Roller Press applications along the value chain of iron

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Abstract. Rollers Presses for Briquetting, Compaction and High Pressure Grinding Rolls (HPGR) offer variable flexible applications across multiple industries. This contribution will focus on examples along the production chain of iron from raw material in an ore mine to steel making process. High volume opportunities with HPGR and pellet feed activation between rollers are addressed in the field of comminution. In addition, basic theories of roll processing are explained to bridge them to circular economy applications like Briquetting of steel mill dust and inertisation during green steel DRI-HBI.

1 Basis

Global steel industries support significant customer needs as the basis supply for building materials, transportation and modern consumable goods. As recycling technologies and the life cycle preservation of metals are of growing interest, the majority of steel suppliers still depend on a high volume iron ore processing.

Various processing routes are available on the market [Stahl und Eisen]. Within highly optimized applications roller presses can often be found and are known for their low energy consumption, high throughput and availability, small factory footprint and preferable downstream effects [Heinicke]. By varying operating pressure and mechanical set ups (e.g. surface design), the machine can both comminute and agglomerate feed materials, even if these processes seemingly differ in physical nature. This contribution will detail roller press use cases in the production chain of iron ore and report on the linking of physical principles.

2 Physics principle

Figure 1 shows a state-of-the art Köppern type roller press. The machine consists of two counter rotating rollers, which are pressed against each other by hydraulic systems. Strong drive trains including variable speed drives and gear reducers deliver the torque needed to nip the material on the roller surface, transport it through the operating gap and perform the pressing process to enable agglomeration or comminution.

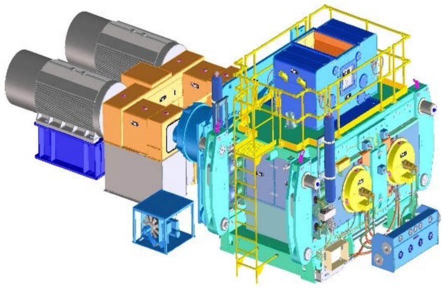

Figure 1: state of the art roller press

As every application has its own defining characteristics, regarding throughput, energy consumption and roller lifetime often determined by the feed material, a set of normalized scaling values can be used. These values are very ore dependent. Therefore, lab scale tests are done at suppliers' facilities. One major key factor is the pressure needed to transform the material within comminution or agglomeration process [Johanson].

The specific pressing force (Fspec), in units of kN/m2, is the total pressing force applied to the floating roll by the hydraulic system divided by the projected area of the roller [Schönert].

$$F_{spez}=F/(D*L)$$

Where: F [kN] - total pressing force
D [m] - roller diameter
L [m] - roller width

Although the installed absolute forces differ significantly for different roller sizes the specific pressing force stays constant. The pressing process between the HPGR

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rollers requires about the same specific pressing force for lab scale and industrial size units to achieve the desired beneficiation effect. Therefore, a larger HPGR needs higher absolute forces.

In addition to this effect, roller press agglomeration uses significantly higher specific forces than grinding applications as per Figure 2.

