IMPROVED FINAL COMPONENT CONSISTENCY USING FLEXBAG HANDLING SYSTEMS

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ABSTRACT

Segregation of alloying elements in powder mixes creates issues in final components such as increased dimensional variation and increased property variation. Material handling systems that promote mass flow have been shown to reduce segregation during powder handling, leading to improvements in consistency. This paper will describe the bulk bag handling system as a method to reduce the segregation of alloying elements. Case studies comparing the bulk bag system to traditional material handling systems will also be described.

INTRODUCTION

The requirements for powder metal components in applications such as automotive, are becoming more and more stringent. New applications require tighter dimensional control and more consistent properties. Therefore, it is important to identify and eliminate causes for property inconsistency, such as segregation [1].

A typical mix for a powder metal application can contain iron powder, graphite powder, powdered lubricant, copper powder, and/or nickel powder. The homogeneity of these particles can affect physical and dimensional characteristics on a local scale (within a component) and on a macro scale (within a production run). The physical characteristics of the powders (i.e., particle size and shape, composition), blending techniques, and handling/discharge techniques all work against mix homogeneity [2].

Segregation of mix components, such as copper and graphite, can affect property consistency, including dimensional change. For example, a typical PM mix would be an FC-0205 mix with copper target of $2.5^{w}/_{o}$. If the percentage of copper varies from 2.25 to $2.75^{w}/_{o}$, the dimensional change may vary from

0.20% to 0.30% (Fig. 1). If the copper segregation in reduced by half through improved handling techniques, the dimensional change can also be reduced by half (Fig. 1) [3].

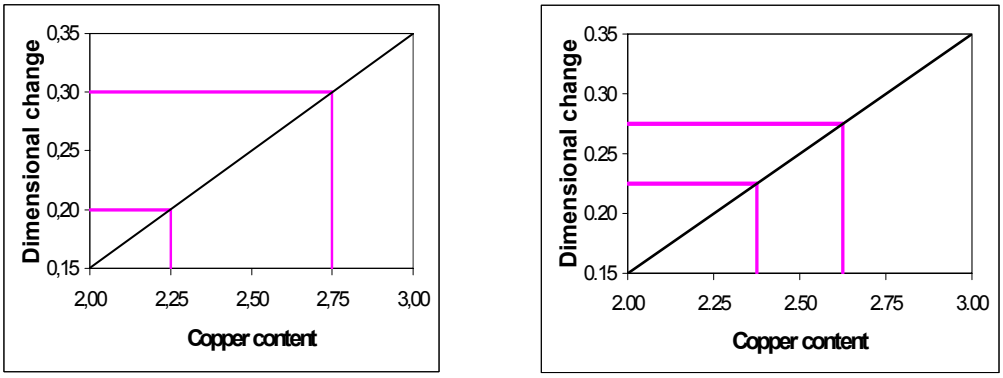


Figure 1: Affect of Copper Content on Dimensional Change

The same affect can be identified for carbon. If the target is 0.35$^{w}/_{o}$, and the composition is allowed to vary from 0.25 to 0.45$^{w}/_{o}$, the dimensional change can range from 0.175 to 0.325% (Fig. 2). By utilizing proper handling techniques, the variation in carbon content can be reduced to 0.05$^{w}/_{o}$, and the dimensional change reduced to 0.05% (Fig. 2) [3].

