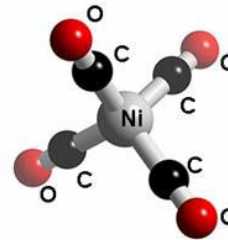
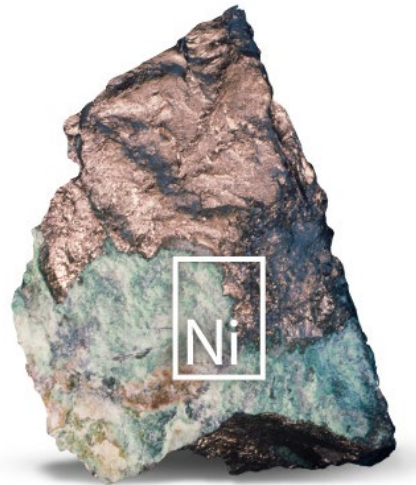


STATE-OF-THE-ART OF INDUSTRIAL CARBONYLATION PROCESSES



August 19, 2026



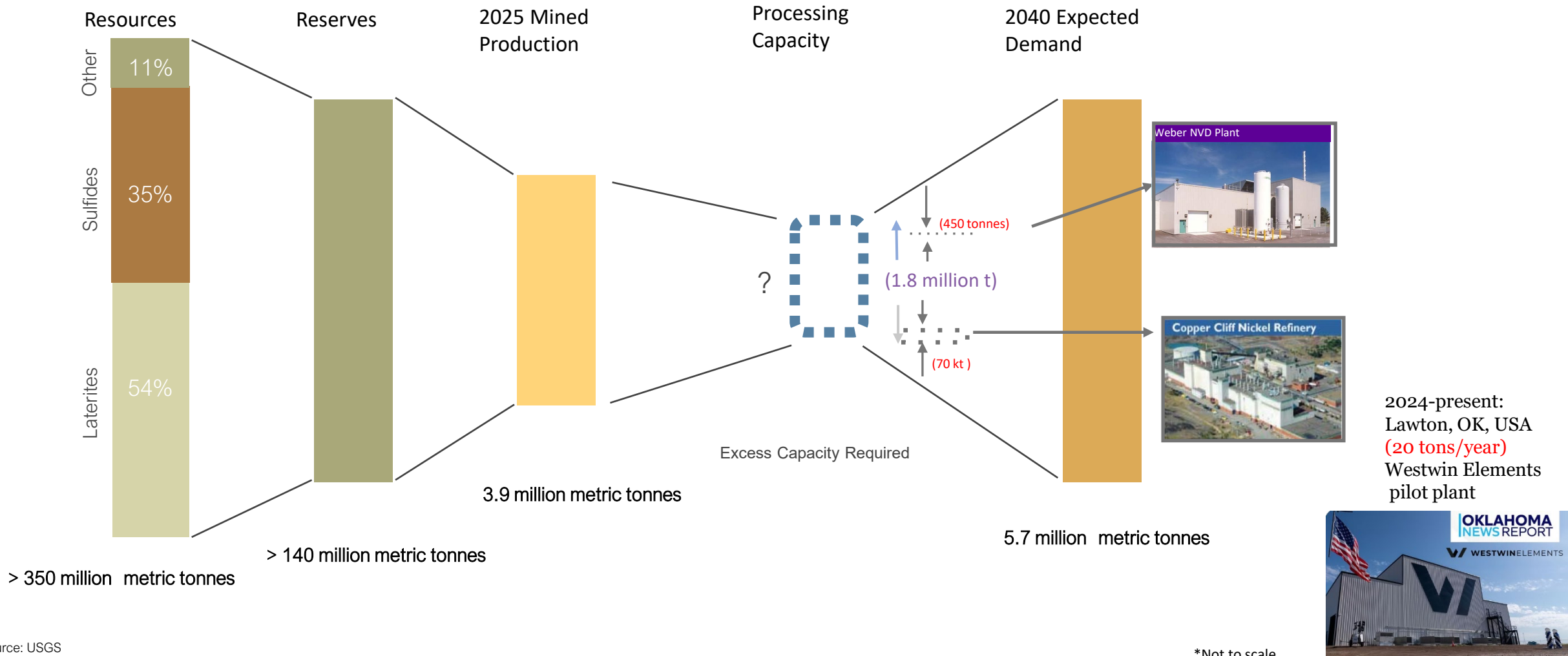
Vlad Paserin¹, Vahid Barahimi¹, Mark Fuller², Chris Holsgrove², Eric Croiset¹, Komal Habib³

