Iron Ore Pellet Dustiness Part II: Effects of Firing Route and Abrasion Resistance on Fines and Dust Generation

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Iron ore pellets abrade during their production and handling, which lowers product quality and leads to dustiness issues. Pellets were collected from a variety of plants (operating either Straight-Grate (SG) or Grate-Kiln (GK) furnaces) to understand whether furnace type affects fines and dust formation. Results showed that pellets fired in SG furnaces were less abrasion-resistant (3.5 lower) than pellets fired in GK furnaces. Concurrently, laboratory pellets were prepared using various ores, binders, and firing temperatures. These were tested to understand the relationship between abrasion index and dustiness. AI was observed to range from 1 to 14%. Dustiness, determined via AI and size distributions of abrasion progeny, ranged from 0.2 to 1.6%. For AI greater than 5%, AI can be used to indicate potentially high levels of dust. For AI less than 5%, there was a poor correlation between AI and dustiness. This was explained by the observation that as AI decreased, the abrasion product fineness increased. The results from parts I and II of this investigation suggest that material loss and levels of pellet dustiness may be significantly affected by pellet quality up to a certain point. Poorly fired pellets will be dusty during handling and transportation, while well-fired pellets will generate less – but finer – material as their quality improves. This could lead to little observed changes in dust generation over a wide range of pellet quality. Dust generation at each site would then depend on the quantity of material produced and their extent of handling.

Keywords: abrasion, dustiness, grate kiln, iron ore pellets, pelletization, straight grate, tumble

Introduction

Many challenges are present when processing iron ore. Problems that have been investigated recently cover flotation reagents and chemistry (Manouchehri 2014; Sandvik and Larsen 2014), filtration (Carlson and Kawatra 2008; Haselhuhn et al. 2012b), water chemistry (Carlson and Kawatra 2011, 2013; Westerstrand and Ohlander 2010; Haselhuhn 2012, 2013; Haselhuhn et al. 2012a), and agglomeration (Kawatra and Halt 2011). However, the formation of fines and dust from pellets (a) is not understood well, and (b) may become a more common problem as greater quantities of pellets are produced.

The generation of iron ore pellet fines can lead to increased material loss, operational problems, and costs throughout the entire production and handling chain. For example, inside of induration furnaces, dust particles from pellets and coal combustion deposit on furnace walls and degrade refractory liners (Jonsson et al. 2013). Furnace gases must then be extensively scrubbed using wet scrubbers, cyclones, baghouses, or electrostatic precipitators (Bolen 2014) before they are emitted to the atmosphere. Pellet fines have also been reported to blind voids and lower the permeability in shaft furnaces, and increase coke consumption and reduce specific output during their operation (Fagerberg and Sandberg 1973). Clearly, fines and dust are undesired and should be minimized.

In an earlier work (Halt et al., in press), it was shown that high abrasion indices (AI), caused by insufficient pellet firing, led to high levels of dust. However, considering good quality pellets from a wide variety of sources, there was no correlation between abrasion indices and dustiness. The purpose of this work was to investigate effects of firing route (straight grate (SG) vs. grate kiln (GK)) on pellet dustiness, and explain the relationship between abrasion index and dust generation for good quality pellets.

Background

Iron Ore Pellet Degradation

Fagerberg and Sandberg (1973) reported how lump iron ore and pellets degrade under various handling conditions. Samples were subjected to 20-m high drop tests and repeated 2-m drops, as well as the standard tumble drum test for iron ore pellets. Fines were defined as the −0.5-mm fraction, as is common in the iron ore industry. The authors concluded that in general, reducing the number of drops and the total drop height, and screening out material closely sized to 0.5 mm greatly reduced fines generation. Important material variables affecting fines generation were mechanical strength, density, size, size distribution, and initial fines content. Hard materials such as well-fired pellets resisted drops without significant breakage and generated fines “almost entirely by abrasion.”
However, many actions taken to reduce ore and pellet breakage by impact will increase the occurrences of abrasion and suggest that studying abrasion fundamentals is warranted.