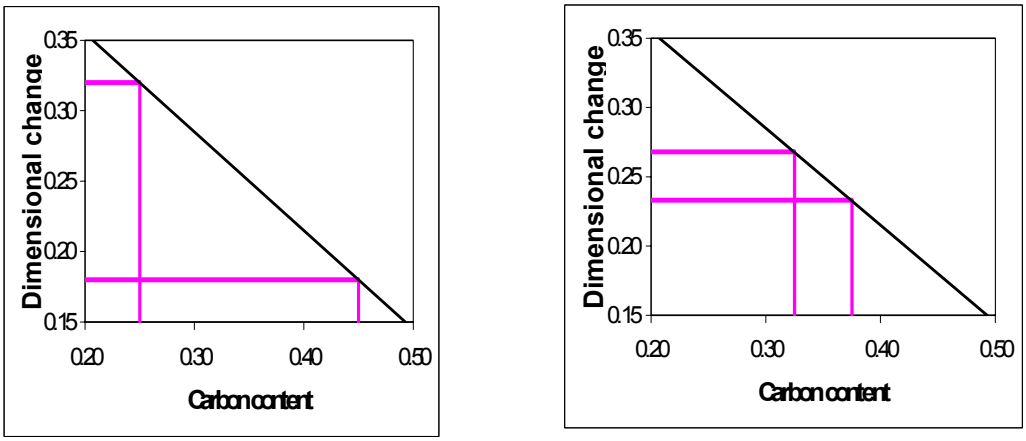


Figure 2: Affect of Carbon Content on Dimensional Change

Segregation of particles in a mix can happen through a variety of processes. The five main segregation processes are [2]:

1. Particle entrainment (dusting)
2. Air entrainment
3. Sifting
4. Sliding on a surface
5. Dynamic Effects

All of these segregation methods can be present, to a greater or lesser extent, in a powder handling system. The powder mix itself also contributes to the segregation method. Sifting segregation, for

example, can be caused by particle size difference, free flowing material, and interparticle motion. All of these factors are present in a typical mix, such as an FC-0208 or an FN-0205 [2].

In order to reduce or eliminate the causes of segregation, methods such as changing the properties of the powder and changing handling equipment are required [4]. Changes to properties of the powder could be changing to a bonded mix, such as a Starmix™, where additives with small particle size, such as graphite, are bonded to larger iron particles to prevent segregation [5]. Or a master additive, such as D.Cu™ or D.ACu™, where the copper is diffusion bonded to the base iron could be utilized [3].

Changes to handling equipment are typically directed toward reducing segregation by promoting mass flow and reducing particle entrainment (dusting) [4]. Mass flow reduces interparticle motion by providing a consistent velocity for all particles as they flow out of the container. With funnel flow, there are velocity gradients between the particles due to uneven emptying of the container (Fig. 3) [4].

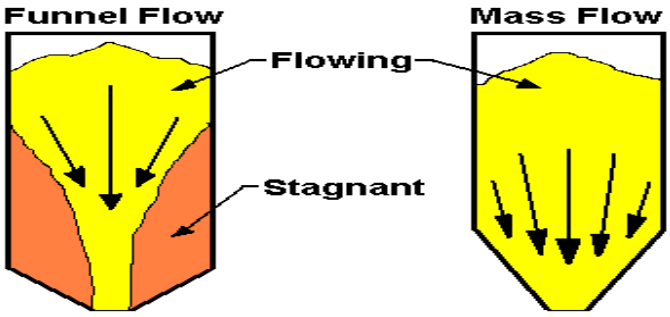


Figure 3: Funnel Flow vs. Mass Flow [4]

DISCUSSION

The Flexbag packaging system (Fig. 4) comprises a nylon outer shell with lifting straps and a plastic inner liner. The packaging has a spout on the bottom for pouring out the powder. They are available in 1,000 lb., 1 mt (2,200 lbs.), 3,000 lbs., and 5,000 lb. sizes.



Figure 4: 1mt Flexbag

Flexbags improve segregation by inducing mass flow. As the Flexbag drains, the bag collapses around the powder, creating an inverse cone shape which produces mass flow (Fig. 5). This prevents segregation, particularly sifting segregation. The Flexbag system, when properly utilized can also prevent segregation related to entrainment of air (fluidization) and entrainment in an airstream, by reducing the amount of freefall experienced by the powder mix.