¹ Department of Chemical Engineering, University of Waterloo

² Weber Manufacturing Technologies Inc., Midland, Ontario

³ School of Environment, Enterprise and Development, Faculty of Environmental Science, University of Waterloo

Nickel Production Landscape: Current Capacity & Expected Demand

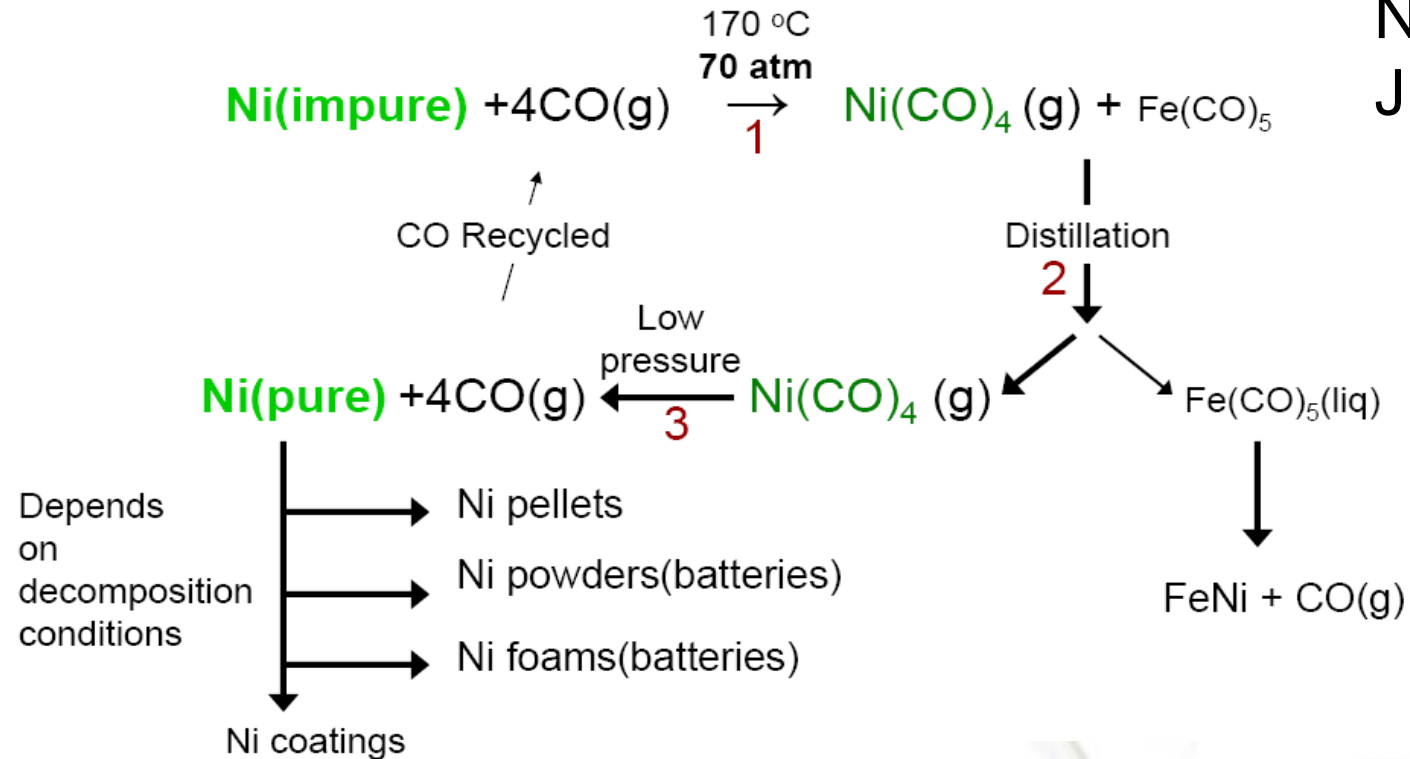


Credit: Jamie Faubert, University of Waterloo

Nickel Carbonyl Process

(Vale,
Norilsk,
Jinchuan)

Similar carbonylation and decomposition reactions apply to Fe and Co



+ complex 3-D shapes

- apart from carbonyl toxicity, the process is environmentally benign



Application of the Mond Process on Commercial Scale

Current nickel production plants using the Mond process [4]

Production Plant/Owner	Location	Feed Type	Annual Capacity	Products
Copper Cliff Nickel Refinery / Vale	Sudbury, Canada	Sulfide ore – originating metallics ~ 70% Ni	70 kt	Class 1 Ni and FeNi (pellets, powders)
Clydach Nickel Refinery / Vale	Wales, UK	Nickel oxide sourced worldwide	40 kt	Class 1 Ni (pellets, powders)
Jinchuan Nickel Refinery	Jinchuan, Gansu Province, China	Nickel concentrates from China and Indonesia	10 kt	Class 1 Ni and FeNi (pellets, powders)
Jilin Jien Nickel Industry Co. *	Jilin Province, China	Nickel oxide from China and Indonesia	2 kt	Class 1 Ni and FeNi (powders)
Nornickel	Norilsk, Krasnoyarsk, Russia	Nickel concentrates originating in local sulfide ores	5 kt	Class 1 Ni (pellets, powders)