Copeland and Kawatra (2005) showed that different types of iron ore pellets generated varying quantities of fine particles (<600 μm) using a set of mechanically agitated screens. Fines generation rate varied from 0.21 to 0.88 g/kg min (1-kg sample; 15 min generation time), and the size distribution of the fines ranged from 23 to 43% passing 10 μm. The authors suggested pellet firing route –SG or GK – could be an influential factor. Sivrikaya and Arol (2013) showed that pellet dustiness can be reduced by using binders. All airborne material collected during their dust tower study that pellet dustiness can be reduced by using binders. All airborne material collected during their dust tower study (using the Michigan Tech University dust tower) was less than 100 μm in diameter, and the quantity of particulates finer than 10 μm ranged from 30 to 40% for pellets made with bentonite, organic, and calcined-colemanite binders.

**Aerodynamic Diameter**

The aerodynamic diameter is used to explain the behavior of dust particles in air. It is defined as the diameter of an ideal, equivalent, and spherical particle with a density of 1 g/cm³ that has an identical settling velocity as the particle of interest (Baron and Willeke 2001). Aerodynamic diameter (dₐ) is influenced by particle diameter (dₚ) and density (ρₚ) as shown in Equation (1), which neglects a correction factor for non-spherical particle shapes,

\[ d_a = d_p \left( \frac{\rho_p}{\rho_a} \right)^{1/2} \]  

(1)

In Equation (1), ρₚ is the aerodynamic density (1 g/cm³). Equation (1) is relevant for the particle sizes of interest in this study (dₚ > 1 μm). Thus, if the density and spherical diameter of particles generated by abrasion are known, it follows that the aerodynamic diameter can be estimated. Deviations away from spherical shapes tend to increase the aerodynamic diameter.

**PM₁₀**

Particulate matter with aerodynamic diameter equal to or less than 10 μm is called PM₁₀. These are considered to be coarse, inhalable particles, and their emissions may be regulated. In the Results and Discussion section, PM₁₀ is denoted as dust or dustiness. Using Equation (1) and a solid particle density of 4.25 g/cm³ (typical value for powdered iron concentrate), particles behaving as PM₁₀ would visually appear to have diameters (dₚ) less than 4.85 μm. Particles with 10-μm diameter would be characterized with an aerodynamic diameter of 20.62 μm.

**Materials and Experimental**

**Materials**

Iron ore pellets were made in the laboratory from iron ore concentrates and commercially available binders, and compared with five industrial pellet types.

**Laboratory Pellet Materials**

Two different iron ore concentrates were used to make pellets. Concentrate D was a fluxed, magnetite (Fe₃O₄) concentrate with an 80% passing size of 49 μm. Fe and flux contents were 62.2% and 5.3%, respectively. The main gangue mineral was SiO₂. Concentrate F was a fluxed, hematite (Fe₂O₃) concentrate with an 80% passing size of 30 μm. Magnetite was present as a secondary iron mineral and SiO₂ was the principal gangue component. Fe and flux contents were 60.6% and 10.7%, respectively. Bulk concentrate samples were split into approximately 2.5-kg samples prior to agglomeration.

Bentonite clay was used as the standard binder. The sample had a Plate Water Absorbance (PWA) value of 1000, and an 80% particle passing size of 14.3 μm.

Three types of organic binders were evaluated in this study: sodium carboxymethylcellulose (Na-CMC), cornstarch, and polyacrylamide (PA). The number of samples of each organic binder type tested during this study is as follows: cornstarch (one sample); Na-CMC (three samples); and PA (six samples). The binders spanned a range of molecular weights, ionic contents, and type and quantity of inorganic additive. Detailed binder characteristics were not provided due to their proprietary nature. All organic binders were applied as dry powders.

