

Figure 2.3.: Spiral Classifier

particle. From the surface foam the ore can be skimmed off, whereas the gangue remains in the suspension. Flotation is always supported by special - mostly sulfur containing- chemicals and can be further controlled by the  $pH$ . By different  $pH$  and different chemicals even different ores with different metals can be separated - like molybdenum from copper.

Magnetic separation is based on the differing degrees of attraction exerted on various minerals by magnetic fields. This is especially the case with iron containing minerals, which are magnetic. Iron containing non-ferrous metals ores have to be separated by a very strong magnetic fields, because its magnetisms is low, compared to pure iron ores like magnetite. High-intensity devices can separate iron-bearing manganese, titanium, and tungsten ores and some silicates.

The electrostatic method separates particle, which can be charged by an electric field. Electrostatic separation is used in all plants, that process heavy mineral sands bearing zircon (zirconium) , rutile (titanium), and monazite (rare earth metals). In addition, the cleaning of cassiterite tin concentrates as well as the separation of cassiterite-scheelite (tin-tungsten) ores are conducted by electrostatic methods.

If separation is done in aqueous media like flotation and separation by gravity, the mineral slurry has to be dewatered and dried. Dewatering can be done by thickening, meaning separation by gravity and time, which forms a pulp, which has normally to be dewatered further by filtering, which leads to a filter

### 3. Production by Extractive Metallurgy

As hydrometallurgy is performed in aqueous solutions temperatures are normally below 100 °C, the reaction is not so fast than in pyrometallurgy and needs a much higher reaction volume for the same throughput.

**Leaching** The first step in hydrometallurgy (see figure 3.2) is leaching, to separate the valuable metal from other material. In most cases the valuable metal is in the aqueous phase in a concentration of some grams/liter to max. 200 g/l. As leaching agents often acids like diluted sulfuric acid or hydrochloric acid are used. In some cases also strong basic agents like caustic soda is applied. In other cases especially in precious metals metallurgy not the solution, but the residue contains the valuable metal.

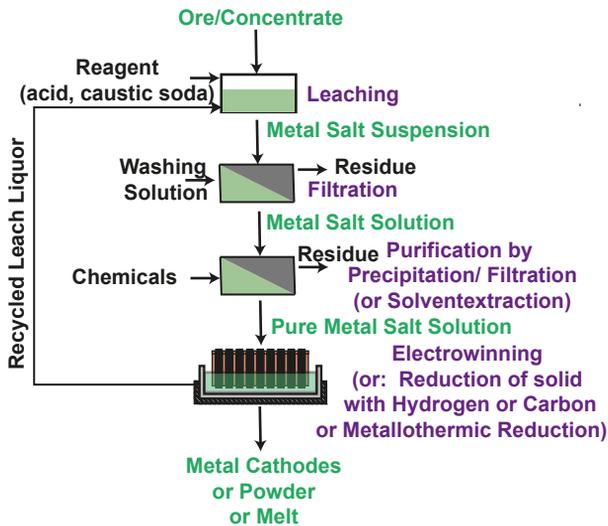


Figure 3.2.: Flowsheet for a Leaching Process

After the leaching process the residue has to be separated by filtration, decantation or centrifugation. To get a high yield of the valuable metal the residue has to be washed with the aqueous solution. In several cases filtration and washing is difficult, because of colloidal ingredients leading to a lot of water, which has to be treated afterwards.

**Extrusion:** Metal Extrusion (see figure 5.2) is a metal forming manufacturing process in which a heated cylindrical billet inside a closed cavity is forced by a mechanical or hydraulic press to flow through a die of a desired cross-section.

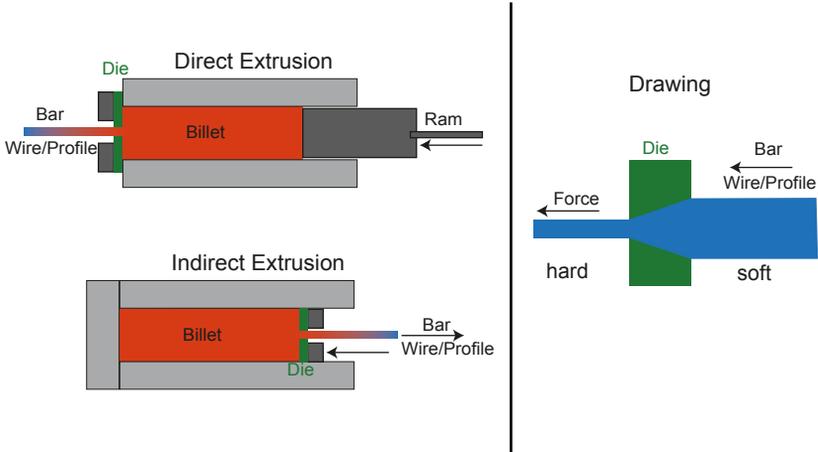


Figure 5.2.: Extrusion and Drawing of Bars/Wires/Profiles

Direct Extrusion, sometimes called forward extrusion is the most common type of extrusion. A heated billet lies in a press cavity container, where a block is placed behind it. Then the mechanical or hydraulic ram presses on the material to push it out through the die. In indirect extrusion, the die is located at the end of the hydraulic ram and moves towards the billet inside the cavity to push the material through the die. Indirect extrusion has less friction, so it needs less energy. But the use is limited due to the limitation of the load ram because the ram is hollow.

As not the whole billet can be pressed out of the cavity, there remains always a rest, which has to be remelted.

**Rolling** Rolling is a process to produce flat materials like strips, sheets and foils. Rolling is classified according to the temperature of the metal rolled. If the temperature of the metal is above its *recrystallization* temperature, then the process is known as hot rolling. If the temperature of the metal is below its recrystallization temperature, the process is known as cold rolling. Normally rolling is done in several steps as one cannot achieve the final thickness from a