Weber Manufacturing Technologies Inc. **	Midland, Ontario, Canada	Ni powder	0.5 kt	Nickel carbonyl for class 1 nickel for tooling and powder products

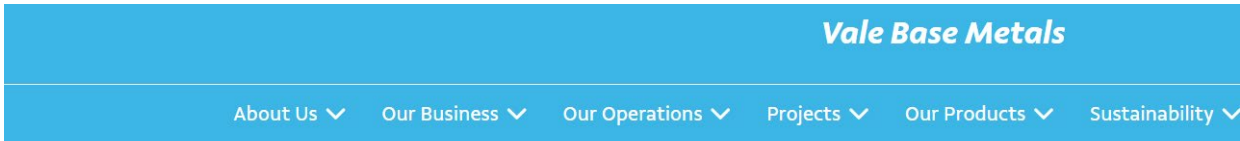
* Carbonyl circuit not operating as of 2026

** Information sourced directly from production plant

Total current capacity: ~**0.13 million metric tonnes**

Expected processing capacity required by 2040: ~**5.7 million metric tonnes**

Recent industry initiatives - Vale (\$500K CMIF grant)



[← Back to News page](#)

Stories - 21 Oct 2025

Vale Base Metals Obtains Government Funding For Next Generation Carbonyl Refining



- Vale Base Metals (‘VBM’) has been awarded C\$500,000 by the Government of Ontario’s Critical Minerals Innovation Fund (CMIF) to support research into next generation carbonyl refining at our Copper Cliff Refinery in Sudbury, Ontario.
- The CMIF funding will support project to design and pilot VBM’s next generation carbonyl reactor

[Valebasemetals.com/news](https://valebasemetals.com/news), accessed August 13, 2026

Recent industry initiatives – Weber (\$5M NRCAN grant, 2024-27)

Natural Resources Canada (NRCan) has awarded Weber Manufacturing Technologies Inc. a \$5,000,000 project funding agreement to scale up the domestic recovery of high-purity nickel from recycled lithium-ion batteries using the industrial carbonyl process.