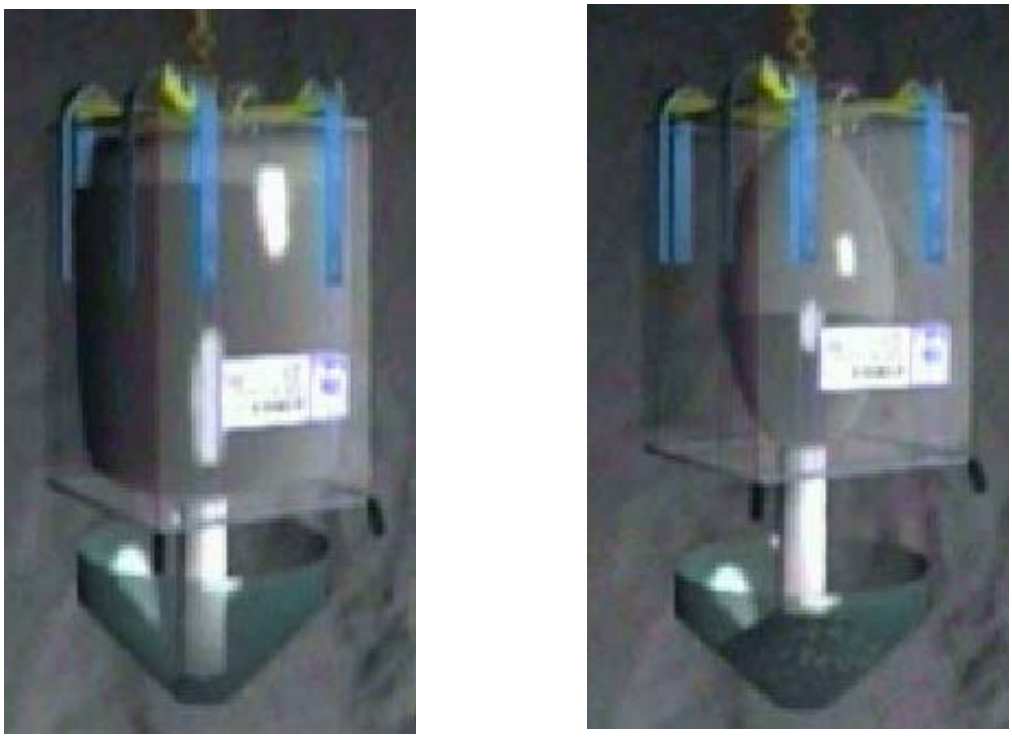


Figure 5: Flexbag Discharging

Flexbags offer significant advantages over cardboard bulk packs with respect to recyclability. The outer shell of the Flexbag can be recycled up to 5 times. Each time the bag is recycled, the inner liner is removed, the outer shell is cleaned and inspected for damage, and a new inner liner is inserted. The outer shell has a recycling tag on the outside that is marked after each cleaning and the shell is discarded after the fifth use. The bags can be placed on a rack system (Fig. 6) that uses no more floor space than an average pallet. When the rack is full, the recycling company is contacted and a free of charge pick up is arranged.



Figure 6: Flexbag Recycling

EXPERIMENTAL PROCEDURE

The level of improvement available when using the Flexbag system was evaluated by conducting a comparison test at a customer location. An existing bulk pack dump and auger system was compared to a flex bag system. The dimensional and chemical consistency of the components was compared to measure the level of improvement.

The existing system used a bulk pack dump to remove the powder from the bulk pack. A corner was removed from the bulk pack, and bulk pack tilted to approximately 45^{o}, allowing the powder to flow into a hopper. The powder is then transferred from this primary hopper to the press hopper with an auger system.



Figure 7: Auger System

The new system suspends a Flexbag directly over the press hopper (Fig. 8). The Flexbag is moved into position in the stand. The operator then attaches a lifting device to the bag, and lifts it to the correct height. It is then traversed into position over the press hopper and opened.

