**Physico chemical And chemical Method**

There are nine methods which are included into this class as mentioned earlier. The first two may be classified as physical method and others may be regarded as the chemical methods except number.

4)may be considered as an electro – chemical method.

1- condensation .

2- thermal decomposition. (physical method)

3-Reduction

4- Electrode deposition (electro – chemical) e.ch

5- precipitation from aqueous solution.

6- precipitation from fused salt.

7- hydrometallurgical or gaseous reduction process. ( chemical

8-Intergranular corrosion. method)

9- oxidation and Decarburization.

So the chemical method are

**1) Reduction:-**

Reduction of compounds particularly oxides by the use of producing a gent in the form of either solid or gas is the most widely employed and probably the oldest method of producing metal powders.

It is extensively employed for the manufacture of (Fe, Cu, Ni, W, Mo, and Co though Ta, Th, Zr, Ti and even Al and Cr are also being produced. This process Yields externally fine powders with irregularly shape particles and considerable porosity.

Gas such as hydrogen, dissociated NH3, CO, Coal gas enriched blast furnace gas, natural gas, partially combusted hydrocarbons or alkali vapours, carbon and metals are used as producing agents, but the choice of reducing agent is made from the viewpoint of convenience and economy of operation.

Carbon is the cheapest reducing a gent. But with its use difficulties have been experienced in closely controlling the carbon content of the final powder.

Zr powders are produced by reduction of Zirconium oxide with Ca or Mg in inert gas atmosphere.

Reduction by hydrides is applied where very active nascent hydrogen is necessity for the reduction of more stable oxides.

The chemical reaction for the hydride process is expressed by the equation:-

M x Oy + y CaH2 = xM + y Ca + y H2­O

By Varying

1- The degree of purity.

2- Particle size and shape of the raw material.

3-The temperature and time of reduction.

4-The type of reducing agent.

5-In case of gaseous reductant.

The pressure and flow rate of the gas, close control over.

The Purity, particle size and shape, apparent density. and related properties of the deposited metal powder and completeness of reduction can be obtained. Since oxides are generally brittle and easily comminuted to the desired degree of fineness, it is possible to obtain very fine metal powders.

**2)Electro deposition:-**

Metal powders can be produced by electrodeposion from aqueous solutions and fused salts. This method is a reversed adaptation of elcotroplating.

As many as 30 metals, have been prepared as powder by electrolysis of aqueous solutions accompanying simulta – neous refining. But this technique is mainly employed for the commercial production of metal powders such as Co, Be, Fe, Sn, Ni, Cd, Zn, Ag + pt. There are three different types of electrodeposiotion which are in practical use :-

1. Deposition as a hard, brittle mass, which is subsequently ground to powder.
2. Deposition as a solt, spongy substance, only loosely adherent with fluffy texture and easily pulverized by light rubbing.
3. Direct deposition as powder from the electrolyte which drops to the bottom of the cell.

The process has a number of advantages which are as follows.

1. The possibility of compacting economically with other methods used for the production of cheaper powders.
2. Remarkable uniformity of characteristics, accompanied by higher degree of purity, excellent compatibility and sinterability.
3. Possibility of obtaining a wide range of powder, qualities by altering both composition.
4. Production of high quality sintered machine parts because of very attractive properties of the powders.

There are, however, the following drawbacks:-

1. It is time consuming.
2. High cost of powders due to low productivity of the process and high operating cost.
3. The deposited powders must be thoroughly washed and dried or annealed to avoid rapid oxidation which is mainly responsible for its high cost.
4. The process is usually unsuitable for the manufacture of alloy powders and usually confined to special – purpose powders.

**3)precipitation from a aqueous solution.**

The principle of precipitating anetal from its aqueous solution by addition of a less noble metal which is higher in the electromotive series has been applied in numerous metallurgical processes. This process permits the production of very fine metal powders of low apparent density which are occasionally used for sintering purpose.

Ag powder is produced in quantity from its nitrate solution by adding copper or iron powder is precipitated by metallic zinc from stannous chloride, copper, iron, and Nickel powders are obtained by adding Al to their sulphate solution containing Hgcl2, HCl or alkaline salts which serve as activating agent Gold powder is obtainable by precipitation with Zinc and copper.

The precipitated metal powders are in general porous A drawback of the precipitation method less in the fact that the adherent or entrained salts are more difficult to remove that in electrolytic powder products.

**4)Precipitation from fused salts:-**

Powders, particularly of reactive metals, are also prepared by precipitation from fused salts. For the production of zirconium powder the Zrcl4 salt is mixed with an equal amount of KCl, and some magnesium. Magnesium replaces the zirconium when heated to 1380°F (749°C) and particles of latter settle at the base of the chamber.

Another method use the introduction of Zrcl4 Vapor to a salt bath of Nacl and Mgcl2.

**5)Hydrometallurgical or gaseous reduction process.**

In recent years, metal powders particularly Ni, Co and cu are precipitated on commercial scale by hydrometallurgical method by the reduction of aqueous solution or slurries of salts of metals with hydrogen when subjected to the correct combination of high pressure (between 400 and 900 P. s. i) and temperature (between 130°c and 210°c) according to the following type of reaction.

M++ + H2 M + 2H+

This technique is characterized by a very narrow range of particle size distribution, spherical shape, high apparent densities and flow rates of the powder.

**6) Intergranular corrosion**

This process is based on the fact that the grain boundaries of the heat treated alloys are more susceptible to chemical attack than the grains, thus freeing particles of bulk material.

This method, which has been developed by (Wulff) consists in carburizing stainless steel scrap at a proper temperature ( 500 - 750° c) for a definite time in order to precipitate chromium carbide at the grain boundaries and corroding the boundary region of the sensitized material by corrosive solutions, for example, by a boiling aqueous solution of 11% copper sulphate and 10% sulphuric and so as to cause disintegration of the stainless steel into powder.

Rapid disintegration may be obtained using stainless steel as anode and solutions of a mixture of (cuso4 H2So4) acid as electrolyte in an electrolytic cell. The powder particles possess angular shape and the final particle size is determined by the grain size of the sensitized material.

**7)Oxidation and Decarburization**

This method has been developed for the production of pure reactive metal powders, particularly niobium, by reacting metal carbide with metal oxide in vacuum at elevated temperature so that both oxygen and carbon are removed as Co.Mannesmann process employed for the production of iron powders (where cast iron is atomized with compressed air), since it also involves the elimination of both carbon and oxygen.