Recent industry initiatives – Norilsk Nickel (carbonyl dept. update)

The company also increased production of premium nickel products catering to China's electroplating market, alongside advancements in developing specialized nickel powders Kola Division. The carbonyl nickel department was successfully launched after annual schedule capital maintenance.



Nickel carbonyl powder produced by Nornickel's Kola Division serves as a base for the development of new materials

Reference: CarbonCredits.com
and Nornickel.com

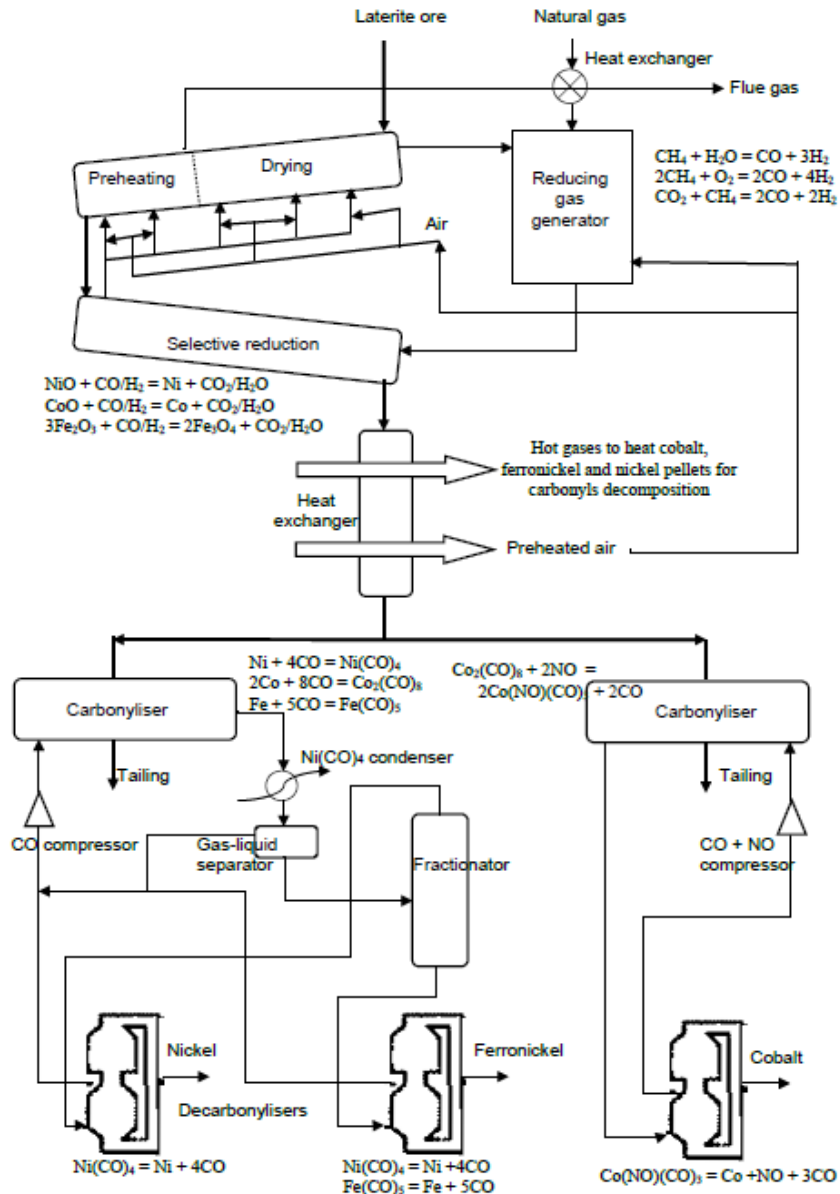
Recent industry initiatives – Jinchuan (carbonyl products update)

Jinchuan claims to have **25 carbonyl-product specifications/products**, including carbonyl nickel powder, carbonyl iron powder and carbonyl nickel pellets. Total output remains at 10 kt per annum.

“In 2025, the carbonyl metallurgical plant experienced explosive growth in export orders.”