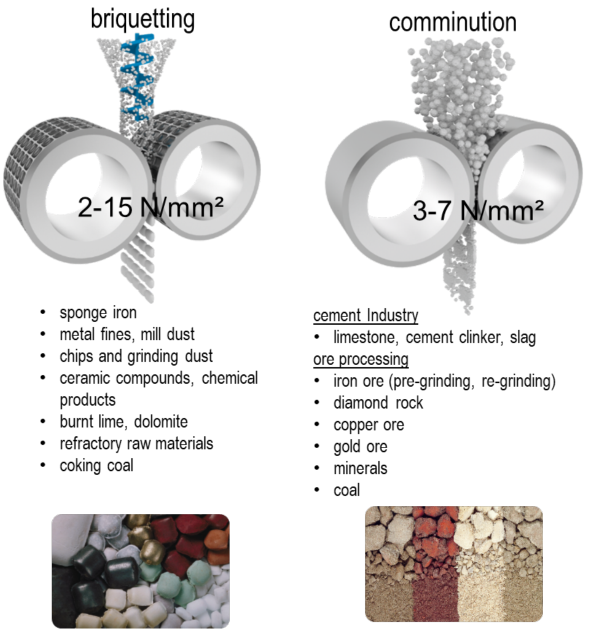


Figure 2: differences in Fspez in agglomeration and comminution applications

In general, the roller press comminution process (known commonly as high pressure grinding roll, HPGR) focuses mainly on the breakage of particles along the grain boundaries while roller press agglomeration, known as briquetting, focuses on forming the single components into a compound of material. Nevertheless, agglomeration can also be found in the physics of comminution, especially if compound forming materials (e.g. clay) are included in the feed material (example for flake as per figure 3).

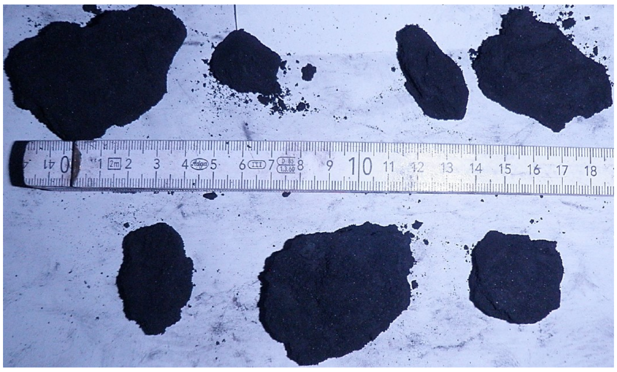


Figure 3: example of flake from iron ore grinding

In this scenario however, the flake formation is not a goal and deagglomeration must be installed causing additional plant efforts and investment costs to overcome the problems of separation/screening downstream. Sometimes those effects are intended as they push downstream processability like stacking or pelletizing. One other option is to reduce the pressing force for this application with limiting effect for the grinding connected to it.

In the absence of those natural binders, formation of agglomerates can sometimes be problematic even at higher forces. Highly enriched iron ore normally tends not to agglomerate therefore binders must be added to assist the material processing. While bentonite has a long tradition in standard fine iron ore travel grate operations, new types are being heavily researched on the market in order to limit C02 emissions caused in iron ore processing [Vale]. Again, the specific pressing force can be used to limit consumables by applying higher forces. At those effects the force action scenario at the roller surface tends to force material out of the operating gap even more. Therefore, screws are introduced to guide the material in between the rollers, beneficiate deaeration of material and increase capacities of the press.

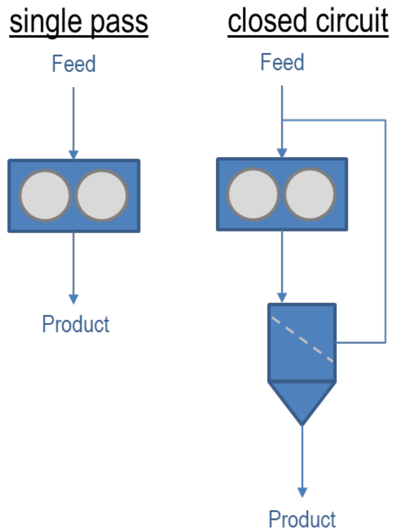
Other tricks are available to adjust the presses for comminution and agglomeration to the individual needs of the process. Experience in the detailed applications and test work is therefore a key challenge and offers the solution to overcome such limitations [Drzymala]. Some typical examples are given below.

3 Example Iron Ore PREGRINDING

A typical application for roller presses is in the tertiary crushing stage of iron ore processing. The key task is to reduce particle size for the downstream ball mill as per figure 4. Machines are operated at feed sizes of <30mm (<50mm for very big roller diameters) in open and closed circuit design. The advantage of closed circuit designs is the full limit of the maximum transfer size is sent to the downstream ball mill, as otherwise not possible in an open circuit environment.