**Industrial Pellets**

Five types of industrial iron ore pellets were analyzed during the pellet breakdown study, and were also used for comparison with the laboratory-made pellets (Table 1). The pellet samples represented dominant furnace types (SG and GK); binder types (bentonite and organic); and major ore types (hematite and magnetite) found in industry.

**Pellet Breakdown Procedure**

In order to compare fines generation rates from pellets fired in SG and GK furnaces, the method of Copeland and Kawatra (2005) was directly followed. In brief, pellet samples were dried (105°C for 24 hr), screened (+3 mesh was retained), and 1 kg was weighed out and placed on top of a stack of test sieves (3 mesh, 35 mesh, pan). The loaded sieves were covered and placed in a Tyler Rotap and agitated for 15 min. The amount contained in each size fraction was recorded after the test. Fines generation rate is reported as the quantity of −35-mesh fines generated per minute (g/min). The particle size distribution (PSD) of the fines fraction generated during pellet breakdown was determined for each pellet type. Our results were directly compared with the previously published data (Copeland and Kawatra 2005).

It should be noted that the pellet breakdown procedure cannot be used in a direct comparison with any standard abrasion index procedure unless the pellet degradation mechanisms in the two are identical. However, the pellet breakdown test was conducted using a test sample weight (1 kg) that significantly filled the available volume of the upper test sieve to ensure that pellets degraded only by abrasion. No significant quantity of material was produced in the 3 × 35-mesh size class.
Pellet-Making Procedure

Green balls were prepared following standard agglomeration procedures. In brief, moist iron ore concentrate samples were mixed with the desired binder quantity (5 min), and agglomerated into 11.2 × 12.7-mm balls by continually adding fresh feed and water into a rotating steel drum (46-cm dia, 25 rpm). Green balls were dried (105°C, 24 h) and fired at a predetermined temperature (1 h) in a box furnace in air.

Abrasion Test Procedure

Abrasion resistances and dustiness potentials of granular and powdery materials are commonly determined by tumbling materials in a rotating drum (Petavratzi et al. 2005; Gill et al. 2006; Bach and Schmidt 2008; Pensis et al. 2010). In this study, iron ore pellets were screened (+6.4 mm, 30 s) and blown off with compressed air before testing their abrasion resistance. One kilogram of pellets was placed in a cleaned drum (203-mm dia) and rotated at 57 rpm for 5 min. The drum had two antipodal lifters 1.2-cm wide. The lifters aided pellet mixing (instead of lifting-dropping pellets) due to their narrowness. After tumbling, the drum contents were removed, loaded onto a stack of sieves, and hand-sifted for 15 s into three size fractions (+6.4-mm pellets, −6.4 + 0.5-mm chips, and −0.5-mm fines). The mass retained on each screen was recorded. Pellets (+6.4 mm) were placed back into the drum for further tumbling, while powder samples (−0.5 mm) were analyzed for size distribution and density. The abrasion index was defined as the quantity of −0.5-mm fines produced after 30 min, normalized to the initial pellet charge.

Particle Size Distribution

The PSD of the abrasion powder was characterized using a Microtrac SRA 9200. PSD were determined for 5-, 15-, and 30-min powder samples. PSD was fit using a log-normal function, which described the data well.

Powder Density

Powder density was determined using specific gravity bottles. The 10-, 20-, and 25-min powder samples were combined and mixed together to provide a composite sample for each type of pellet. Consequently, powder density was assumed to be constant with respect to abrasion time and particle size.

Calculating the Quantity of PM$_{10}$ Generated during Abrasion

The quantity of PM$_{10}$ produced during abrasion was calculated as follows. The particle size distribution for each time interval, measured by laser diffraction, was “shifted” following Equation (1) to produce an aerodynamic size distribution. The percentile passing of 10 μm was recorded as the PM$_{10}$ level at that time. Using the mass of powder produced during each interval and the percentage of PM$_{10}$, the mass of PM$_{10}$ was calculated for each time interval. A representative cumulative weight percentage PM$_{10}$ curve for plant C pellets is shown in Figure 1. The cumulative weight percentage PM$_{10}$ calculation was more sensitive to changes in the particle size distribution than to powder density.

