

## CHALLENGE RECYCLING - POSSIBILITIES BY USE OF AGGLOMERATION PROCESSES\*

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### **Abstract**

Increasingly pelletizing discs are used for the recycling of dust and sludge. The applied pellet feed is highly variable, for example in terms of chemical composition, grain size distribution and raw density. These raw materials related factors lead to a destabilized pelletizing process, which initially must be homogenized through special mixtures, as well as the use of binders or additives. There are many possibilities to reach stringent restriction of material related target factors. On the one hand it is helpful to be flexible by changing the process parameters of the pelletizing disc. On the other hand, it is necessary to use a material-binder-formulation, which leads to a highly stable pelletizing process. The paper deals with an example of the use of agglomerating device, pelletizing disc, to prepare different dusts and sludges for material recycling. These dusts and sludges are mostly generated in metallurgical processes, e.g. sinterplant, blast furnace and steelworks.

**Keywords:** Pelletizing process; Recycling; Dust; Sludges; Pelletizing disc.

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## 1 PREFACE

Dust and sludge by-products from steelmaking are a hard-to-solve waste problem for the steelmaker as they require costly processing before they can be recycled. A variety of resource recovery technologies to add value to by-products through blending and processing of different materials.

Significant economic savings can be generated by micro-pelletizing waste oxides, through the raw material replacement and elimination of landfill charges. Those micro-pelletized can be directly inserted back to the process as for example inserted into the sintering process, as a substitute for low-grade iron ore or scrap.

A variety of by-products can be included in the mix of materials for micro-pelletizing to improve the sintering process, including converter sludge (BOS sludge), blast furnace sludge, ladle slags, sinter fines, millscales, bag house dusts, iron ore fines, lime and dolomite dusts.

### 1.1 Agglomeration

Agglomerates are the hidden companions of our day-to-day life. Every day we use a multitude of products from different branches of industry that are produced with the help of agglomeration technology. The main objective of the agglomeration is to make fine-grained materials into agglomerates or pellets. The products produced exhibit considerably improved properties for transport, processing and use. Depending on the type of bonding force, the pelletizing process can be classified into three main groups: pelletizing, briquetting and sintering. Accordingly, agglomerates are designated as pelletizing and compacting agglomerates, or as sinter. When using every-day terminology, the pelletizing agglomerates are simply referred to as pellets, and compacting agglomerates are mainly referred to as briquettes. This paper deals exclusively with pelletizing in pelletizing drums and first of all in pelletizing discs.

### 1.2 Fundamentals of Pelletizing

Crucial for the formation of agglomerates are forces of attraction between the particles. During agglomeration in pelletizing discs, attraction is based mainly on capillary bonding forces caused by particle collisions. The necessary relative movements in the material bed are generated in a tilted, rotating, flat cylindrical vessel (refer **Figure 1**). The fine-grained feed material is, depending on the agglomeration requirements, fed in an exposed position into the interior of the process chamber. Owing to the rotation of the vessel, the fines are swept along as a function of the coefficient of entrainment, the speed and the inclination to the highest position of the disc and then roll down onto the material bed.