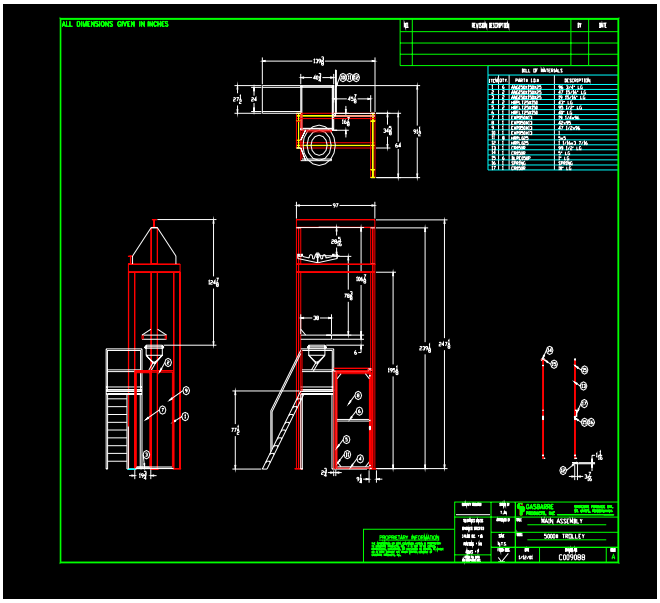
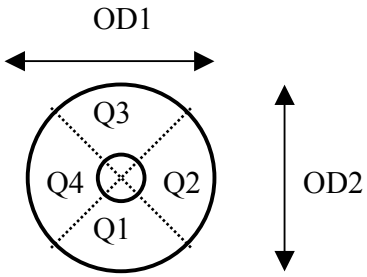


Figure 8: Flexbag Handling System Manufactured by Gasbarre

For the comparison study, an existing component (Fig. 9) used in an automotive application was evaluated. The chemical consistency and dimensional consistency were. The copper and carbon content were evaluated, as well as the weight, height, and outside diameter variation. All measurements were conducted after sintering. Components were sectioned and evaluated for chemical content (Fig. 9). The dimensional variation was evaluated by measuring the variation in height and outside diameter (Fig. 9).



Fig. 9a: Component



Chemical Scatter = MaxQ – Min Q

OD Scatter = ABS(OD1 – OD2)

Fig. 9b: Test Plan

A mix was manufactured using the current composition (Table I). One half the mix was packed into 3,000 pound bulk packs to use on the auger system. The second half of the mix was packed into 2,200 pound (1 mt) Flexbags. The Flexbag handling system was temporarily installed parallel to the existing system.

Table I: Mix Composition

Base Iron	Copper (%)	Acrawax (%)	1651 Graphite (%)	MnS-E (%)
2068	2.00	1.00	0.80	0.50

Approximately 6,000 pounds of the component were produced from each delivery system (two bulk packs and three Flexbags). Samples were collected every 15 minutes during the production trial and set aside. The production samples collected from each delivery system incorporated not only package changes, but also shift changes.

The component consumed approximately 6,000 pounds per shift. Parts were collected from two bulk packs and 3 Flexbags. This incorporated shift changes into the evaluation. After the parts were collected from each shift, they were sintered together to reduce the influence of sintering conditions on the dimensional scatter. The sintering furnace was a mesh belt furnace operating at 2050^{o}F, with an atmosphere of 90%N_2/10%H_2, and approximately 30 minutes at temperature.

RESULTS

Based on the experimental procedure described previously, the following variations in dimensional and chemical consistency were observed.

Figure 10 shows the standard deviation of the height scatter. Figure 11 illustrates the difference in the standard deviation of the weight scatter.