Results and Discussion

Two studies are outlined in this section: (i) A comparison between the fines generation rates for pellets fired in SG

<table>
<thead>
<tr>
<th>Pellet plant</th>
<th>Pellet S.G.</th>
<th>Powder S.G.</th>
<th>Pellet Porosity</th>
<th>Failure Load (N)</th>
<th>Pellet screen size distribution (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.54</td>
<td>4.66</td>
<td>0.24</td>
<td>1750</td>
<td>6.4 × 9.5 mm: 5.2</td>
</tr>
<tr>
<td>C</td>
<td>3.85</td>
<td>4.78</td>
<td>0.19</td>
<td>3160</td>
<td>6.4 × 9.5 mm: 19.8</td>
</tr>
<tr>
<td>E</td>
<td>3.38</td>
<td>4.59</td>
<td>0.26</td>
<td>2000</td>
<td>6.4 × 9.5 mm: 5.8</td>
</tr>
<tr>
<td>F</td>
<td>3.34</td>
<td>4.70</td>
<td>0.29</td>
<td>2110</td>
<td>6.4 × 9.5 mm: 16.6</td>
</tr>
<tr>
<td>G</td>
<td>3.48</td>
<td>4.69</td>
<td>0.26</td>
<td>2340</td>
<td>6.4 × 9.5 mm: 10.7</td>
</tr>
</tbody>
</table>

S.G. = Specific gravity.
Screen size distribution is determined by sieve analysis.
Pellet specific gravity is determined following ASTM (2009).

Fig. 1. Effect of tumble time on the generation of −0.5-mm fines and PM$_{10}$. This example data are from pellets collected from pellet plant C. The quantity of fines and PM$_{10}$ generated by abrasion was linearly proportional to the tumble time, with approximately 1/3 (by weight) of the fines comprising PM$_{10}$.
and GK furnaces; and (ii) an investigation of the relationship between abrasion index and iron ore pellet dustiness.

**Breakdown of Iron Ore Concentrate Pellets**

The fines generation rates for pellets fired in SG and GK furnaces were determined following the method by Copeland and Kawatra (2005). The results are presented in Figure 2. Error bars represent the standard deviation of four measurements.

As previously suggested (Copeland and Kawatra 2005), there was a significant difference between fines generation rates for pellets indurated in SG and GK furnaces. On average, the fines generation rate for pellets indurated in SG furnaces was 3.5 times higher than that for GK-indurated pellets. Although it is not clearly understood why SG furnaces produce dustier pellets than GK furnaces, there may be a number of potential factors. Several hypotheses are discussed below.

In horizontal SG (or Traveling Grate) furnaces, a temperature gradient across the pellet bed can lead to variations in pellet physical and metallurgical quality with depth and transverse position in the bed. In a pilot-scale study using a pot-grate furnace, Oja (2013) showed that pellets fired on the bottom of the bed had a greater percentage of weak pellets (% >300lbs) and a lower tumble index (% +6.4mm) compared with pellets located in the top and middle layers. Concurrently, the top-most pellets were brittle, as indicated by a very wide deviation in the percentage – 6.4-mm material produced by 10–50-ft drops, compared with the pellets from the middle and bottom layers of the pot.

Gudenaau et al. (1985) also showed that pellet quality deviated due to their depth in the pellet bed. Furthermore, the deviations were pronounced in the larger-sized pellets (>10-mm diameter). They explained that larger pellets in the bottom layer were insufficiently fired, and larger pellets required longer firing times for complete induration. Consequently, one hypothesis was that the SG furnace pellet samples may have had larger quantities of insufficiently fired pellets, leading to higher observed levels of fines.

