XI. AGGLOMERATION

Often concentrates are produced from mineral processing plants in fine particulate form and as such those can not be utilized for metal extraction unless they are bound into some compacted or lumpy form called 'agglomerates' suitable for handling and feeding into furnaces. The process of 'agglomeration' can be classified mainly into the following groups, namely, Briquetting, Nodulizing (rotary kiln sintering), Vacuum extrusion, Sintering and Pelletizing.

Briquetting : This is a very simple process, in which fine grained materials are pressed into briquettes with the addition of moisture and/or another binder under high mechanical pressure. The briquettes may undergo further treatment or thermal processing before their use. Although their metallurgical behaviour in melting or reduction furnaces is very good, iron ore briquetting could not make headway since the processing cost is relatively higher and the production capacity of briquetting units is limited compared to sintering or pelletisation units. Also, getting suitable strength becomes a problem and their handling produces undesired fines. The briquetting process is still utilized to agglomerate small quantities of flue dust or other circulating materials produced in integrated iron and steel plants.

Nodulizing : In this process, iron bearing fines and carbon are passed through a rotary kiln, inclined at a few degrees to the horizontal, counter current to hot gases produced by a gas fired burner. The flame temperature is about 1300-1400°C and the maximum temperature of the agglomerates is about 1100-1200°C. The exhaust gases leave the kiln at 300-400°C. The hot agglomerate discharges on to a water cooled chute and is removed by a water cooler conveyor. The agglomerate quickly builds up in the walls of the sinter zone to form rings. These are removed at frequent intervals by means of scraper. The product from the kiln is in a semi-plastic state, and when cooled, is dense, slaggy and difficult to reduce.

The ore fines and/or flue dust are mixed with water, and a binder such as bentonite is added if necessary. The mix is fed into a de-airing chamber, which is connected to a vacuum pump, by means of a scroll feeder, and extruded through a series of dies by means of an auger. Short cylinders are produced by means of a knife which slices through the extruded material at regular intervals. The cylinders fall on to a conveyor, where they remain for a curing time of approximately forty-five minutes. They may be charged to the furnace as cured or may be fired.

Pelletisation : This consists of two distinct operations, namely, forming the ball shaped pellets at atmospheric temperature and then firing them at a temperature below the softening temperature. Iron ore fines and concentrates are ground to suitable fineness generally 50-70% below 50 microns and mixed with some quantity of moisture and a suitable binder e.g., bentonite, lime etc and the mixture rolled in either a horizontal drum or an inclined disc. At this stage, the spheres known as green balls or pellets have adequate strength to withstand handling to the firing stage. Pellet firing, called induration, is normally carried out using either a gas or oil. Initially, shaft kilns were used but

later, horizontal traveling grates, or a combination of horizontal traveling grates and rotary kilns, were developed for this purpose. During induration, not only the crystal structure is changed but also other bonds appear by reactions between slag forming constituents - both between each other and with iron oxides. In another pelletisation process, called 'Cold bonded pelletisation', binders like calcium hydroxide or cement is added during green ball formation. They are indurated by using steam under high pressure in an autoclave or keeping the green pellets under moist condition over a long period of time to complete the setting process.

Although, studies on pelletisation started some time in 1913 in Sweden, the first commercial plant came into existence in Sweden in 1950.

Sintering : The sintering process consists, in essence, of mixing iron ore fines, moisture, other fine iron bearing recycling material like mill scale, flue dust etc., fluxing material e.g. lime, limestone, dolomite, quartz etc. and solid fuel, normally coke breeze, and loading the mix on to a permeable grate. The upper surface is ignited by oil or gas burners and air is sucked downwards through the grate. After a short ignition period, heating of the top surface is discontinued and a narrow combustion zone moves downwards through the bed, each layer in turn being heated to 1200-1500°C. In advance of the combustion zone, water is evaporated and volatile compounds are driven off. In the combustion zone, bonding takes place between the grains and a strong agglomerate is formed. Most of the heat in the gases leaving the combustion zone is absorbed by drying, calcining and pre-heating the lower layers in the bed. When the combustion zone has reached the base of the sinter mix the process is complete, and the sinter cake is tripped from the grate and roughly broken up. After screening, the undersize is recycled and the oversize is cooled and sent to the blast furnaces.

The sintering of non-ferrous ore fines is sometimes carried out in the reverse direction. A thin layer of mix is first charged on to the grate and ignited, mix is then added to bring the bed up to the full height and air is blown upwards through the bed. The process is complete when combustion at the bed top has been completed. This process is referred to as up-draught sintering, in contradiction to the normal down draught sintering.

Evaluation of properties of agglomerates : In order to evaluate the suitability of the agglomerated products in the blast furnaces, direct reduction reactors and smelting reduction furnaces, certain test procedures have been assigned by standardization organizations around the world. So far physical properties are concerned, they are strength indices, namely, Shatter Index and Tumbler Index. The other important properties are chemistry, reducibility, reduction degradation index (RDI) and softening-melting characteristics.

Of all the agglomeration processes, only the continuous sintering strand and pelletizing are now of any significance. The reasons for the failure of other processes are:

1. High fuel cost due to thermal inefficiency
2. Mechanical unreliability leading to high maintenance costs and low availability
3. Liability to serious operating problems

4. Unsuitability for large scale production

5. Poor quality of product

Briquetting generally is liable to mechanical problems. Unfired briquettes have very little strength when heated under reducing condition. Therefore, they break down in the furnace stack causing serious dust loss. Fired briquettes are much more satisfactory but the extra cost is a serious economic burden. Vacuum extrusion gives rise to a product which is unlikely to be strong enough to withstand degradation in the blast furnace stack unless it is fired before being charged, which puts up the production cost to an uneconomic level.

Both the continuous sintering and pelletizing process yield a satisfactory product. It is also possible to maintain high plant availability and to scale up the units to a high output rate. The sintering process is particularly suited to treat ore fines, and has the advantage that it is quite practicable to add flue dust and flux to the sinter mix. Coke breeze, which is a by product of the blast-furnace coke manufacturer, is a very suitable fuel. The sintering process is not suitable for agglomerating fine concentrates, and here the pelletizing process is most suitable. When the ore fines or coarse concentrates are to be pelletized, it is usual to carry out further grinding before pelletization is carried out.