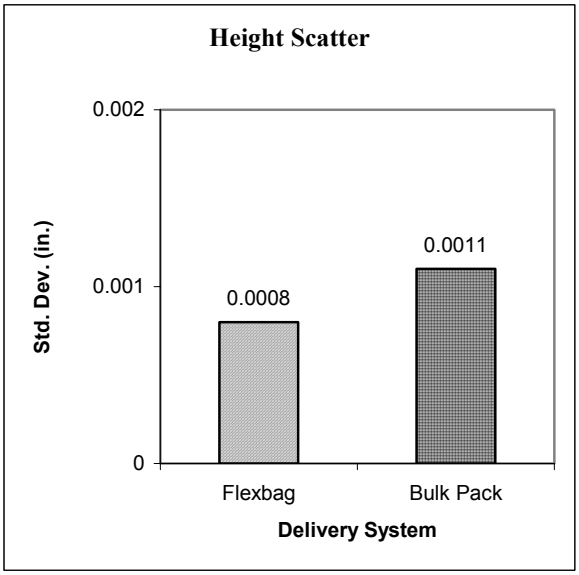


Figure 10: Height Scatter

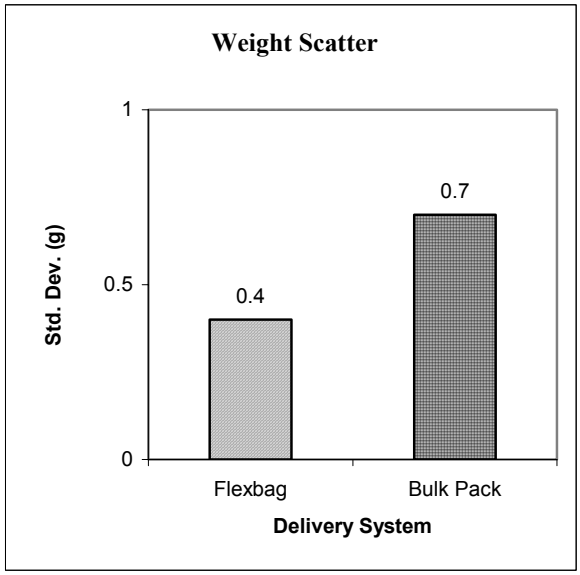


Figure 11: Weight Scatter

Figure 12 is the difference in standard deviation of the sintered outside diameter measurements. Figure 13 shows the standard deviation in the sintered carbon, sampled according to Figure 9.

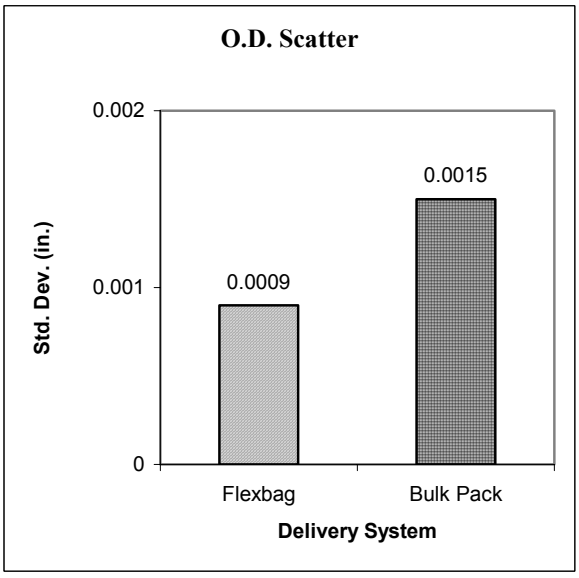


Figure 12: O.D. Scatter

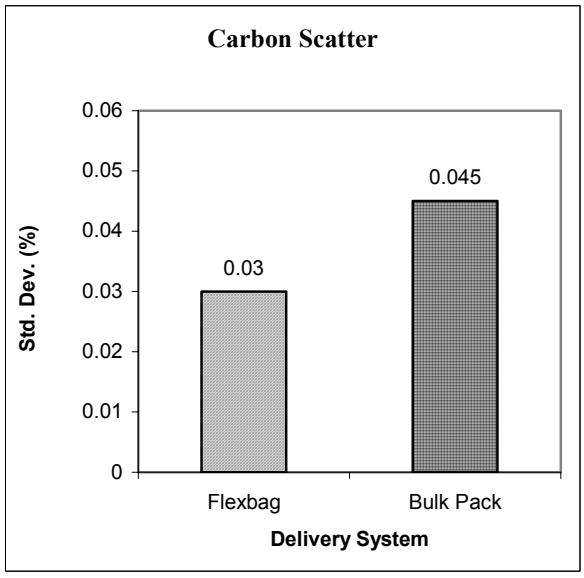


Figure 13: Carbon Scatter

Figure 14 illustrates the difference in the standard deviation of the copper content according to figure 9. Figure 15 tracks the adjustments made by the operator during the course of the production trial.