If temperature gradients in the pellet bed and under-firing were the dominant factor, it had been expected that the compression strengths of pellets indurated in SG furnaces would have a higher relative standard deviation (RSD) than GK-indurated pellets. For pellets collected in this study, the RSD of compression strengths (pellets 9.5–12.7 mm in diameter) closely ranged from 10 to 16% for pellets fired in both types of furnaces.

The second hypothesis was that in GK, pellets are tumbled at high temperatures, so all pellets are sintered to more similar levels. Furthermore, the tumbling action in the kiln, and the drop from the horizontal grate to the rotating kiln, may break weak pellets and remove surface irregularities that would contribute to fines and dust generation outside the furnace. Rough pellets are thought to contribute to high abrasion indices, and plant personnel have felt that GK pellets are smoother than SG pellets.

**Size Distribution of the −35-Mesh Fines**

In the −35-mesh degradation products produced by the Tyler Rotap procedure, 29 to 45% of the particles were smaller than 10μm in diameter. Although not shown here, there was a general correlation between the generation of fines (−35 mesh) and the generation of −10-μm diameter particles. Altogether, these results potentially suggest that the different firing routes could explain the different levels of dustiness observed in good-quality pellets tested in the part I of this paper (Halt et al. 2015). As a cautionary note, any comparison between the Tyler rotap study and an abrasion index test, or the Tyler rotap and a dust tower test may be flawed as the mechanisms of particulate generation in the tests may substantially differ. As discussed in the Materials and Experimental section, efforts were made to minimize any potential differences.

**Abrasion Resistance of Iron Ore Concentrate Pellets**

As size distributions of the degradation products varies with pellet type in this work, in Copeland and Kawatra (2005), and in Sivrikaya and Arol (2013), it seemed reasonable to assume that pellets could produce a large quantity of fines, whereby the particles are relatively coarse, or a small quantity of fines comprising very fine particles. These occurrences could lead to similar levels of dust formation across a wide range of abrasion indices, which would explain the poor correlation observed in part I of this paper (Halt and Kawatra, 2014). This thought led us to examine how pellet abrasion resistance and the fines size distribution are related.

The abrasion index and generation of PM10 for 45 types of iron ore pellets were determined by tumbling pellet samples for 30 min in a 203-mm dia drum. Qualitatively, pellets were observed to become more rounded over time due to attrition,
and became redder in appearance as the pellet surfaces were coated with fine particulate matter. Essentially, only abrasion occurred in the drum, as the chips to fines ratio (−6.4 +0.5 mm:−0.5 mm) was around 5% for each type of pellet.

The abrasion rate, taken as the natural log of the ratio between pellet weight and the initial pellet weight, was the first-order rate process. The first-order abrasion rate processes (linear with respect to time) have been observed with other iron making materials, such as coke and model coke materials (Litster et al. 1986). Similar to the observations made by Fagerberg and Sandberg (1973) and Sivrikaya and Arol (2013), the abrasion rate did not correlate with compressive strength. This suggests that the abrasion mechanisms are strongly influenced by fundamental pellet properties other than strength; the fundamental material properties were not examined in this work.

Effects of Binders on Abrasion Index

The effects of binder type and dose on the abrasion index of concentrates D and F are shown in Figure 3. Organic binder dose ranged from 0.5 to 2 kg/t, while bentonite dose ranged from 2 to 10 kg/t. Organic binders and bentonite clay were added at different doses in order to produce similar green-ball behavior during agglomeration and acceptable green-ball properties. For both concentrates, using organic binders resulted in higher abrasion indices compared with bentonite-bonded pellets. Lowering the bentonite dose increased the abrasion index as reported by Meyer (1980), and a similar trend was observed for PA binders. There was no clear trend for the cornstarch binder.