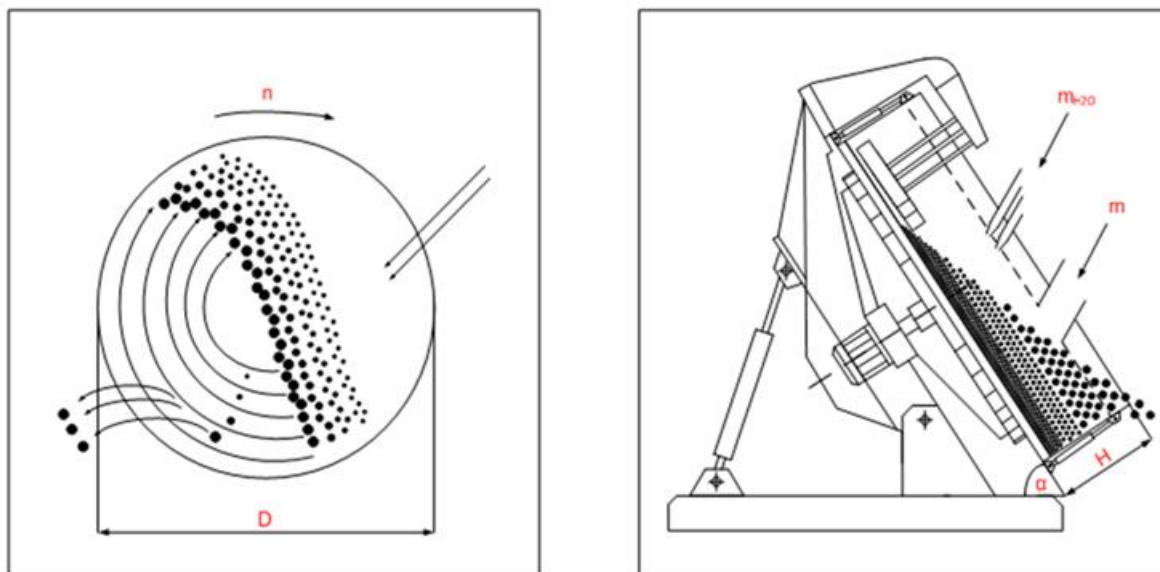


Figure 1. Schematic represents a pelletizing disc with height-adjustable disc edge and segregation

To produce the adhesive conditions, the material is sprayed with binder, usually water. In this wet material bed, liquid bridges are formed as a result of irregular, random particle contacts, leading to the aggregation of individual particles. These pellet seeds are transported upwards on the fines in the material bed, and other particles and pellet fragments attach themselves to the seeds. On account of the random particle movement, separating forces such as abrasion, breakage or disintegration of the pellets also take effect. For this reason, feed material, pellet seeds and pellets as well as their fragments and abraded material are all contained in the material bed of the pelletizing bed at the same time (refer Figure 2).

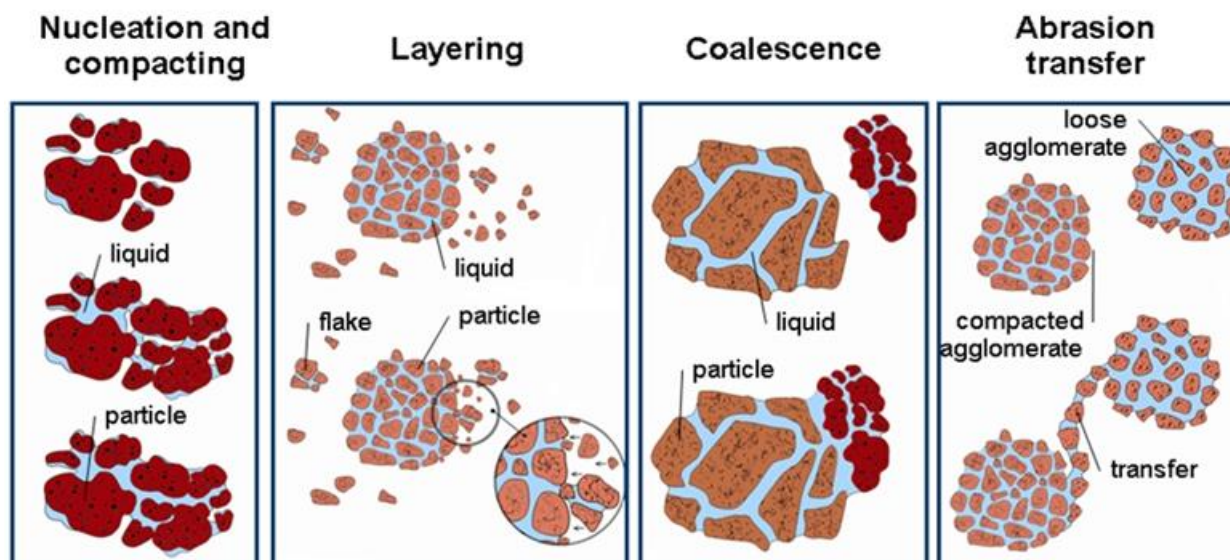


Figure 2. Mechanisms of pelletizing

## 2 PROJECT

The process involves putting the ingredients – primarily in the form of dust from the gas purification installations in electric steelworks and iron foundry cupola furnaces, or as slurries from the galvanizing industry – into the charging end of the 40 m long and 3.1 m diameter furnace, and adding coke and lime (refer Figure 3).