As material passes the gap of the rollers in a full bulk scenario it might happen that coarse, top size particles are embedded in finer material which protects force introduction to those particles. Thereby there is still a statistical chance a coarse particle can survive in a HPGR and would report to downstream without introducing screen limitations.

One key advantage within the HPGR process is the introduction of so-called microcracks within the material. This means a deformation of the natural grain of the ore which reports to the downstream. The following fine grinding apparatus (e.g. ball mill) can therefore grind the materials at lower energy need and thus much higher throughput rates are achieved. By changing of the applied pressing force those effects can be boosted and adjusted to the ore variability introduced into the system [Michaelis].



P80 [mm]	single pass	closed screen circuit	
	6,8mm	CS@6,3mm	3,1mm
		CS@8mm	3,9mm

Figure 4: examples of flowsheets for pregrinding application of HPGR and typical product sizes

4 Example Iron Ore REGRINDING

After fine grinding and beneficiation (sorting) stages for iron ore further processing of iron ore pellet feed is of major global interest. To transform iron ore pellets for ship transport and preparation for steel industries the material can be agglomerated. It is beneficial to introduce wide size distributions at high Blaine numbers to form good green pelletizing strength for rotating disks/tubes and roller presses are used to perform this task [Pietsch].

Iron ore pellet feed has special properties where water saturation and stickiness are of most interest. Figure 5 shows typical material behaviors and feeder solutions to overcome limitations [Guenter]

The pressing force again is an influencing factor as iron ore concentrate behaves like a sponge during the pressing process. If external pressure is applied, the internal pores are compressed and may be saturated with water. Thus, the internal water will drop off the material at too high forces and find its way to surfaces of the rollers then.

Figure 5: stickiness of iron ore pellet feed and step feeder solution for HPGR

This will reduce nipping behavior of machines and limit their production. Detailed knowledge on internal structure and pressure/density behavior is one key understanding, which is accessed during test work in order to find the right optimization for the specific material [Staskiewicz].

5 Example Iron BRIQUETTING

Using iron ore concentrate in the sintering process demands for adding bentonite binder as standard process for travel grate applications and agglomeration disks. Disks are limited to gravity forces by building the compound of materials for the green pellets. To increase binding forces roller presses might be used to enable lower binder demand and ongoing research is being done in this field. This may also optimize the high temperature needs for the downstream beneficiation as well. Applications of roller presses for fine powders are not new as dust residues in steel mill plants have been processed for many decades.

One special application is the briquetting of direct reduced iron under inert conditions by roller presses to meet global shipping standards. Figure 6 shows a typical press and principle of a DRI-HBI application. Forces are very high as to form a solid unlimited agglomerate, which must be separated directly after the press for handling purposes. The briquetting forces deactivate highly reactive surfaces of the pure iron, so that the re-oxidation process is highly inertisated and allows for long range transport without firing risk [Bergendahl].

Again, the specific pressure is set and checked during test work to clear safe densities for >5 t/m³. With respect to changing industries in the field of H2 operations, the agglomeration behavior needs consideration along with research into roller surface options and pressure ranges.

Nevertheless, these examples show again that the physical details of the process require adjustments of the roller press to the individual task in order to enable higher flexibility.

Figure 6: DRI-HBI application of roller presses

6 Summary

The value chain of iron is geographically dispersed and includes various processing facilities and methodologies across the globe. Roller presses can contribute to optimization of the production through the ability to adjust pressures during operation. This enables fine-tuning of the roller press to the local need of iron ore grinding, pellet feed preparation or agglomeration processes. Changing goal definitions towards future applications of H2 routes or recycling technologies are boosted not only by this pressuring flexibility but also by expanding the range of specialty surface designs, which have been developed and proven through more than 100 years of experience in various roller pressing applications.

7 Literature

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