At a single binder dose (1 kg/t, concentrate D), using different organic binders produced an abrasion index that ranged from 4 to 6.5%. The wide range in abrasion indices may be due to the properties of each organic binder. Organic binders are consistent, homogenous products but the properties vary with binder type. Using different binders could have affected the agglomeration process variability. As an example, final green-ball moisture ranged from 8.5 to 10% (wet basis) for those samples, which would tend to affect final pellet porosity. Increased pellet porosity, and the loss of additional inorganic material due to organic binders have been the major reported drawbacks to organic binder use (Halt and Kawatra 2014).

Effects of Firing Temperature on Abrasion Index

At a constant bentonite dose of 6.6 kg/t, pellet firing temperature significantly affected abrasion index (Figure 4). Increasing firing temperature from 1150 to 1300°C decreased abrasion index from 12–14 to 1–2%, with a slight increase in abrasion index at 1350°C. A maximum value was observed in the compression strength curve at 1300°C, which has been explained by lower oxygen potential at higher temperatures. Lower oxygen potentials would cause hematite to revert to
magnetite, disrupting the pellet structure. Concentrate D was less abrasion-resistant at all temperatures, perhaps due to its coarser grain size (Meyer 1980) but followed a similar trend as concentrate F.

Figure 4 illustrates the sensitivity of abrasion index to temperature under typical operating conditions. The abrasion index for concentrates D and F decreased from 9.92 to 3.99%, and from 7.55 to 1.69%, respectively, when firing temperature was raised from 1200 to 1250°C. Pellet firing temperature had the greatest effect on abrasion index under the conditions tested here. However, bentonite effects may have been more pronounced if tested at lower firing temperatures.

Size Distributions of Particulates Generated by Abrasion

The effect of revolution time on powder fineness was determined by measuring the size distribution of powders after they were removed from the drum. The weight percentage of material with an aerodynamic diameter of 10 μm and smaller is shown in Figure 5. Powder size distributions for each pellet type became finer with tumble time and appeared to stabilize at a specific percentile for each type of pellet.

Similar time-dependent behavior was observed with all pellet types, suggesting either a radial distribution of properties or structure within the pellet, or the attrition of coarse fragments from pellet surfaces during the so-called “stabilization” period. This second view would confirm previous results showing the importance of surface roughness on dust generation in the previously used dust tower (Sivrikaya and Arol 2013). The time-dependent behavior also illustrated that higher levels of degradation should occur during testing as dustiness rankings can change with time unless low levels of handling and abrasion are expected – that is not the case for iron ore pellets.

Powder fineness (described by the 30 min % PM10) did not tend to vary with organic binder dose, but varied with organic binder type, and increased with increasing pellet temperature and bentonite binder dose (common agglomeration variables that affect abrasion indices). In general, the material-specific stabilization level is not understood but thought to be influenced by pellet mineralogy and porosity, and their distribution within the pellet. It could also be related to the grind size of the pellet feed.

Pellets that resisted degradation and abrasion the most tended to produce the finest powder size distributions. This was observed for both concentrate types balled in the laboratory and in the five industrial pellet samples used for comparison. In effect, decreased pellet abrasion index appeared to lead to significantly greater proportions of material in size fractions generally considered as dust. Pellets with lower abrasion index tended to produce powders with finer size distributions. This is shown in Figure 6, with good-quality pellets defined as having abrasion index <5%.

Regression Between Pellet Dustiness and the Abrasion Index

The authors originally hypothesized that the abrasion index can be used as an empirical test of iron ore pellet dustiness. Consequently, the total quantity of PM10 was regressed to the abrasion index. Considering all 45 types of pellets, higher abrasion index led to higher quantities of PM10 or potential material loss ($R^2 = 0.58$). Higher deviation existed at higher AI, potentially arising from the different particle size distributions between the two iron concentrates. Concentrate F was finer ($P_{80} = 30 μm$), and logically had higher quantities of PM10. Concentrate D was coarser ($P_{80} = 49 μm$), and total PM10 stabilized at 0.8%. The higher abrasion index and dustiness levels were caused by under-firing pellets, as shown in Figure 4 and supported by the dust-tower conclusions in Part I of this study (Halt et al. 2015). Simply put, firing temperature was the greatest factor affecting the abrasion resistance and dustiness of iron ore pellets.

