

RESEARCH AND DEVELOPMENT INNOVATIONS

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R&D is a major driver behind the implementation of the Company's strategic priorities. In 2019, Nornickel's R&D and feasibility studies mainly focused on providing research data for the updated Norilsk Nickel Group Strategic Development Plan. Operations. Mining, processing, metallurgy.

Gipronickel Institute is Nornickel's main R&D facility. Part of the Norilsk Nickel Group, it is also one of Russia's largest research and engineering hubs for mining, concentration, metallurgy and processing of minerals, providing a wide range of research and technology services.

PATENTS AND LICENCES

Implementation of uniform approaches to intellectual property (IP) management is a major driver of Nornickel's innovative development.

The Company registers its exclusive rights to inventions and means of identification both in Russia and beyond.

International registration process for Nornickel's Method for Continuously Converting Nickel-Containing Copper Sulphide Materials is now in progress, with a Kazakhstan patent for this invention granted in 2019.

A Certificate of State Registration for 10-day/shift Operations Planning and Control System for Underground Mines software was also granted in 2019. The software solution is being rolled out across the Group as part of its mining automation project.

Also in 2019, the Company completed the registration process and obtained an international certificate of registration for the NORNICKEL trademark in the USA for the first time in its history.

DIGITISATION

Nornickel is the industry's digital leader:

- Nornickel won the first place and the gold award in the Business Transformation Category at SAP Quality Awards in the CIS region for two years in a row – 2018 and 2019 – for its project to roll out SAP ERP
- The Company won the first place for the Machine Vision-Based Detection of Ore Contaminants on Concentrator Conveyors project
- Bronze award was given for the Smart Tailing Dump project leveraging all currently available state-of-the-art dam movement monitoring technologies
- Nornickel's project to optimise flotation processes at Talnakh Concentrator was awarded a BCG Olympics medal in 2019 as the best project internationally to win this highly prestigious annual global competition

Adoption of state-of-the-art technology, including digital solutions, is critical to business competitiveness. Nornickel places considerable emphasis on researching and adopting various digital technologies to optimise production processes, improve overall business performance, and eliminate bottlenecks, resulting in a higher conversion productivity, lower costs and a streamlined organisation. The Company has built a portfolio of various applied technology solutions which can be of interest to other players in the metals and mining industry as well as other industries.

In July 2019, Rosbank and Nornickel migrated the interface between their information systems to a host-to-host digital platform developed by Rosbank and Nornickel's experts supported by BDO Unicon Business Solutions. The host-to-host solution provides a high-speed secure data transfer directly between Nornickel's corporate SAP system and Rosbank's host-to-host service.

It now takes Nornickel's Treasury barely a moment to send payment orders to Rosbank and receive settlement account statements from it. Migration

to the host-to-host solution has not only made payments faster and more secure but also streamlined Nornickel's internal processes and going forward enables fundamentally new, digital business use cases around interfaces with banks and counterparties.

TECHNOLOGY BREAKTHROUGH PROGRAMME

The Company runs the Technology Breakthrough programme to integrate advanced technologies into the design, planning and operational control processes of its mining activities, driving the operational efficiency of its production processes. About 40 IT initiatives were developed during its first phase (Technology Breakthrough 1.0).

The key projects within the programme: development of mining equipment and personnel positioning and communication systems; mining operations planning and dispatch; and deployment of various solutions including geological modelling and mine planning solutions, metals balance calculation, industrial asset management, process data storage, and health and safety systems.

Basic infrastructure building

Nornickel has equipped all of its underground mines with positioning and communication systems. More than 300 kilometres of fibre have been laid, with over 1,000 Wi-Fi access points installed underground. Every day, each person out of more than 6,500 is given special equipment with an RFID tag to track the person's movements within the mine. Similar tracking solutions are installed on moving machinery, totalling more than 500. Video surveillance is provided for key infrastructure facilities underground. A control room operator monitors movements of each employee and can contact them by phone. An anti-collision technology is used to warn drivers of people in the way. The Company has deployed a powerful system providing complete information on people and machinery positions and ore flows in mines by feeding virtually unlimited volumes of data from the surface underground and back.

Geological modelling and mine planning solutions

The deployment of geological modelling and mine planning solutions has enabled the development of a single mining database and 3-D models of underground ore bodies. The software can also be used to design underground workings and obtain survey data. The system enables data preparation and feeding to automated drill rigs, with significant gains to be achieved in drilling and blasting performance. Geological modelling and mine planning software can also accelerate development and analysis of multiple mining options to identify the most effective one and plan mining accordingly.

Simulation modelling system

The software analyses data on underground workings, their geometry, underground transport and ore production plans to calculate an optimal quantity of required underground machinery. The purpose is to optimise ore production and transportation from the mine to the surface. Nornickel's mid-term plans are to use the simulation modelling system to test the use of remotely controlled underground machinery.

Smart digital mines

It took a lot of time and effort to develop underground infrastructure across all mines operated by the Company before operational control centres could launch and assume associated control and management functions. Wireless data transmission system points and fibre links were installed under the Polar Division's machinery tracking and radio communication project, implemented as part of the Technical Breakthrough programme. Each underground working now has Wi-Fi access and is fitted with video cameras.