Reference: cnmn.com.cn





Recent industry initiatives - Australia perspective: Vapometallurgical processing of Ni, Fe and Co - process flowsheet (academic work)

“A sustainable technology for the extraction of cobalt and nickel from laterite ores” by Guangqing Zhang, University of Wollongong, Australia

20th international conference of Advanced Energy Materials, Dublin, Ireland, August 2018

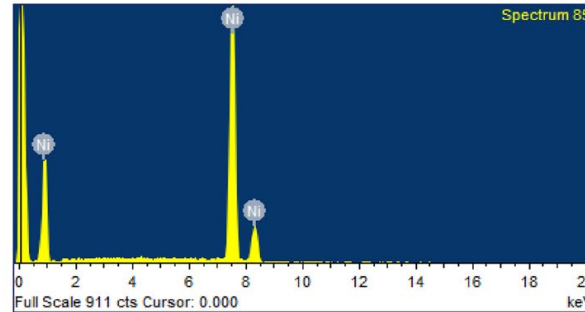
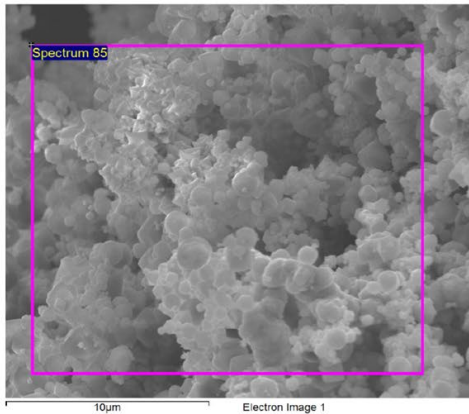
UW vapometallurgy-related research 2021-2026



- S. Young et. al. \$ ~1M 2024-27 (NSERC, granted, in progress)
Industry partner: Teck, Weber, CCMMA
- K. Habib & E. Croiset \$ ~500K 2024-27 (NSERC, granted, in progress)
Industry partner: Weber, Nickel Institute, ES Recycle
- E. Croiset - \$90K (2025-27) (Mitacs, granted, in progress)
Industry partner: VMI Inc. (Vapometallurgy Innovations)
- Ontario Vehicle Innovation Network \$1.8M(2024-26) (granted)
Industry partners: Weber, BGM, VPM Research Inc. (completed January 2026)
- Y. Wu – OCI \$300K (2021-23)
Industry partner: Weber
- Weber NRCAN \$5M (2024)

Nickel Extracted From Recycled Battery Material → Recovered as High Purity Nickel Powder

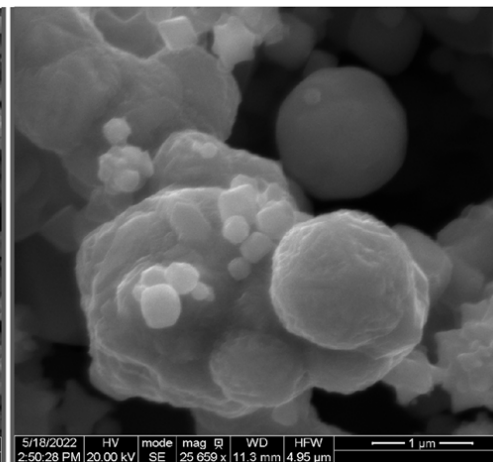
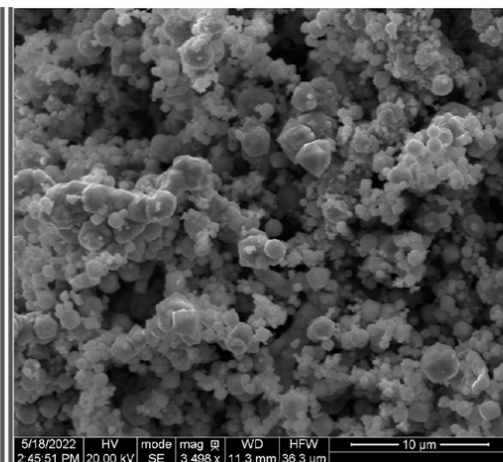
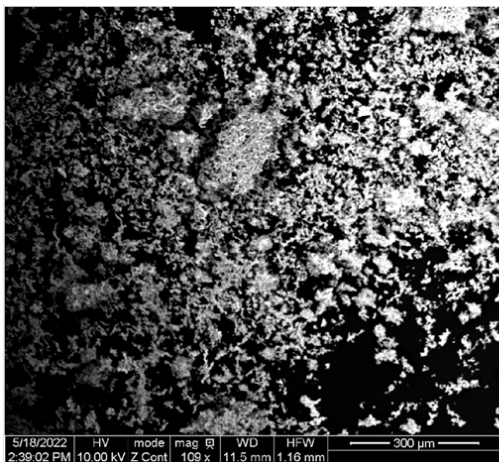
Elemental Composition of Extracted Nickel: Region 3