The correlation between the total PM10 and abrasion index was weak when only considering well-fired pellets with abrasion index less than 5% (Figure 7). For well-fired pellets, the quantity of PM10 ranged from 0.2 to 0.7%. Laboratory pellets made from concentrates D and F, and the industrial

Fig. 5. Effect of tumble time on abrasion powder fineness. Laboratory pellets are made from plant D concentrate. Organic binders are at 1.0 kg/t; firing temperature: 1250°C. The abrasion products became finer as tumble time increased, and pellets became smoother as tumbling time increased.

Fig. 6. Effects of abrasion index on abrasion product fineness. The abrasion index was defined as the quantity of ~0.5-mm fines produced after 30 min, normalized to the initial pellet charge. The abrasion products became significantly finer as the abrasion index decreased.
pellet samples generally appeared to lie on a single curve. The poor correlation may be explained by the effects of abrasion index on the size distributions of abrasion powders.

In general, powder fineness significantly increased as the abrasion index decreased. Abrasion index decreased from 5 to 1% (80% decrease), while the powder fineness increased from 16.3 to 32.2% over the same range (97% increase). As total quantities of PM10 generated by abrasion depend on the quantity of fines generated and the powder fineness, relatively small changes in the total levels of PM10 were observed.

Pellet Microstructures

Figures 8 and 9 present representative micrographs of pellet microstructures taken near the pellet surface. Five samples at abrasion index ranging from 2 to 7% were visualized. These are arranged according to abrasion index (low-left to high-right) and total quantity of PM10 (low-bottom to high-top) in the figures.

Individual grains in plant A pellets were very angular in nature with minimal growth between adjacent particles. Distinct layers or shells were observed in the pellets, and some regions of very high porosity were present. Plant C pellets, with a lower abrasion index, were compact, dense pellets with significant interconnectedness between adjacent grains. E- and G-type pellets had higher porosity than pellet types A and C (see Table 1). From the limited samples visualized, it qualitatively appeared that the pellets with coarser and angular grains had higher abrasion indices, while the total PM10 increased with decreasing porosity.

Further work should be conducted on a wider range of pellet types, including varying pellet basicity, increased number of ore types, and using a pot-grate firing procedure mimicking industrial pellet firing. A new abrasion unit is proposed which will continuously sample airborne particles during their generation.

Conclusions

Pellets fired in SG furnaces are less abrasion-resistant than pellets fired in GK furnaces, leading to higher levels of fines and potentially higher levels of dust.

The quantity of fines produced during abrasion and their size distribution are affected by pelletizing conditions, including ore type, binder type, binder dose, and firing temperature. These variables were varied within industrially relevant ranges.
Iron Ore Pellet Dustiness, Part II

and their effects on fines generation and material loss were determined. Following conclusions are made from the study:

- Firing temperature is the most important factor affecting pellet abrasion indices and dust generation.
- Abrasion-resistant pellets tended to produce finer abrasion products than weak bonded pellets. This observation may explain the poor correlation between abrasion index and PM$_{10}$ for well-fired iron ore pellets (AI <5%).

The results from parts I and II of this investigation suggest that material loss and levels of pellet dustiness may be significantly affected by pellet quality up to a certain point. Poorly fired pellets will be dusty during handling and transportation, while well-fired pellets will generate less – but finer – material as their quality improves. This could lead to little observed changes in PM$_{10}$ generation over a wide range of pellet quality. Dust generation at each site would then depend on the quantity of material and their extent of handling.

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