

# Nickel

**Nickel** is a metallic chemical element with the symbol **Ni** and atomic number 28.

## Characteristics



Nickel

Nickel is a silvery-white metal that takes on a high polish. It belongs to the transition metals, and is hard and ductile. It occurs most usually in combination with sulfur and iron in pentlandite, with sulfur in millerite, with arsenic in the mineral nickeline, and with arsenic and sulfur in nickel glance.

Similar to the massive forms of chromium, aluminium and titanium, nickel is a very reactive element, but is slow to react in air at normal temperatures and pressures. Due to its permanence in air and its inertness to oxidation, it is used in coins, for plating iron, brass, etc., for chemical apparatus, and in certain alloys, such as German silver.

Nickel is magnetic, and is very frequently accompanied by cobalt, both being found in meteoric iron. It is chiefly valuable for the alloys it forms, especially many superalloys, and particularly stainless steel. Nickel is also a naturally magnetostrictive material, meaning that in the presence of a magnetic field, the material undergoes a small change in length.<sup>[4]</sup> In the case of Nickel, this change in length is negative (contraction of the material), which is known as negative magnetostriction.

The most common oxidation state of nickel is +2, though 0, +1, +3 and +4 Ni complexes are observed. It is also thought that a +6 oxidation state may exist, however, results are inconclusive.

The unit cell of nickel is a face centered cube with a lattice parameter of 0.352 nm giving a radius of the atom of 0.125 nm.<sup>[5]</sup>

Nickel-62 is the most stable nuclide of all the existing elements; it is more stable even than Iron-56.

## History

The use of nickel is ancient, and can be traced back as far as 3500 BC. Bronzes from what is now Syria had a nickel content of up to 2%. Further, there are Chinese manuscripts suggesting that "white copper" (i.e. baitung) was used in the Orient between

1700 and 1400 BC. However, because the ores of nickel were easily mistaken for ores of silver, any understanding of this metal and its use dates to more contemporary times. Nickel is used today as common household utensils, such as silverware.

Minerals containing nickel (e.g. kupfernickel, meaning copper of the devil ("Nick"), or false copper) were of value for colouring glass green. In 1751, Baron Axel Fredrik Cronstedt was attempting to extract copper from kupfernickel (now called niccolite), and obtained instead a white metal that he called nickel.

In the United States, the term "nickel" or "nick" was originally applied to the copper-nickel Indian cent coin introduced in 1859. Later, the name designated the three-cent coin introduced in 1865, and the following year the five-cent shield nickel appropriated the designation, which has remained ever since. Coins of pure nickel were first used in 1881 in Switzerland.

## Occurrence

The bulk of the nickel mined comes from two types of ore deposits. The first are laterites where the principal ore minerals are nickeliferous limonite:  $(\text{Fe, Ni})\text{O}(\text{OH})$  and garnierite (a hydrous nickel silicate):  $(\text{Ni, Mg})_3\text{Si}_2\text{O}_5(\text{OH})$ . The second are magmatic sulfide deposits where the principal ore mineral is pentlandite:  $(\text{Ni, Fe})_9\text{S}_8$ .

In terms of supply, the Sudbury region of Ontario, Canada, produces about 30 percent of the world's supply of nickel. The Sudbury Basin deposit is theorized to have been created by a massive meteorite impact event early in the geologic history of Earth. Russia contains about 40% of the world's known resources at the massive Norilsk deposit in Siberia. The Russian mining company MMC Norilsk Nickel mines this for the world market, as well as the associated palladium. Other major deposits of nickel are found in New Caledonia, Australia, Cuba, and Indonesia. The deposits in tropical areas are typically laterites which are produced by the intense weathering of ultramafic igneous rocks and the resulting secondary concentration of nickel bearing oxide and silicate minerals. A recent development has been the exploitation of a deposit in western Turkey, especially convenient for European smelters, steelmakers and factories. The one locality in the United States where nickel is commercially mined is Riddle, Oregon, where several square miles of nickel-bearing garnierite surface deposits are located.

Based on geophysical evidence, most of the nickel on Earth is postulated to be concentrated in the Earth's core.

## Applications

Nickel is used in many industrial and consumer products, including stainless steel, magnets, coinage, and special alloys. It is also used for plating and as a green tint in glass. Nickel is pre-eminently an alloy metal, and its chief use is in the nickel steels and nickel cast irons, of which there are innumerable varieties. It is also widely used for many

other alloys, such as nickel brasses and bronzes, and alloys with copper, chromium, aluminium, lead, cobalt, silver, and gold.

Nickel consumption can be summarized as: nickel steels (60%), nickel-copper alloys and nickel silver (14%), malleable nickel, nickel clad, Inconel and other Superalloys (9%), plating (6%), nickel cast irons (3%), heat and electric resistance alloys, such as Nichrome (3%), nickel brasses and bronzes (2%), others (3%).

In the laboratory, nickel is frequently used as a catalyst for hydrogenation, most often using Raney nickel, a finely divided form of the metal.

Nickel has also been often used in coins, or occasionally as a substitute for decorative silver. The American 'nickel' five-cent coin is (75%) copper. The Canadian nickel minted at various periods between 1922-81 was 99.9% nickel, and are magnetic.

## Extraction and purification

Nickel can be recovered using extractive metallurgy. Most sulfide ores have traditionally been processed using pyrometallurgical techniques to produce a matte for further refining. Recent advances in hydrometallurgy have resulted in recent nickel processing operations being developed using these processes. Most sulfide deposits have traditionally been processed by concentration through a froth flotation process followed by pyrometallurgical extraction. Recent advances in hydrometallurgical processing of sulfides has led to some recent projects being built around this technology.

Nickel is extracted from its ores by conventional roasting and reduction processes which yield a metal of >75% purity. Final purification of nickel oxides is performed via the Mond process, which upgrades the nickel concentrate to >99.99% purity. This process was patented by L. Mond and was used in South Wales in the 20th century. Nickel is reacted with carbon monoxide at around 50 °C to form volatile nickel carbonyl. Any impurities remain solid. The nickel carbonyl gas is passed into a large chamber at high temperatures in which tens of thousands of nickel spheres are maintained in constant motion. The nickel carbonyl decomposes depositing pure nickel onto the nickel spheres (known as pellets). Alternatively, the nickel carbonyl may be decomposed in a smaller chamber at 230 degrees Celsius to create fine powders. The resultant carbon monoxide is re-circulated through the process. The highly pure nickel produced by this process is known as *carbonyl nickel*. A second common form of refining involves the leaching of the metal matte followed by the electro-winning of the nickel from solution by plating it onto a cathode. In many stainless steel applications, the nickel can be taken directly in the 75% purity form, depending on the presence of any impurities.

Nickel sulfide ores undergo flotation (differential flotation if Ni/Fe ratio is too low) and then get smelted. Smelting a nickel sulfide flotation concentrate requires a MgO level of <6% otherwise the temperature at which the smelting will be run at will be too high and lead to higher operating costs. After producing the nickel matte, further processing is done via the Sherrit-Gowden process. First copper is removed by adding hydrogen

sulfide, leaving a concentrate of only cobalt and nickel. Solvent extraction then efficiently separates the cobalt and nickel, with the final nickel concentrate >99%.

In 2005, Russia was the largest producer of nickel with about one-fifth world share closely followed by Canada, Australia and Indonesia, as reported by the British Geological Survey.