As the materials pass through the rotary furnace, the zinc oxide is reduced to metallic zinc by the carbon dioxide and the metallic zinc evaporates and reoxidises in the free gas space of the oven when it reacts with the air blown in from the end of the furnace. It produces a zinc-rich dust which is removed with the waste gas and precipitated out in a tube filter plant (refer Figure 4). The product is transported in silo trucks to the clients, zinc electrolysis operations or thermal zinc smelters.

The slag remaining after the zinc has been removed, falls out of the end of the rotary furnace where it is shock-cooled in a water bath. After cooling down, it is used either for recultivation measures on the landfill or used externally for landfill recovery projects.

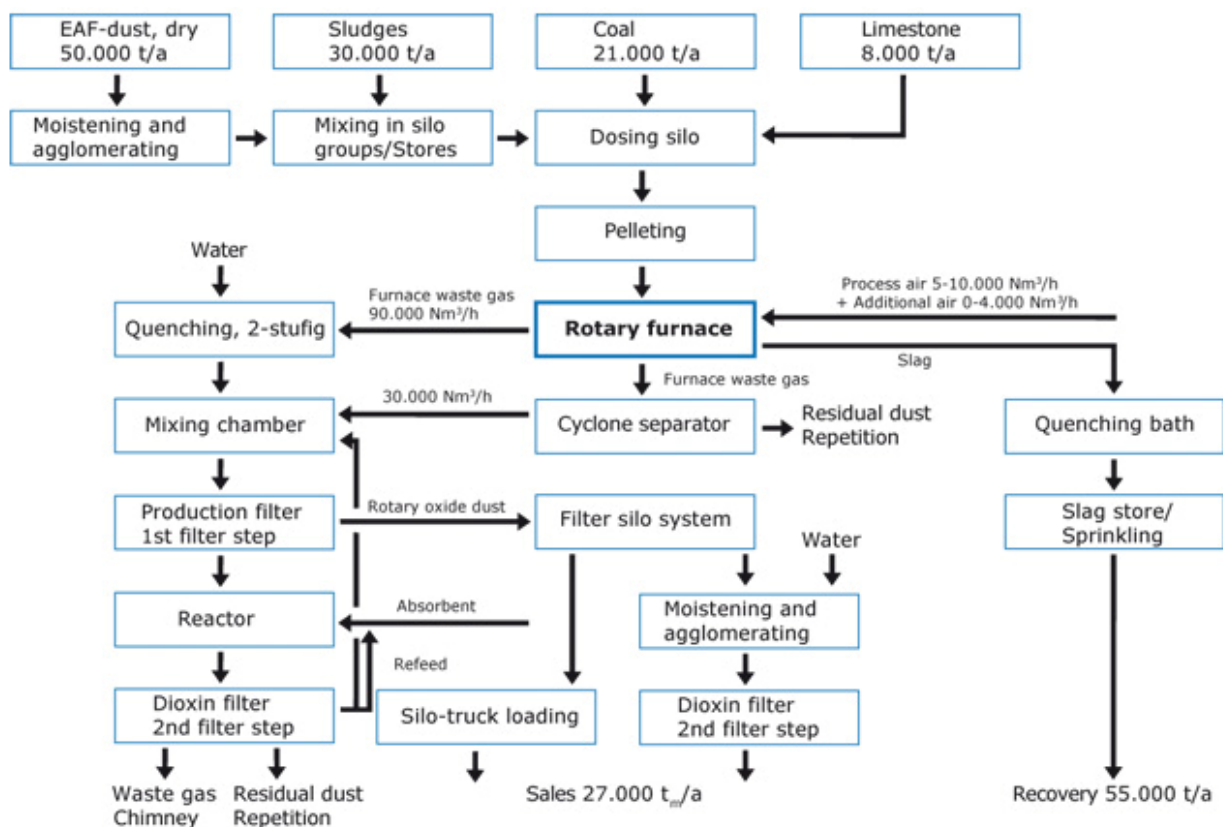


Figure 3. Flowsheet of the whole process

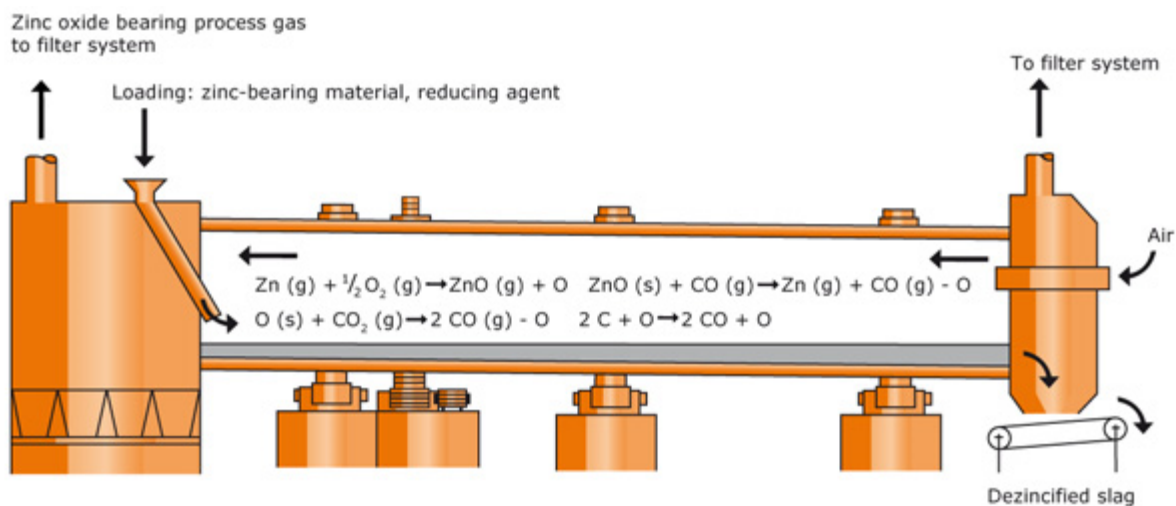


Figure 4. Block diagram of the rotary furnace process

### 3 TESTWORK PERFORMANCE

Homogenizing of the customer's material and the binders are done using an intensive mixer (refer Figure 5). Pelletizing of the homogenized mixture is done using a lab pelletizing disc with a diameter of 1000 mm (refer Figure 6). The rim height of the disc, the inclination and the rotation speed are variable. The mixed material is fed to the disc by a belt conveyor. The material is then wet by a spray nozzles during feeding. The pellets are discharged in a narrow grain size distribution over the rim of the disc. The green pellets, which are wet pellets, are used to determine the green pellet strength.

A sample of the green pellets are then dried at 105 °C in a compartment drier and are measured for moisture, cured pellet strength, pellet bulk density, size distribution using CPA (Computerized Particle Analysis) and abrasion resistance.



Figure 5. Intensive mixer



Figure 6. 1000mm pelletizing disc (SC1000)

### 3.1 Product Characterization

#### 3.1.1 Moisture content

The moisture content of the materials is determined using a thermogravimetric balance dryer. A sample is dried at 105°C until mass constancy, three measurements are carried out, and then the arithmetic mean is determined.

#### 3.1.2 Bulk density

The bulk density is measured according to DIN ISO 697. Three measurements are carried out and then the arithmetic mean is determined.

