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ADVANCEMENTS IN CHINESE CARBONYL NICKEL POWDER PRODUCTION

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ABSTRACT

Jinchuan Group, China’s largest nickel mining and refining company, recently commissioned the world’s fourth carbonyl nickel refinery with a design capacity of 10,000 metric tons of carbonyl nickel products. This paper will review the production process in which nickel carbonyl gas is synthesized by reacting impure nickel metallics with carbon monoxide inside a carbonylation reactor at an intermediate pressure, followed by distillation to further purify the nickel carbonyl gas prior to final decomposition into nickel powders, nickel pellets and ferronickel powders. The new refinery produces a range of nickel powder products suitable for applications in powder metallurgy, battery and fuel cell electrodes, electronic components, chemicals and catalysts. Comparison of physical and chemical properties of Jinchuan’s nickel powders to existing products will be reviewed. Also discussed will be Jinchuan’s ongoing research efforts to develop new forms of nickel powders.

INTRODUCTION

Nickel carbonyl, or nickel tetracarbonyl $Ni(CO)_4$, is a covalent compound consisting of a nickel atom and 4 CO ligands in a tetrahedral configuration. At ambient pressure, $Ni(CO)_4$ is a volatile liquid with a boiling point of 43ºC. The carbonyl process, or the Mond process, was discovered by Ludwig Mond and his assistants Carl Langer and Friedrich Quincke in 1889[1], and the first carbonyl refinery – Mond Nickel Works, was built at Clydach, South Wales to produce high-purity nickel pellets in 1902[2]. The carbonyl process harnesses the ability of nickel in an impure form to be extracted into a nickel carbonyl gas at ordinary temperatures with the process gas carbon monoxide, CO, via the following carbonylation reaction:

$$Ni + 4CO = Ni(CO)_4 \qquad K_{eq}\,(50^{\circ}C) = 3.78\times10^{4} \qquad (1)$$

At atmospheric pressure and 50ºC, nickel carbonylation equilibrium constant is about 3.78×10^{4}, calculated using the HSC Chemistry® Software. The carbonylation reaction is exothermic, with a negative reaction enthalpy ΔH (ΔH^{o} = -189.6 kJ/mol). Carbonylation results in the reduction of the number of molecules in the gaseous product. Consequently, increasing reaction pressure with continuous reactor cooling favors the carbonylation equilibrium.