Element	Weight%	Atomic%
Ni K	100.00	100.00
Totals	100.00	



- Black mass obtained from Chevrolet Bolt recalled NMC batteries
- Nickel extracted and turned into pure Ni powder at Weber in Midland
- Dry step, 100% pure Ni powder composition in the final product



(Patent-pending applications)

JOHNSON MATHEY

TESLA

JOHNSON MATTHEY

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(54) Title: METHOD OF RECYCLING NICKEL FROM WASTE BATTERY MATERIAL

KEY

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(71) Applicant: TESLA, INC. [US/US]; 13101 Harold Green Road, Austin, Texas 78725 (US).

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TESLA

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(10) International Publication Number
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TER, Alex; c/o Tesla, Inc., 13101 Harold Green Road, Austin, Texas 78725 (US).

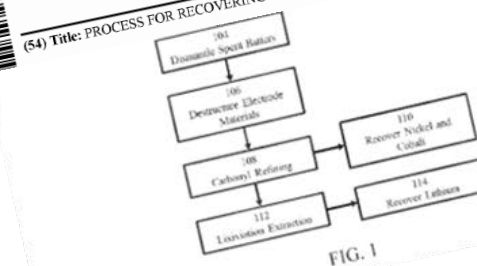
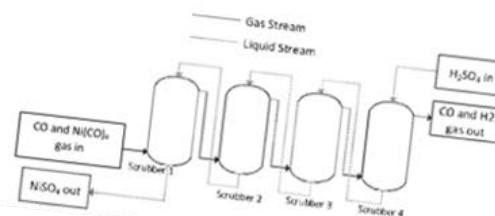
(74) Agent: FULLER, Michael L.; Knobbe Martens Olson & Bear LLP, 2040 Main Street, Fourteenth Floor, Irvine, California 92614 (US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

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(54) Title: PROCESS FOR RECOVERING MATERIALS FROM SPENT RECHARGEABLE LITHIUM BATTERIES

but monoxide optionally in the presence of a gas to yield a solid carbonylation residue containing a carbonyl which comprises nickel and/or cobalt containing compounds, and (3.1) separating the carbonyl from the solid carbonylation residue.



University of Waterloo: A new home of Vapometallurgy Research in Canada

- Studies in high-pressure catalytic carbonylation
- Extraction of Ni, Fe and Co from spent batteries
- High-rate nickel and iron deposition via carbonyl CVD
- Studies in process intensification
- Several NSERC co-funded projects (granted and in application process)
- Research supported by several industry partners
- More details in our second presentation at this conference by Vahid Barahimi

www.vapomet.com



Weber Manufacturing in Midland, Ontario – Large-scale Nickel CVD process (“NVD”)