#### 3.1.3 Drop number

The drop number is an important criterion for detailed plant design. The drop number defines the maximum number of delivery positions a cured pellet can handle without any visible disruptions or breaks during transport. The drop number is determined by dropping cured pellets from a height of 0.46 m on to a steel plate (refer Figure 7). To get a representative drop number of a pellet sample, ten measurements are carried out and then the arithmetic mean is determined.

#### 3.1.4 Pellet strength

Green and dry (or cured) pellet strength are determined by loading one pellet until it breaks. The representative pellet strength of a pellet sample is the average value of 30 single measurements (refer Figure 8).

The unit of pellet strength is N/Pellet. Because the unit N/Pellet depends on the size of the pellets, pellets in the size range of x50 are used.

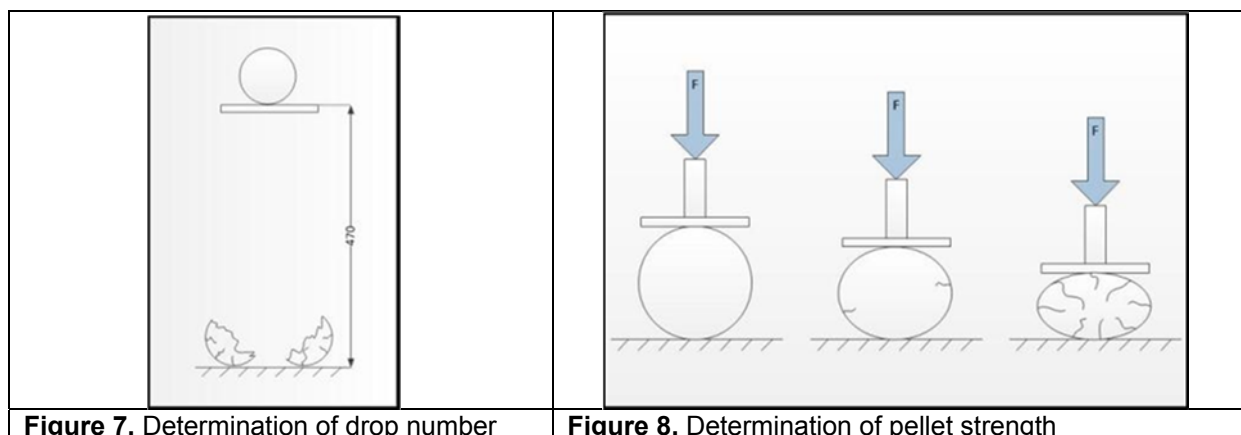


Figure 7. Determination of drop number

Figure 8. Determination of pellet strength

#### 3.1.5 Pellet size

The pellets are analysed using a CPA (Computer Particle Analyser).

Using photo-optical image processing, the CPA analyses the particle size distribution and form characteristics. There are various methods of measurement available for determining the particle size distribution and these can be chosen according to the application. To analyse the pellets the equivalent diameter is chosen as the measuring method. This is the diameter of a coextensive circle, whose surfaces are the same as the projection surface of the actual particle.

#### 4. RESULTS

The zinc dust from the gas purification (refer Figure 9), the slurry from the galvanizing industry (refer Figure 10) mixed with the ingredients coke (refer Figure 11) and lime (refer Figure 12) to form the mixed material (refer Figure 13) to feed the granulation step are represented below:



Figure 9. Zinc Dust



Figure 10. Slurry



Figure 11. Coke



Figure 12. Lime



Figure 13. Mixed material

The requirement specification and the feed material characterization to the testwork are shown on the table 1.

**Table 1.** Requirement specification and Material Characterization

Target particle strength	Conveying with max. 3 drop high 0.5 m in rotary kiln.
Others	Dimensioning pelletizing disc throughput of 15 t / h.
Mixed Material Characterization	Bulk density – 1,05 kg/l Moisture – 9...10 M.-% Grainsize – X50 = 97µm

The characterization of the agglomerated product (refer Figure 14) is represented by table 2.