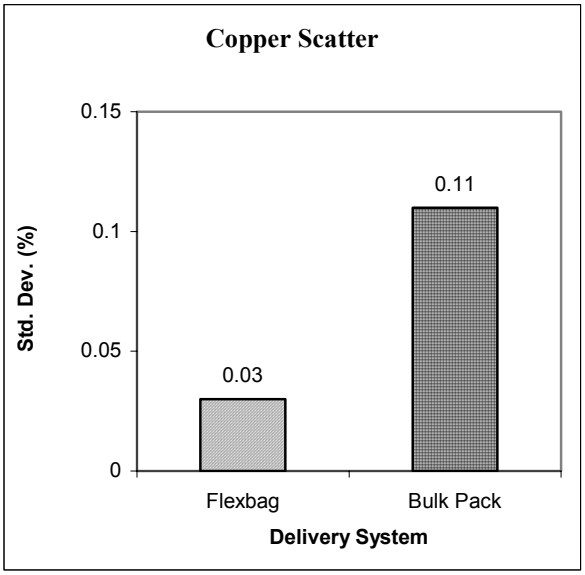


Figure 14: Copper Scatter

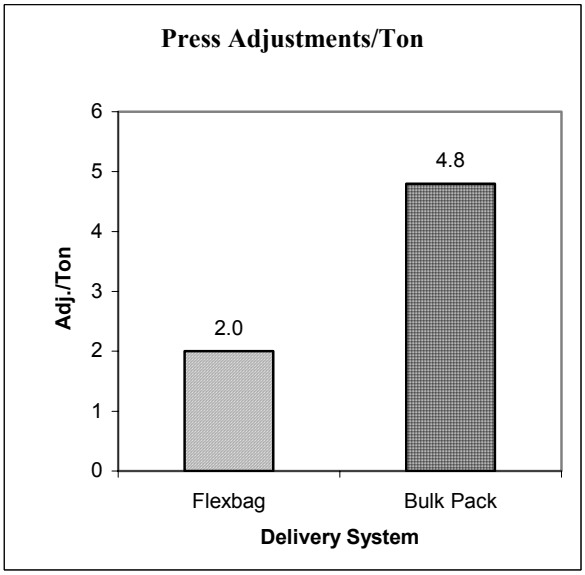


Figure 15: Press Adjustments/Ton Produced

DISCUSSION OF RESULTS

The analysis of the sintered components revealed improvement in the dimensional stability, particularly with respect to the outside diameters (Fig. 12). The standard deviation was reduced from 0.0015" to 0.0009", a reduction of 40% improvement.

There was also a reduction in the weight variation (Fig. 11). Using the Flexbag system, the standard deviation was 0.4g (±3s = ±1.2g). The standard deviation of the bulk pack system was 0.7g (±3s = ±2.1g). This is a 42% reduction in the variation.

Similar improvements were revealed in the consistency of the chemical constituents, particularly with respect to copper (Figs. 13 and 14). The standard deviation of the copper was $0.03^{w}/_{o}$ (±3s = $\pm 0.09^{w}/_{o}$) for the Flexbag compared to $0.11^{w}/_{o}$ (±3s = $\pm 0.33^{w}/_{o}$) for the bulk pack system, resulting in a 70% improvement.

The improvement in dimensional consistency can be attributed to the improved stability in chemical consistency. Swelling caused by copper in the system will allow for symmetric growth of the component. However, when the amount of copper is inconsistent, this swelling can also become inconsistent. Areas with higher levels of copper swell more, and vice versa, leading to potential out of round conditions.

Another process improvement, not originally intended to be part of the study is shown in Figure 15. While reviewing the production data for the components, it was discovered that the press had to adjusted

during the production run fewer times using the Flexbag delivery system. The bulk pack/auger system required 4.8 adjustments/ton produced, compared to only 2.0 for the Flexbag system. This improvement in process stability may provide a future opportunity for cost reduction by reducing the need for set up personnel to monitor the press as frequently.

CONCLUSIONS

Segregation of mix constituents can increase the amount of dimensional and property variation within components and within production lots.

The Flexbag system provides the opportunity to reduce these variations by improving the powder handling methods. By reducing the potential for segregation methods such as sifting and entrainment, overall component consistency can be improved.

Finally, Flexbags offer savings through ease of recycling and ease of handling.

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