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ABSTRACT IN ENGLISH

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Title of the dissertation

Development of an innovative technology for the recovery of molybdenum and other metals from spent petrochemical catalysts

Abstract

The subject of this doctoral dissertation was the development of an innovative technology for the selective recovery of molybdenum and accompanying metals (nickel and cobalt) from spent petrochemical catalysts using pyrometallurgical and hydrometallurgical processes. The research aimed to verify whether it is possible to recover at least 85% of molybdenum and at least 70% of nickel and cobalt in the form of useful chemical compounds, namely ≥95% H_2MoO_4 and nickel–cobalt hydroxide concentrates. The research area is closely aligned with current standards of secondary raw material recycling and the recovery of elements of high economic importance in key sectors of modern industry.

Molybdenum is valued primarily for its resistance to high temperatures and mechanical properties, making it an essential alloying addition in advanced structural materials used in the production of cutting tools, drills, milling cutters, saws, knives, casting molds, and forming plates. Nickel, due to its unique physicochemical properties—including high melting point, plasticity, corrosion resistance, and recyclability—plays a vital role in energy transition and the low-emission economy. It is also applied in medical implants, ceramics, specialty chemicals, electronics, and electromobility. Cobalt's principal use lies in superalloys containing about 45% Co, which are essential for jet turbine blades, binders in tungsten carbide tools, and high-performance permanent magnets.

Within the scope of the dissertation, studies were conducted on oxidative roasting of spent catalysts to enable the conversion of MoS_2 to MoO_3, while minimizing molybdenum losses and sulfur compound emissions. Subsequent experiments involved alkaline leaching to transfer molybdenum into solution as sodium molybdate, followed by its conversion into molybdic(VI) acid through the salting-out effect. In parallel, recovery procedures for nickel and cobalt were developed, employing acid leaching of the residues after molybdenum extraction and precipitation of $Ni(OH)_2$ and $Co(OH)_2$ from sulfuric(VI) acid solutions using sodium hydroxide.

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The experiments were carried out both on a laboratory and semi-technical scale, which enabled process parameter analysis, optimization, and validation of the developed solutions for potential industrial application. The obtained results confirmed the validity of the research hypotheses. The designed process sequence enabled molybdenum recovery exceeding 85% in the form of molybdic acid with >95% purity. Nickel and cobalt were recovered with efficiencies ≥70%, yielding products meeting industrial quality requirements. The innovation of the developed technology lies in the application of low-temperature roasting without mineral additives, combined with the novel use of the salting-out effect as an effective tool for molybdenum precipitation from process solutions.

The findings demonstrated the feasibility of comprehensive management of spent petrochemical catalysts, classified as hazardous waste, while simultaneously reducing their environmental impact and enabling efficient recovery of valuable metals. The technology was successfully validated under industrial conditions and showed significant commercial potential, as evidenced by the sale of the obtained molybdic acid.

keywords
molybdenum recovery; spent petrochemical catalysts; molybdenum; nickel; cobalt; hydrometallurgy; oxidative roasting; alkaline leaching; salting-out effect; circular economy; hazardous waste