The Company has also developed a unique 10-day/shift scheduling software to eliminate the decentralised approach and manual planning for certain mine parts. The software allocates tasks and equipment to workings and shifts in accordance with the process cycles and pre-set inputs to create the mine operation 10-day/shift schedule with 10-day increments and task scheduling for each specific shift. Mining plans covering different periods and parts of all underground mines are integrated

into higher-level plans within a single centralised planning system. The operational control centres now operate in accordance with the new mining planning processes. The 10-day/shift scheduling software creates work plans using data from the Micromine geological modelling and mine planning software which creates a 3D model of the mined ore body with a clear representation of beds and seams and helps optimise reserve development sequencing and production techniques.

Process data storage

All data is fed into a process data warehouse, which also collects telemetry data from moving machinery: motor RPM, fuel consumption, working hours, etc. The single process data warehouse collates over 60,000 parameters for all enterprises of Nornickel. The data is then used in other Technology Breakthrough systems such as Production Dispatch, Metals Balance, and in the SAP ERP equipment maintenance and repair management system.

Technical Breakthrough 1.0 has improved total metal recovery and increased the quality of saleable ore by 6.5% between 2016 and 2019, achieving total savings of billions of Russian roubles.

In 2020, Nornickel will launch the second phase of the programme – Technical Breakthrough 2.0, which will include 11 projects. The second phase will mostly focus on Industry 4.0 levers, with certain autonomy embedded in all mine development projects. The Company will now harness big data to improve production planning and overhaul the production process, implementing projects to roll out artificial intelligence, robotics, digital twins, etc.

Nornickel is developing a database enabling it to plan for unmanned production. In particular, mining at depths between 2 km and 2.5 km in the Glubokaya mine (at the Skalisty Mine site) will maximise the use of autonomous mining systems.

DIGITAL LAB

Nornickel actively deploys digital technologies to address local production tasks. Its R&D division Digital Lab has been active for almost two years.

Two initiatives of the Digital Lab won awards at the Mine Digital contest held as part of the Minex Russia geological forum. The gold winner was the Conveyor Contaminant Identification project applying artificial intelligence technology to recognise non-metallic matter on the conveyor which, if entering the concentrator's crusher, can damage the equipment. Bronze award was won for the Smart Tailing Dump project which focuses on the analysis of satellite radiolocation data to track potential strata movements with a millimetre accuracy.

Concentrator conveyor contaminant identification system

The Digital Lab won the gold award for this initiative at the Mine Digital contest held as part of the Minex Russia geological forum.

The system uses artificial intelligence technology to recognise non-metallic matter on the conveyor which, if entering the concentrator's crusher, can damage the equipment. The system will reduce the wear of crushing equipment and the frequency of unscheduled repairs, and is planned to be launched in the mid-term across all of Nornickel's sites.

Industrial exoskeletons

In 2019, Nornickel made its first-ever public presentation of an exoskeleton system developed jointly with the South-West State University. The presentation featured rapid training and testing of exoskeletons on a testing ground, providing the companies in the audience with an opportunity to get a first-hand feel for the new solution. The presentation generated great interest from many companies, and as a result several exoskeletons were shipped for testing to production sites of several Russian metals companies. The exoskeletons were also presented by Nornickel at an advanced project exhibition held by the Agency for Strategic Initiatives.

Industrial exoskeletons are designed for use in harsh environments, helping to resolve health and safety issues and improve operational efficiency. An exoskeleton is put on over the safety workwear and is attached to the person's body by special straps. It can help persons lifting or carrying weights of up to 60 kg by taking up to 90% of the weight. Thanks to its small size, an exoskeleton can be used in hard-to-reach areas inaccessible to specialised machinery. Nornickel's exoskeletons have some smart features: apart from the exoskeleton itself, the system also includes an onboard computer to monitor ambient air pollution concentrations, temperature, illuminance levels, and the user's operating modes in real time.

H&S compliance monitoring solution

Health and safety violations are detected and recorded by video cameras using machine vision and artificial intelligence. The system drives employee accountability, simplifies monitoring and reduces accidents at work.

Short circuit detection in copper electrolysis at metallurgical plants

An integrated hardware/software solution has been developed to detect short circuits in copper electrolysis, stabilising the electrolysis process and increasing the output of copper cathodes.

Drones for aerial surveillance of hard-to-reach areas

Nornickel is developing drones capable of video recording and autonomous movement deep underground without relying on GPS. The drones will be used to inspect the condition of facilities in hard-to-reach areas, enabling faster inspections, reduced diagnostic costs, and most importantly, improved safety. Nornickel has also designed drones for automatic scanning of mine areas that are out of bounds for employees, which will also prevent unscheduled shutdowns and accidents.

Mine surveying robot

Nornickel has piloted a robotic system capable of laser scanning and autonomous movement in workings, which enables high-quality 3D surveying including for hard-to-reach areas. The Company will be able to use the data feed from the robot for integration with its geological modelling and mine planning system.