Fig. 2.6. Iron carbonyl decomposition process

### 2.2.4 Atomisation

It is estimated that nowadays some 1.2 Mt/a of metal powders are made in the world by atomisation, to which one could add 1 Mt/a of shot (both steel and iron) which are made by similar techniques, but are largely coarser than some definitions of powder as sub-millimetre particles. This quantity is made up very roughly as follows:

1. Zinc powder 400 kt/a - 500 kt/a  
2. Iron, steel and ferroalloy powders 450 kt/a - 600 kt/a  
3. Aluminium powder 100 kt/a - 150 kt/a  
4. Copper and alloy powder 50 kt/a - 80 kt/a  
5. Others (Sn, Pb, Au, Ag, Co, Ni etc) 20 kt/a - 30 kt/a  

Total 1020 kt/a - 1360 kt/a

These volumes can be roughly broken down between the different atomisation techniques as follows:

1. **Zinc**  
   - Air atomised 90%  
   - Water atomised 5%  
   - Centrifugally atomised 5%

2. **Iron and steel**  
   - Water atomised 93%  
   - Inert gas atomised 5%  
   - Air/steam atomised 2%

3. **Aluminium**  
   - Air atomised 99%  
   - Inert gas atomised 1%

4. **Copper and alloys**  
   - Water atomised 80%  
   - Air atomised 19%  
   - Inert gas atomised 1%

5. **Others**  
   - Inert gas atomised 40%  
   - Air atomised 40%  
   - Water atomised 15%  
   - Centrifugally atomised 3%  
   - Ultrasonically atomised 2%
For clarity no tolerance levels are given here, but accurate figures are impossible to prepare for the whole world, and are not available even for the US or EC. The figures can only indicate roughly the relative scale of application of each technique. Although inert gas, centrifugal and ultrasonic atomisation are used on a small scale, they are for relatively high value products, so their “importance” is understated by the above figures which refer to tonnage produced only.

2.2.4.1 Basic considerations

We shall now discuss the performance of gas (air) and water atomisers in these applications. First we must define what factors constitute “performance” and how they are defined and measured.

2.2.4.1.1 Performance of atomisers

All quality factors demanded by the powder user, together with economic factors important to the producer, must be considered together to establish performance criteria for atomisation equipment or processes. Thus, some factors depend on the product and market to a very large extent, e.g. oxygen content, shape or particle size, while others, especially economic factors such as energy consumption, productivity and production costs are always of importance. The technical parameters that comprise “performance” need to be defined. First are the powder properties.

2.2.4.1.2 Particle size distribution parameters

It is found that atomised powders (before screening or classifying) are in most cases well described by a log-normal distribution function (Fig. 2.7, next page). When the cumulative particle size distribution is plotted on a log-normal grid, a straight line is found. Substantial deviations from a straight line plot almost always show defects and problems in the process. However, care must be taken that sampling of the powder is representative and that no particles are lost in the process, as might occur with fines being carried away to a filter or coarse particles being trapped inside an atomiser.

A log-normal distribution has the useful property that it can be fully described by just two parameters; median particle size (D50%) and standard deviation sigma (D84%/D50%). These two parameters describe how fine or coarse the powder is and how narrow the distribution is. Sigma for two-fluid atomisers (i.e. gas or water atomisers) is about 2.0, and values above 2.5 are indicative of major problems.

2.2.4.1.3 Sphericity or particle shape

The meaning of sphericity is easily described, but very hard to define. Perfect sphericity is clear, but in practical terms which is more spherical, a smooth particle with major and minor axes differing by 10% or a perfect sphere with a satellite particle of 10% of its diameter sticking firmly to it as shown in Fig. 2.8.

As sphericity or particle shape is normally specified to affect the practical properties of packing density or particle flow, it is normally unnecessary to debate this question, but sufficient to measure these practical properties, most commonly with a Hall flowmeter (see ISO 4490 and 3923 for details). The bulk density, either loosely filled or tapped down, is of considerable importance and flow rate as well. One problem can be that some flow properties, e.g. of a high density slurry in MIM, are dependent on shape, but the powders are too fine to flow in the standard test.