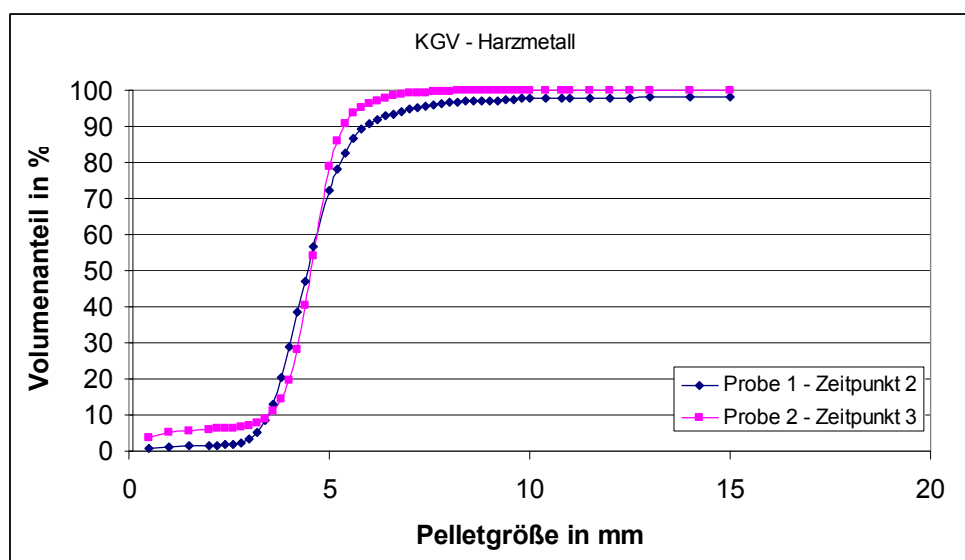
**Table 2.** Product Characterization

Target moisture	14 M.-%
Grainsize	50 mm
Green Strength	50 N
Dried Strength (105°C)	140 N
DropNumber	> 10
Pellet form	Spherical



**Figure 14.** Final Pellets

The pellets (refer Figure 14) were analysed using a CPA to display a representative grainsize distribution (refer Figure 15).



**Figure 15.** Pellets Grainsize Distribution

## 5 CONCLUSION

This paper showed an example of up-scaling possibilities industrial size and with the lab-scaled effort to increase pellet properties of recycled material. At least an outlook about possible other aspects of recycling in use of pelletizing. At the pictures Figure 16



and **Figure 17** show the machine designed and the technical specifications as result study from this testwork.

The machine carry the follow list of advantages:

- Rugged and vibration free design
- Automatic inclination adjustment during operation
- Wear protection on the pelletizing disc (comb bottom)
- Flexible bottom surface and sidewall scrapers
- Flexible spray system
- Central lubrication system
- Energy efficient and low maintenance drive unit torque motor
- Start-up even under full load



**Figure 16.** Pelletizing Discs SC 4200.

<b>Disc diameter</b>	<b>Weight</b>	<b>Drive unit</b>	<b>Rotary speed</b>	<b>Large roller bearing unit</b>
4.2 m	16,5 t	Direct drive 123 kW	0-20 rpm	with internal gearing
<b>Lubrication pinion</b>				
made of PU				
<b>Sidewall height</b>				
450 mm				
<b>Automatic inclination adjustment using a threaded spindle</b>	<b>Installed power for inclination adjustment</b>		<b>Adjustment speed</b>	<b>Wiper</b>
stepless 40° to 60 °	1,1 kW		1.2 °/m in	Ceramic / tungsten carbide
	<b>wear resistant cladding</b>	<b>wear resistant cladding, disc bottom</b>		
	PE 1000 (UHMW PE)	Fiberglass-reinforced plastic or steel grating		
	<b>inclination angle [ ° ]</b>	<b>A [mm]</b>	<b>B [mm]</b>	<b>C [mm]</b>
min/max	40-60	5330	4820-4953	4554 - 5110

**Figure 17.** Technical specifications

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