simulator, artisans, environment, metal extraction, mineral processing, nondestructive testing.

THE CSIR–National Metallurgical Laboratory (CSIR–NML) has been pursuing a large number of industry-supported projects with emphasis on technology development in the broad domain of mineral processing, ferrous and non-ferrous extractive metallurgy, alloy development and forming, materials processing and characterization, surface engineering and resource conservation, including waste utilization. Here, I highlight the R&D achievements of the laboratory in the past one year and its likely impact on the strategic sector, industrial sector and society.

Magnesium (Mg) holds the key for the success of the national programme for titanium and zirconium extraction and Mg-alloys are seen as the next-generation material for the automotive sector. The contribution of CSIR–NML to Mg technology development goes back to 1971, when a 250 tonnes/annum pilot plant based on the Pidgeon process was commissioned. The plant and technology were subsequently transferred to an industry (M/s Southern Magnesium and Chemicals Ltd, Hyderabad), which was the only commercial producer of Mg in India until 2002, when the plant closed down unable to compete with Chinese dumping, which continues to be currently the largest world producer/supplier of the metal. CSIR–NML has under the 12th Plan taken up a programme for the development of a novel magnesium extraction technology (Magnatherm process), which aims to produce magnesium cheaper than that in China. This process employs direct heating and lower vacuum levels vis-à-vis the traditionally used Pidgeon process, which will significantly reduce the specific energy consumption. With the help of Hind High Vacuum Pvt Ltd (HHV), Bengaluru a 300 kg pilot plant was commissioned and has been operational. Over a dozen pilot-scale trials have been successfully conducted using this reactor and magnesium has been produced successfully. Design changes based on process diagnostics and mathematical modelling (in partnership with IIT Kharagpur) have been introduced to overcome challenges related to condensation/collection of magnesium and its purity. The design data being generated based on these pilot trials will be used for further scale-up of the plant to ~1000 kg reactor.

Tungsten is strategic for several of our defence and space programmes. While exploitation of low-grade indigenous resources is important from a long-term perspective, immediate efforts need to be directed on the recovery from scraps generated during processing and upon end of life of components. CSIR–NML has developed and perfected a technology for the recovery of tungsten from a large variety of W-bearing scraps (Figure 1). The developed technology is superior in terms of recovery (>90% W), co-recovery of associated metals (e.g. Co, Ni), process economics and environmental considerations. The technology has been transferred to three companies and is likely to be taken up by a few others. Plans are also afoot to put up a pilot plant with support from Defence Metallurgical Research Laboratory (DMRL) to treat the scrap available with some of the defence establishments. In the context of strategic metals research, mention may also be made of the efforts of CSIR–NML towards the development of indigenous sodium extraction technology under sponsorship from the Heavy Water Board (HWB). 50 kVA and 500 kVA electrolytic cells were designed and sodium was successfully produced through electrolysis. This was subsequently successfully scaled to 20,000 amp cells by HWB with support from CSIR–NML. This process is expected to be soon commercialized by HWB.

One of the major achievements of CSIR–NML in the past five years has been the commercialization of column flotation technology for the beneficiation of a variety of minerals such as sillimanite, barite, limestone and iron ores. As on date, there are five commercial installations, put up jointly with McNally Bharat at Indian Rare Earths at Chatrapur, Odisha and Chavara, Kerala, M/s Andhra Barites Ltd, Kadappa, Andhra Pradesh, M/s Oren Hydrocarbons Pvt Ltd, Chennai, Tamil Nadu and M/s Transworld Garnet India Pvt Ltd, Srikakulam, Andhra

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Pradesh. This received the CSIR-Technology Award for 2014.

Almost the entire requirement of potash in our country is imported since resources of traditionally used chloride ores are scarce and extraction from alternate resources such as feldspar is considered uneconomical. An innovative process, possibly the first of its kind has been developed at CSIR–NML under sponsorship from Fertiliser Corporation of India, Aravalli. The process which permits high recovery of potash along with all other constituents present in feldspar (e.g. Si as Fe–Si) has potential to radically change the technology scenario for potash extraction from silicate resources. Encouraged by the success of the process at 10 kg scale, it is now being considered for further scale-up and commercial exploitation.

Utilization of fines and slimes generated during mining and processing of iron ores is of paramount importance from the point of view of resource conservation as well as environmental consideration. In collaboration with Tata Steel, a process was developed for making briquettes of high strength from iron ore slime. About 60 tonnes of briquettes produced were used as a coolant in LD converter steel making (Figure 2). The encouraging results obtained have led to the initiation of a plan to set up a 0.5 million tonnes/annum briquettes plant at Noamundi. Technologies were also developed at pilot scale for the utilization of iron-ore slimes and waste Jhama coal to produce DRI in a tunnel kiln and pig iron in a low-shaft furnace. Hundred tonnes of self-reducing briquettes using iron-ore slime and Jhama coal was successfully tested in a low-shaft furnace at Durg (M/s Polybond Co) for the production of pig iron. Similarly, production of DRI from slimes and Jhama coal was tested in a commercial tunnel kiln at Rairangpur (M/s Mayur Electroceramics).

Figure 1. Waste to wealth – tungsten scraps (left) and products (right).

CSIR–NML has also been engaged in the development of equipment, devices and sensors. A significant achievement in this regard has been the development of an annealing simulator for the simulation of batch and continuous annealing of steel sheets in a steel plant. The simulator can achieve a range of heating and cooling rates (>100°C/s) and a variety of environments during cooling, including H_2, N_2, a mixture of H_2 and N_2, atomized water, air humidification, etc. The equipment has been used for the simulation of batch and continuous annealing processes of a variety of steel grades of Tata Steel (IF steel with desirable dew point setting, ultrafast cooling for dual phase or complex phase steel annealing cycles, etc.). This simulator is marketed by a private entrepreneur (M/s Krisjan India Ltd). NML also has a major programme on the development of sensors and devices for non-destructive evaluation on and off site, of industrial components and materials. A portable magnetic sensing device (Magstar) has been developed for non-destructive evaluation of steel structures/components and is marketed by Technofour, Pune. The device measures magnetic hysteresis loop and magnetic Barkhausen emissions.

Brassware artisans across India are at crisis because of stiff competition from China and the country faces the risk of these age-old practices becoming extinct, in addition to loss of livelihood. The home-based traditional pit furnaces used by the artisans are fuel-inefficient and

Figure 2. Briquettes produced from slime and used coolant in LD converters.

Figure 3. Lacquer developed at CSIR–NML for copper alloys.

polluting. As part of a National Innovation Council initiative, CSIR–NML has developed a cost-effective, fuel-efficient and eco-friendly coke-based, energy-efficient brass melting furnace for metal artisans utilizing waste heat recuperating system and arresting SPM inside the pit. The furnace is designed with minimum alteration of existing operating practices and has the advantages of reduction in energy consumption by 20–40%, reduction in melting cycle time by 20%, increase of productivity by 25% and significant reduction in emission of toxic gasses to the atmosphere. A few such furnaces are installed in Moradabad, Uttar Pradesh and Balasore, Odisha. CSIR–NML has also developed an efficient, low-cost anti-tarnishing lacquer to prevent tarnishing and maintain the metallic luster of brass handicrafts (Figure 3). The developed lacquer has several advantages over the ones available in the market, such as 2–4 times less drying time; no baking oven needed; 50 times more storage life; low gloss (natural metal) finish rather than high gloss finish (plastic like), and can be applied as dip, brush and spray coating. The lacquer technology has been transferred to a private entrepreneur for commercial production.