ISO 9001 : 2008 Registered
www.webermfg.ca

Equipment Highlights



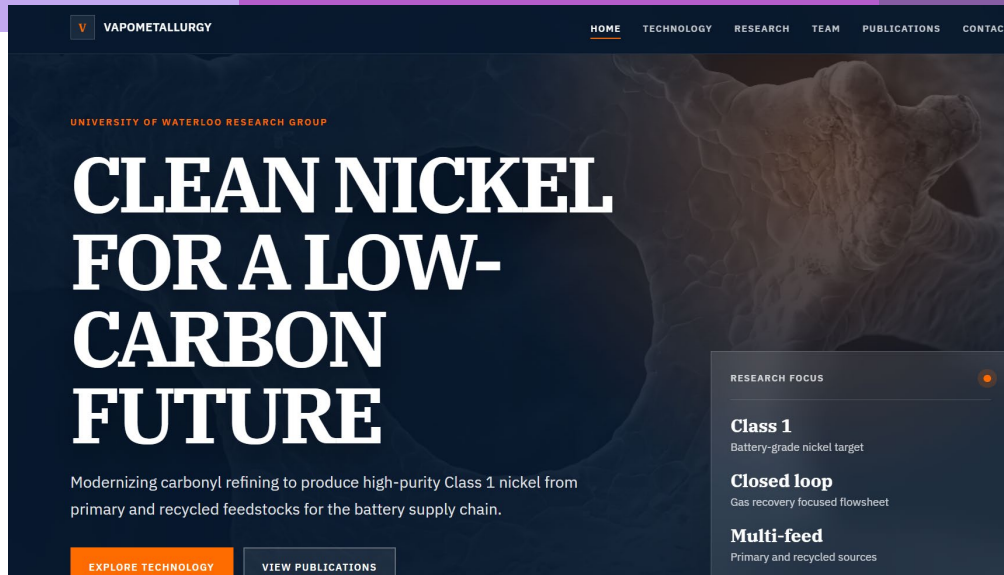
NVD NICKEL PRODUCTION FACILITY

- World's largest Nickel Vapor Deposition facility
- Modern, computer controlled plant, built in 2000
- 4 Production chambers, 1 R&D
- 24 X 7 operation
- 400,000 lbs Ni deposition capacity
- 5.7' X 9.8' shell size capacity



SUMMARY

- The 135-year history of Ni vapometallurgy development led to the current small number of carbonyl refineries located in Canada, UK, Russia and China, producing some 130,000 tons of Class 1 nickel which is gradually finding its way into battery manufacturing processes. The carbonyl process has high attractiveness from environmental impact perspective and potential for development of new products for battery applications.
 - At the University of Waterloo, together with our project partners including Weber Manufacturing Technologies Inc., we are working on accelerating the development cycle for new battery-grade nickel, iron and potentially cobalt production using carbonyl technology.
-



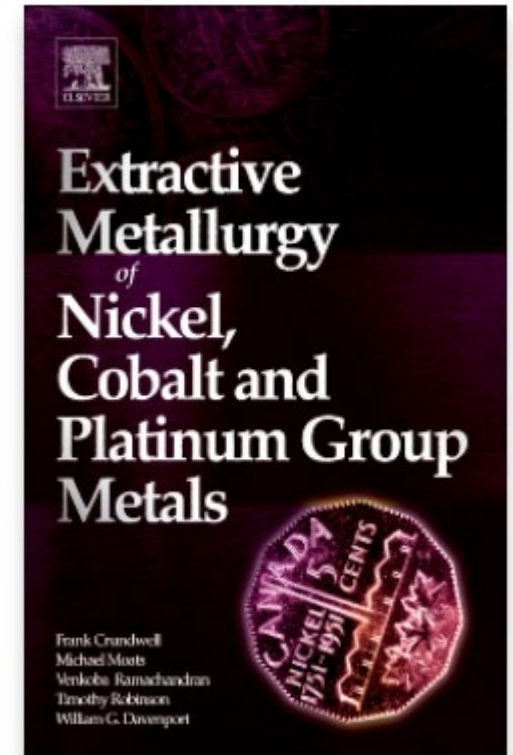
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THANK YOU



Contact: vlad.paserin@uwaterloo.ca