Segregation-free Premixes for Increased Productivity and Improved Performance

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Abstract. Powder mixes used in the P/M industry contain ingredients of substantially different particle sizes and specific gravities that have a strong tendency to segregate during handling. Reducing or eliminating this segregation is essential for the part producer to achieve consistent precision and optimum performance. Treating the premixes with polymer binders helped to resolve this problem. Binder/lubricant systems have been developed that provide improved flow rates combined with increased green densities and green strengths. A review of these developments will be presented and their impact on overall productivity and performance will be outlined.

Introduction

The quest for steady growth in the PM industry requires the continuous development of new materials and new technologies that make it possible to create products with higher performance and better quality. One such invention that was introduced several years ago is the ANCORBOND® patented binder treatment technology [1, 2, 3]. This invention solved the problem of segregation of iron powder premixes. Segregation is a natural tendency of powder mixes of various ingredients with a broad range of particle sizes. Segregation can result in part to part and within part variation of properties. Binder treatment technology successfully prevented segregation resulting in better homogeneity. The effect of bonding is clearly visible in Fig. 1.

Figure 1: Scanning electron microscopy picture of a regular premix (A) and an ANCORBOND binder treated mix (B).

Preventing segregation of the various ingredients yields a more consistent composition, thus ensuring that the desired microstructure is obtained in the sintered part.

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The extent of segregation in a premix during the die filling process was demonstrated in a test where samples were pulled from five different locations within a die. Nickel concentration was found to vary on a broad scale from one location to another (Fig. 2 (A)). The five lines represent five consecutive die fills. The test numbers represent the different locations in the die. The same test performed with a bonded premix yielded significantly tighter variability in nickel content among the five locations and also from one die fill to the other (Fig.2 (B)).

![Figure 2: Die fill nickel variability for (A) a regular premix and (B) a binder-treated premix.](image)

Another problem during the handling of these mixes is a tendency for dusting. Using a binder treated mix reduces dusting dramatically. Figure 3 shows the result of an independent study where the concentration of respirable dust was measured in a production environment using regular premix and a bonded mix of a regular nickel steel (FN-0208).

![Figure 3: Comparison of respirable dust levels for a regular FN-0208 premix and an ANCORBOND premix of the same composition.](image)

Dust samples were collected using NIOSH methods, from three different locations within a PM part-making plant. Background sampling was used to establish baseline information. An air quality monitor was placed in the press operator’s work area. A third sampling station monitored dusting in the area adjacent to the compaction tools.

An order of magnitude reduction in dust level was observed with the ANCORBOND premix near the compaction tool. In the operator’s airspace the respirable dust level went from 1.72 mg/m$^3$ for the regular premix to “not detected” for the bonded mix.

A dust resistance test (elutriation test) was developed to be able to quantify and compare the dusting potential of various bonded and non-bonded mixes. The tester consists of a cylinder with a screen attached to the bottom that is placed on the top of an Erlenmeyer flask. A fixed amount of powder is placed into the cylinder and a constant flow of nitrogen gas is passed through the sample.
for a fixed time. The sample is analyzed for carbon, nickel or any other fine particle size ingredient before and after the dusting test. Dust resistance is determined by the ratio of the test results before and after elutriation and it is expressed as a percentage of the retained fine particle ingredients. Typical dust resistance results together with apparent density and flow rate data for an FN-0208 premix and binder treated mix are shown in Table I.

Table I: Powder properties of a FN-0208 premix.

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<tr>
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<th>Premix</th>
<th>ANCORBOND</th>
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<tbody>
<tr>
<td>A.D. (g/cm³)</td>
<td>3.03</td>
<td>3.00</td>
</tr>
<tr>
<td>Hall flow (s/50 g)</td>
<td>N.F.</td>
<td>26</td>
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<tr>
<td>Dust Resistance</td>
<td></td>
<td></td>
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<tr>
<td>Nickel %</td>
<td>25</td>
<td>83</td>
</tr>
<tr>
<td>Carbon %</td>
<td>66</td>
<td>99</td>
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These data indicate that a bonded mix was able to retain almost all of its graphite content and more than 80% of its nickel content during the elutriation test, while the non-bonded premix lost one third of its graphite and 75% of its nickel content. Bonding also improved the flowability of the powder significantly, from a “No flow” to an acceptable 26 sec/50 g in the Hall flow meter.

Advances in Bonding Technology Towards Higher Density

The continuous quest in the P/M industry for higher performance requires higher density. Higher density can be achieved by using higher compaction pressures and/or higher compaction temperatures. These pressing conditions, when combined with lower lubricant content, yield exceptional densities and performance characteristics.

The ANCORDENSE® Process. The first binder treated process that targeted high density was the ANCORDENSE process that was introduced over a decade ago. It includes heating both the tooling and the iron powder mix to about 130-150°C. This process increased the compressibility of a regular premix by 0.10-0.15 g/cm³ at compaction pressures at least up to 700 MPa. Figure 4 shows a comparison of a regular premix and an ANCORDENSE processed FLN2-4405 premix.

Figure 4: Compressibility of FLN2-4405 mixes with 0.6% total organics.
The AncorMax D® Process. In a more recent development a few years ago the AncorMax D binder/lubricant system was introduced. This system enables the user to reach 0.05-0.15 g/cm³ higher green densities than conventional premixes without the need to heat the iron powder mix. It only requires a die temperature in the range of 55°C to 70°C. This die temperature is frequently reached during regular compaction processes or it can be reached by preheating the die. Figure 5 shows the compressibility of a few regular premixes and an AncorMax D processed FLN2-4405 premix.

![Figure 5: Compressibility of FLN2-4405 mixes.](image)

Conclusions

1. The development of binder-treated premixes has greatly advanced the capabilities of the P/M industry.
2. Various generations of binder-lubricant premixes have been developed to satisfy specific market needs.
3. Binder-treated premixes are engineered materials and it is important that the size and shape of a part and the green density to which it is to be compacted are known so that the correct type of bonded premix may be selected.
4. The better flow properties of binder-treated premixes result in better weight stability and process stability.

References